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The start of a Second Automobile Revolution Corporate strategies and public policies

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The paper compares the current automobile scenario with the debut of the automobile to understand whether the development of cleaner cars could trigger the start of a "Second Automobile Revolution". Four conditions led to the appearance and widespread adoption of the oil car: the crisis of the previous transport system; the development of various technical solutions, thanks to innovations coming from other sectors; the formation of a coalition of actors to implement one of those solutions despite its great uncertainties; and the macro-economic decisions and public policies that ensured the generalization of the adopted solution. Today, the first and second conditions appear to exist in that, it being no longer physically or economically viable to continue the oil car motorization of the large emerging countries, various alternative cars have been designed. At present, we are observing the creation of actors' coalitions to support the various solutions, although commercial, geopolitical and economical reasons could lead to the preponderance of the electric car, making it the car of a "Second Automobile Revolution". That would completely change the architecture, the industry, the geography, the economy, the geopolitics, and the sociology of the automobile.

Automobile Industry, Automobile Revolution, Clean Cars,
Electric Vehicle, Profit Strategy, Actors' Coalition

Introduction. The four stages and conditions of an automobile revolution

To consolidate and develop the hypothesis proposed in the conclusive chapter of the collective book *The Second Automobile Revolution* (Freyssenet, 2009)¹, I sought by investigating the conditions required for an automobile revolution in the true sense of the word, defined as a transformation of the use, production and impacts of cars. Such a transformation has been announced several times in the past, especially on the commercial launch of some electric car models, but each of these attempts failed (Frery, 2000, Loubet *et al.* 2003). So why will the multiplication of alternative motorizations signal the decline of the internal combustion engine?

¹ This book, prepared within the framework of the 5th research program of the GERPISA international network: "Sustainable Development and Automobile Industry", presents the trajectories of the world carmakers in the early years of the 21st century and analyses a possible transition to clean cars. It is the sequel to two previous books: Freyssenet *et al.*, 1998; Freyssenet *et al.*, 2003.

In responding to this question, one could list the technical, economical, commercial, political, sociological, and cultural conditions that would underpin the success of the different power trains proposed², but the incompleteness of that approach raises some problems. It is also necessary to understand what drives the innovation process: what mix of factors and social forces leads to the requisite conditions for the adoption of a solution, and what are the consequences of the choice that imposes the new change. We cannot exclude the possibility that some of the dominant actors will impose a solution despite its disadvantages. If we apply the conditions suggested by this approach to the debut of the automobile, the oil car would never have been adopted as quickly as it was, given that the internal combustion engine was still technically and economically very dubious when it prevailed at the beginning of the 20th century.

Therefore, I set out to find another way to identify the conditions that enabled the oil car to gain supremacy and effectively launch the so-called Automobile Revolution (Bardou *et al.*, 1982) at the cusp of the 19th-20th century and, at the same time, analyse the current situation to pinpoint possible equivalent conditions.

The historical literature indicates that four major stages and conditions set the scene for the advent of the automobile:

- 1. the urgent need to find a solution to the crisis of the horse-drawn transport system;
- 2. the development of various solutions on the back of the innovations made in other industrial sectors;
- 3. the formation of a coalition of forces for one solution despite its great uncertainties; and
- 4. the macro-economic decisions and public policies that ensured the adoption and generalization of the chosen solution.

The article recalls these four stages and seeks to identify their possible equivalents at the beginning of the 21st century. It explains why it is now possible to hazard a forecast about the new type of car that could prevail over the other solutions. Commercial, geopolitical and economical reasons could lead to the preponderance of the electric car, making it the car of a “Second Automobile Revolution”. That would completely change the architecture, the industry, the geography, the economy, the geopolitics, the sociology, and the ecology of the automobile.

1. The urgent need to solve the previous transport system crisis

The horse was as omnipresent in daily 19th-century life as the petrol car is in the 20th century. Indeed, agricultural, industrial, urban and military development in 19th-century Europe and the United States spurred considerable growth in horse-drawn transport. Although the railroads and steamers enabled the transportation of an

² This approach was proposed at the 17th International colloquium of GERPISA by Jean-Jacques Chanaron, who had performed an interesting and useful test of the various current alternative motorizations according to the conditions described. The result was that none filled, either today or in the immediate future, all the requirements to prevail over the others, even though some satisfied more conditions than others. Therefore, Chanaron concluded that the most probable outcome would be a succession of solutions (from cleaner internal combustion engines to hybrid solutions then electric vehicles and finally to fuel cell vehicles) in proportion to the improvement of their technical and economic performance and their acceptance (Chanaron, 2009).

increasing volume of goods over medium to long distances these did not, unlike today, cover the whole of the territory and were thus unable to convey goods and people from the point of departure to their final destination. The horse-drawn vehicle was an essential component of the transport system³.

Neither the cities nor the roads were equipped to suffer a brutal increase in horse-drawn traffic, the parking of the teams or the multiplication of the stables, the consequences of which were pollution of all kinds, the spread of disease, and a high number of often fatal accidents. Traffic needed regulating with the transportation of materials and food products limited to specific times, while higher tolls were levied to finance the road works (Barles, Guillaume, 1998).

Despite the many efforts made to improve the system, these succeeded only in postponing the inevitable crisis⁴, which then hit at the end of the 19th century for two basic reasons. The first was the growing productivity gap between transportation and industry. The initial and the final routings deployed animal-powered vehicles whose slow pace made them extremely time-consuming, also due to the time needed to unload and reload the goods from one means of transport to another, and placed limits on the size of the loads that could be transported, (Tarr, 1969). The second reason was the price hikes in horse feed, with each horse requiring one hectare of oats and one of hay. In addition, horse fodder was produced on land that competed with that for human food crops, making imports necessary. And, while efforts to boost productivity across all sectors enabled the prices of horse-drawn transport to stabilise, it was not enough to rival the performance of steam transport (Bouchet, 1993). At which point, an urgent solution was needed to overcome the crisis.

In seeking to identify analogies common to both the transportation system of the early 21st century and the situation created by the economic rise of Europe and North America at the end of the 19th century, one can certainly cite the extremely fast takeoff of China in the last ten years, that of India and, to a lesser extent, that of Brazil and Russia. Such fast economic growth has made an ecological crisis inevitable, accelerating the depletion of non-renewable energy sources, in particular, oil.

Even the success of the petrol car itself helped to transform more and more of its advantages into disadvantages as this means of freedom, autonomy, social link, speed and discovery of new spaces turned the car into its exact opposite in the developed countries, where it has become a source of lost time, traffic congestion, and the deconstruction and balkanization of spaces, leading to restrictions on its use. It is also a cause of adverse health effects, such as accidents, physical and psychic diseases, and is a contributory factor to global warming, air, water and ground pollution, non-recycled waste and auditory aggression. The decrease in the relative values of some countries is neutralized by an increase in the worldwide absolute

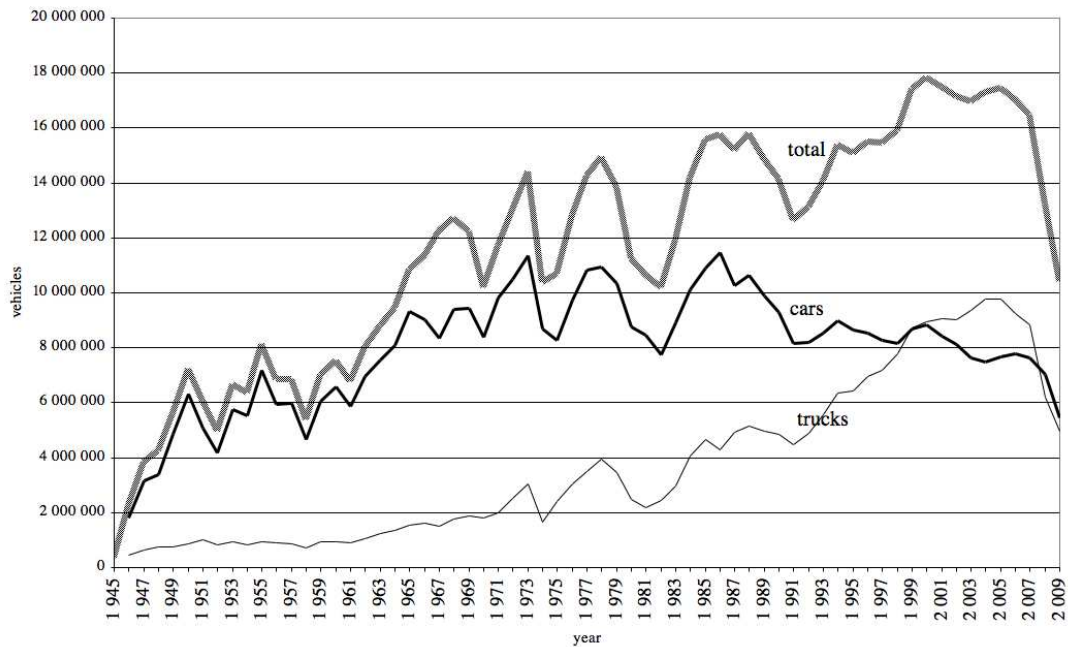
³ The number of horses in London rose from 100,000 in 1850 to 300,000 in 1893 (Turvey, 2005), while the US had 8 million horses in 1867 rising to 21.5 million in 1915, according to Horses Census.

⁴ The horses were better selected, their feed improved and more precisely measured. Medical supervision was enhanced and the stables better isolated, maintained and controlled. The vehicles were better designed and diversified according to their use, and made more robust, while mass production lowered their purchase price (Kinney, 2004). Path and road construction, improvement and maintenance were rationalized and the horse-drawn tram made it possible to transport more people downtown.

values and, in particular, in those countries where motorization is on the ascendency. Furthermore, since the 1980s, the social categories that benefited from the deregulation of wages and the ensuing financial opportunities had bought light urban trucks –the biggest guzzler of oil and emitter of pollution of them all– on a mass scale before the crisis (Figure 1), using them as status symbols to flaunt their good fortune and social distinction.

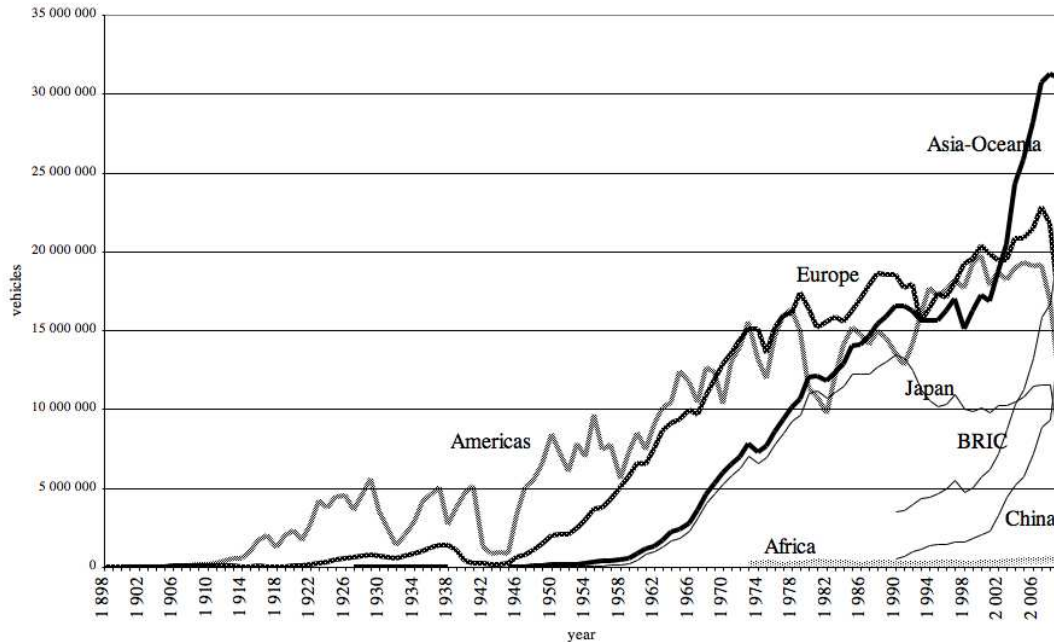
This in parallel to the explosion of the BRIC automobile markets, especially China's. Nothing on this scale has ever happened before in the history of the automobile, not in the United States in the 1950s nor in Europe or Japan in the 1960s. The phenomenon is unprecedented in both absolute value and growth terms (Figure 2).

Figure 1. Sales of new automobile vehicles in USA, 1945-2009



Source: Automotive News

Figure 2. World automobile production by continent and some large emerging countries



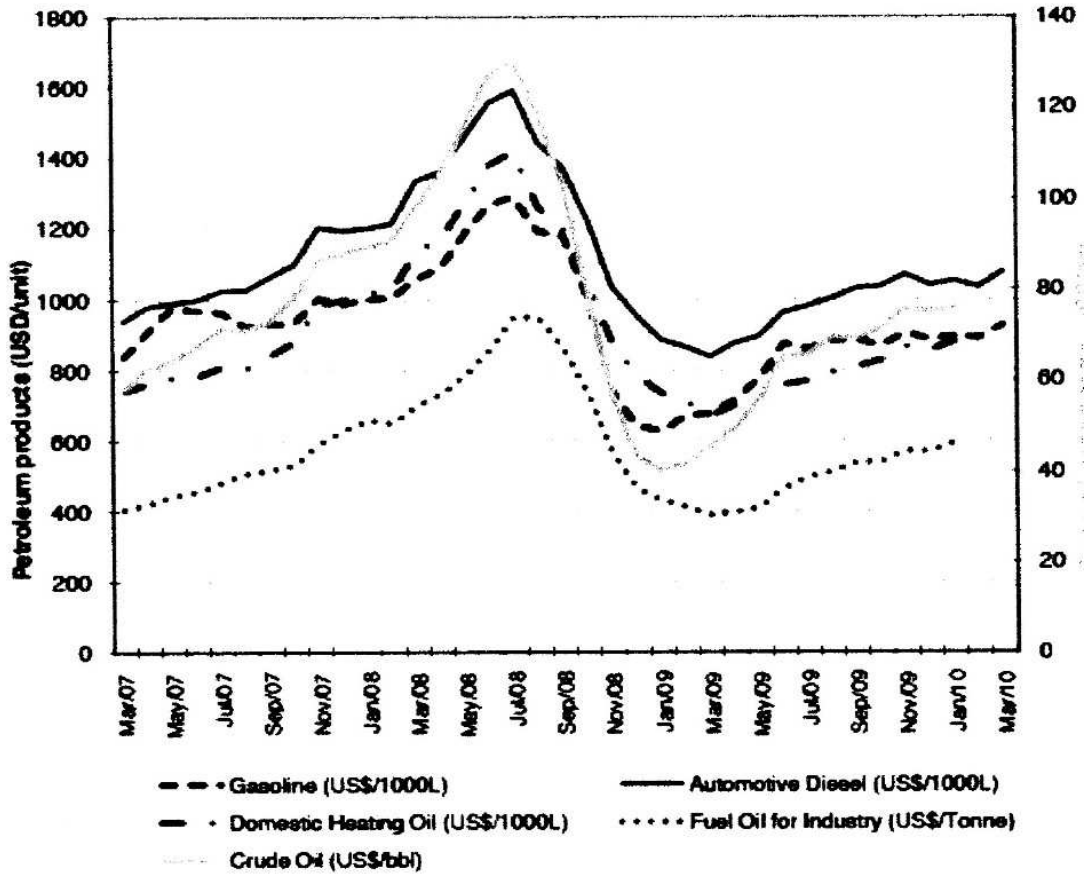
Main sources: WMVD, SMMT, JAMA, IRE, CCFA, OICA.

Elaboration: Freyssenet M. 2004. Updating april 2010.

The worldwide production of motor vehicles fell by 12.3 million units or 16.7% between 2007 and 2009, while Chinese production increased by 4.9 million or 55.7% in the same period. In the space of just ten years, China has become the world's second-largest economy, biggest creditor, and Number One automobile market.

The price of oil per barrel is once again on the rise, whereas in many countries the crisis is far from over (Figure 3). The effects of the price hikes are paradoxical, making it profitable to harvest difficult-to-exploit, lower quality oil resources. The oil companies exert strong pressure to obtain the required authorizations but, even so, the oil peak seems to be looming dangerously fast (Figure 4) and the result will probably be a sharp acceleration in the oil price. China and India are well aware that such conditions would slam the brakes on their industrialization and motorization processes. Consequently, an auto industry based exclusively on the internal combustion oil engine now seems condemned.

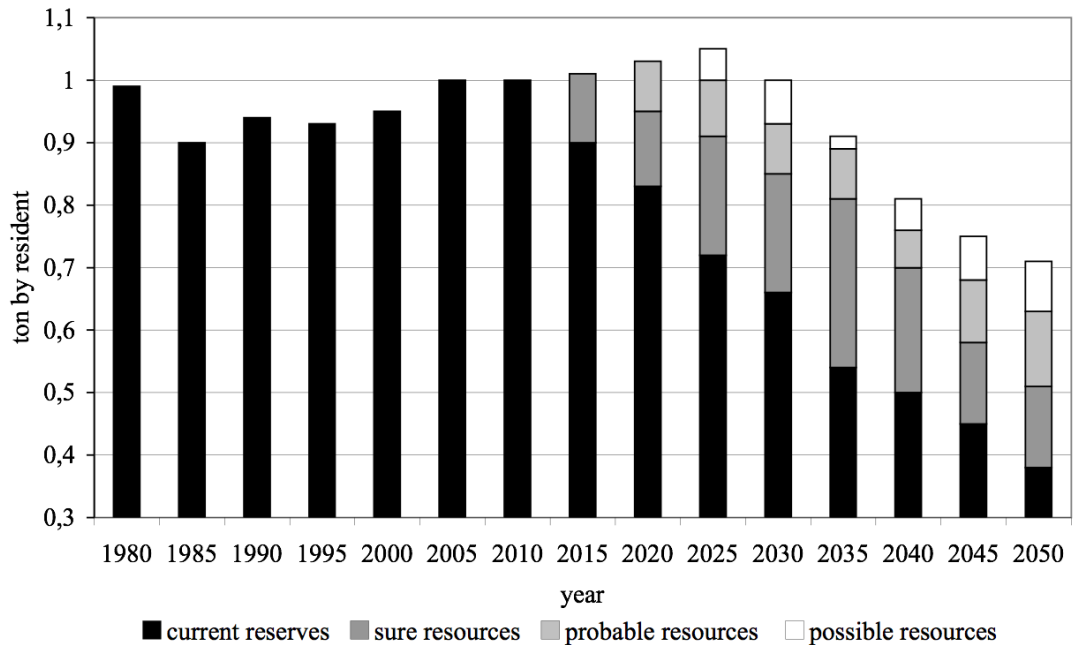
Figure 3. Oil Price Trend March 2007-March 2010



Source: International Energy Agency

Note: the right side scale is the scale of crude oil import costs (USD/bbl)

Figure 4. Average availability of petrol and gas by world resident, 1980-2050



Source: Ungerer P., French Institute of Petroleum, 2009

2. The various solutions that combine and adapt innovations developed in other sectors

Up to now, the sector's possible solutions have remained on the drawing board, their development stalled by the domination of the existing system, but the criticality of the situation now demands their re-examination, also harnessing the innovations developed in other sectors.

In the last fifteen years of the 19th century, the crisis of the horse-drawn system led to a flowering of motorized vehicle prototypes powered by a variety of fuels, above all, steam, electricity, and oil. Several countries made continued attempts to produce a car throughout the 19th century, all of which would have remained long-time failures if not for the urgent need to find a solution. Innovations developed in other industrial sectors led to the surpassing of previous obstacles, in particular, the miniaturization of the boiler, the production of more suitable liquid or gas fuels, the discovery of electricity, the invention of batteries, the miniaturization of the engines for the family workshops, the invention of the ball bearing, the chain of traction, the gear box, the tire, etc. (Mballa, 1998). After which, a large number of start-up companies were established to design and produce four-wheelers using either steam or electricity or a liquid or gas fuel; some even combined two fuels, such as the petrol-electric cars, the precursors of our hybrid vehicles.

Can the same level of momentum be expected today? It seems that the phenomenon is starting to rev up, given the multiplication of technical transfers and inventions, including electronic controls, second-generation agro-fuels, lithium-ion or polymeric lithium batteries, fast chargers, smart grid, fast battery exchange stations, electric engines, and motor wheels, etc.

There is also evidence that an array of start-up companies are being launched by a diverse cast of people: battery manufacturers, aeronautical groups, aluminium producers, equipment suppliers, carriage builders, academics, founders of the Net-economy, rental car enterprises, Indian or Chinese manufacturers and other newcomers. (Table 1).

Some of these start-up companies operate exclusively in niche markets, selling their inventions and/or know-how to the historical car manufacturers. Others have set their sights on becoming or have become mass manufacturers, often betting on the electric car. Nevertheless, the future is not a given and in this arena several energy sources and several types of motorization are in competition with the result that diverse scenarios are possible (Freysenet, 2010).

Table 1. Some cleaner automobile start-up companies and newcomers in some countries

	Startup companies	Suppliers	Newcomers carmakers	Assemblers and others
USA	Azure Dynamic, ELVn E-Z-GO, Fisker, Phoenix, Segway, Tesla,	Johnson Control		Balqon Corp, GEM, Miles Electric, Toro

	Think, Zap			
Canada	Nemo	Magna		
France	Eco&Mobility, Eon-Motors, Electric-car, Fior-concept, Volteis	Bolloré, SVE Dassault, Michelin		Heuliez, FAM, Aixam, Anruet, FAM, Gruau, Heuliez, Innovep, Ligier- Matra, Soffimat, Venturi
Germany	E-Wolf, Ruf, Innovative, Streetscooter			
Italy	Micro-Vett K-Way Motus			Alke, Biro, effedi, Piaggio, Tazzari, Pininfarina
Switzerl and	Protoscar, Rinspeed			
United Kingdo m	Stevens Vehicles, Lightning, Nice car, Murray, Smith Electric	GKN		Lotus, Modec
Sweden	Koenigsegg EV adapt			
Japan	Sim-Drive			
India	Reva		Tata, Mahindra	
China	Eagle, MyCar (Hong Kong), Yulon (Taiwan)		BAIC, BYD, Chana, Chery, Dongfeng, FAW, Geely, JAC, Lifan, Zotye	

Source: my elaboration

What was the decisive factor between steam, electricity, and petrol at the beginning of the 20th century? What will be the decisive factor in the current scenario, which of the four main options will prevail? Less carbon fuels, hybrid, plug-in hybrid or electric?

3. Coalition of actors for one solution despite its great uncertainties

The action of entrepreneurs is needed for an invention to become an innovation. Their role in the nascent auto industry of the late 19th - early 20th century was to perceive the different commercial potential of the various prototypes and

motorizations promoted by the start-up companies and to make them saleable, using their credibility with the banks and the investors to secure financing and their experience of series production and marketing of industrial goods to make them a profitable commodity.

The German engineers Gottlieb Daimler and Karl Benz invented and developed the petrol car but were not the manufacturers who sold the cars for a profit, which enterprise was undertaken by two French entrepreneurs: Panhard and Peugeot. Panhard was a horse-drawn vehicles rental enterprise, Peugeot manufactured tools, coffee mills and bicycles (Law, 1992).

Why did the early manufacturers make such a rapid decision to invest in the petrol car when, at the time, steam traction was the best-controlled technique, boiler miniaturization was underway, steam was replacing coal, the steam car was able to climb hills much more quickly than the other types of cars, and electrical motors gave the best and least harmful performance on flat roads and in urban agglomerations (Garçon, 2003)? But, in the end, the winning solution was the most complicated, the least comfortable, the most uncertain, the most polluting, the most criticized at the time, the most dangerous, and the most expensive..., it was the vehicle with the internal combustion oil engine (Mballa, 1998).

An incredible paradox for which many explanations were forthcoming, but the entrepreneurs had a good reason. At the time, oil was the only energy that was easily storable, relatively compact, immediately transportable and distributable everywhere at an acceptable price. It formed the pre-condition to ensure the car's widespread adoption and use.

Therefore, the electric car was not penalized by the weight, the size and the autonomy of the batteries, which were issues easily solvable if one had access to the substantial financial means dedicated to solving the far more complex problems of the internal combustion engine vehicle (Mballa, 1998).

What penalized the electric car was the absence of pan-territorial electrical networks. Electrification presupposes a general plan and considerable investment, which the industrialized countries managed to complete only 60 years later, but the paraffin oil distribution network already existed and merely required upgrading.

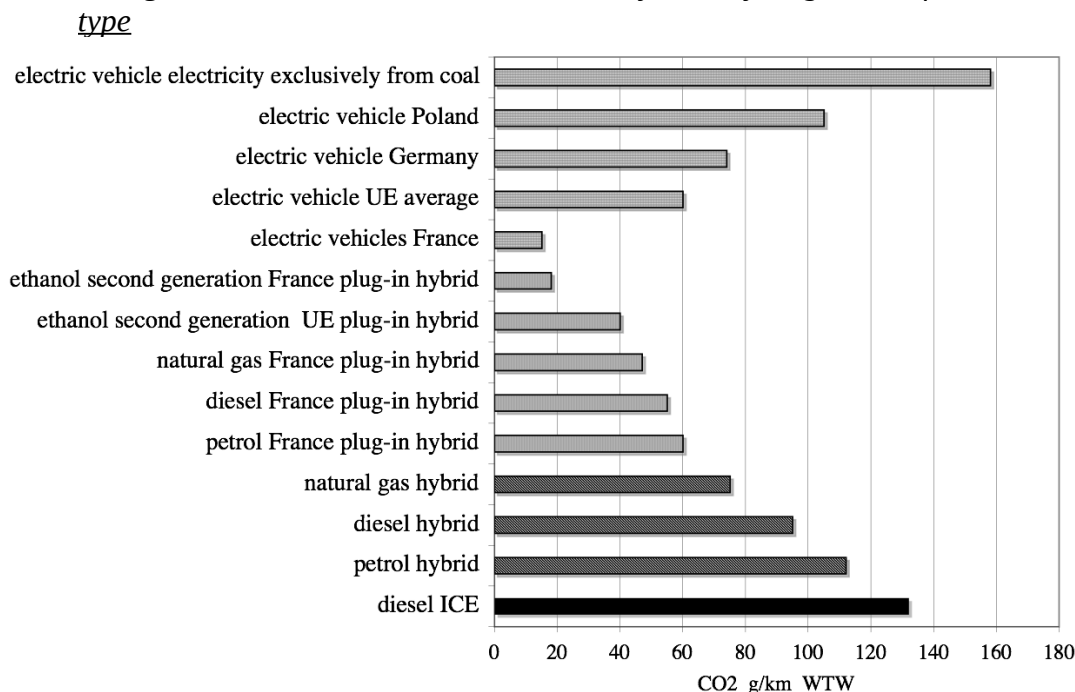
In Europe, the public authorities, in particular, the armed forces, initially hesitated over the which risk was lowest: oil and the loss of energy independence or the impossibility for the armies to have an autonomous vehicle for use in any place and at any time. The choice finally fell to the first option, leading to the progressive creation of a coalition that ensured the prevalence of the petrol car, despite the major technical uncertainties inherent in this choice (Mon, 2004).

Today, as at the end of the 19th century, several solutions are in competition. Two are in continuity with the internal combustion engine: i) improve its environmental performance using less polluting fuels; and ii) recovery in electric form of part of the dissipated or lost energy, the hybrid solution. On the other hand, the other two solutions are disruptive or involve radical change: the battery-powered electric motor or the plug-in hybrid vehicle⁵.

⁵ These various solutions are compatible with the possible change of car status. To reduce the traffic congestion, the car could become increasingly a shared object, whether in public, rental or cooperative form. It is also a supplementary way to reduce the cost and the ecological footprint of the car.

Similar to the first automobile revolution, today's debate focuses on the performances of the various solutions or on what would be responsible to make. Figure 5, below, shows one (source: French Petroleum Institute) of the many studies carried out to assess the well-to-wheel carbon footprint of the various motorizations.

Figure 5. Well-to-wheel CO2 emissions by country, engine and fuel type



Source: Ungerer P., French Institute of Petroleum, 2009

The chart shows that the electric solution can be either the best or the worst solution depending on the origin of the electricity. According to the chart, the plug-in hybrid car powered by second-generation ethanol and the electric car powered by nuclear or renewable electricity produce the lowest carbon assessments.

Any further opinions on this point would serve no purpose seeing that the most technically powerful and the most socially desirable solution at the time the choice was made did not necessarily prevail. The question here is to shed more light on the innovation selection processes and to formulate a hypothesis on the solution that will prevail, even in the face of opposition from many people in terms of its pros and cons.

What direction will the various actors take and what coalitions could emerge? Who will be the winner? This paper focuses on exclusively two of the actors: the manufacturers and aspiring manufacturers and, second, the national governments.

The rapidly shifting positions of the car manufacturers makes it difficult to classify them according to their clean automobile strategy (Table 2). Moreover, some announcements lack credibility. The most notable shift in direction was that of PSA and Volkswagen, both of which had said that the electric vehicle would remain marginal for a long time yet. However, in late 2010 PSA launched clones of its new ally Mitsubishi's i-Miev electric car and electric versions of its two small commercial vehicles, while Volkswagen has just announced the launch of a plug-in hybrid and an electric Golf for 2013 along with an electric taxicab named Milan. In

addition, we underscore that all the major car manufacturers have signed agreements with battery manufacturers.

Table 2. Five (shifting!) strategies: priority to...

less carbon fuels: gas, agrofuel	hybrid versus plug-in hybrid	hybrid versus all types of engine	plug-in hybrid versus electric vehicle	electric vehicle
Fiat Volvo	Toyota Honda Mazda Hyundai Porsche	Ford PSA Volkswagen Daimler BMW	GM Mitsubishi BYD	Renault-Nissan, Chrysler, many Chinese and Indian carmakers, nearly all start- ups and newcomers

Source: my elaboration

At present, five strategies can be identified. The first favours less carbon fuels (natural gas and agrofuels) and was the strategy of Fiat and Volvo, until now that is (May 2010), seeing that Fiat announced recently that its Chrysler ally would produce an electric FIAT 500. The second strategy –pursued by Toyota and Honda but also, it seems, by Mazda, Hyundai and Porsche too– envisages progressively equipping the entire range with hybrid engines and testing plug-in hybridization. The third strategy revolves around four types of cleaner motorizations, according to the country and the uses (urban, suburban, rural, general purpose), and belongs to Ford, PSA, Volkswagen and, possibly, Daimler and BMW. The fourth strategy gives immediate priority to the plug-in hybrid and the electric car, such as in the case of General Motors, Mitsubishi, and the Chinese newcomers BYD. Finally the fifth strategy focuses on the electric car and is the case of Renault-Nissan, Chrysler, many Chinese and Indian carmakers, and nearly all start-up companies and other newcomers. Amongst the historical car manufacturers to choose the electric car, Renault alone offers a broad range of models, including a family car.

The attitude of carmakers who announce plug-in electric vehicles and electric vehicles to meet automobile demand is not the same. Some have taken a wait-and-see stance, letting the market decide. Others a voluntarist approach whereby the market must be created. To date, the former was more generalized and explains the great caution of the offers and investments. The second is that favoured by Renault and Nissan, which are increasing their partnerships with the public authorities, the electricity companies and the research centres in order to exit the vicious circle created by too high price/too weak sales. Several ways to increase the appeal of the purchase price have been thought of: to rent the battery; to ensure the sale of the first 50,000/100,000 cars through agreements with car rental companies, corporations, organizations and municipalities that keep large fleets; to give the buyers significant incentives to purchase clean vehicles; and to ensure that the electricity suppliers or local public authorities install fast chargers. Renault and Nissan will make a

combined investment of US\$4 billion by setting up high-volume production lines and battery factories.

On the other hand, the various national governments and local authorities appear to have a clearer idea of their preferences than the car manufacturers. Brazil and Sweden favour agrofuels. Russia and Italy, prefer natural gas. The United States lean to the plug-in hybrid. China, India, France, Great Britain, Belgium, Ireland, Spain, Portugal, Denmark, Switzerland, and Israel have all elected the electric car. So far, Germany, Japan and the European Union have deemed it enough to lay down consumption and pollution restrictions, leaving it to the automobile producers to choose the solutions, but also these countries seem likely to change their mind.

Thus China and some of its manufacturers know that priority will have to be given to nuclear or renewable energy in order to continue the process of industrialization and the motorization of households. The transition to the electric car also eliminates the need for the lengthy and expensive acquisition of the competences and means that go into making the existing motor vehicles and avoids head-on competition with the historical car manufacturers. In its favour, China is already a mass-producer of batteries and has many research centres working to improve electricity storage, while its drivers basically use their cars in the large urban areas and the immediate vicinity, therefore, widespread adoption of the electric car would enable China and the Chinese manufacturers to become important players more quickly.

Thanks to the plug-in hybrid and the electric vehicle, the United States, where the manufacturers lost the leadership in their own market, Great Britain, which has lost all its national manufacturers, and France, which is planning to exploit an advantageous specialization, have another chance to get back in the race (Table 3).

Table 3. Alternative energies and national preferences for cleaner cars ... until now (May 2010) ...

Agro-fuels	Natural gas	Plug-in hybrid	Electric vehicles	Only objectives of pollutant reduction
Brazil Sweden	Russia Italy	USA Canada	China, India France, Belgium, Great Britain, Ireland, Spain, Portugal, Denmark, Switzerland Israel, etc	Japan Germany European Union

Source: my elaboration

Consequently, the question of the future of the auto industry becomes “what solution will enable the newcomers and the now-weakened carmakers to impose their strategies, if they find the financing to apply it?”.

The most likely solution, despite the current hurdles and uncertainties, would appear to be the electric car, given that the hybrid motorizations, including the plug-in hybrids, are both complex and expensive and consolidate the current automobile architecture. Much uncertainty remains about whether a manufacturer can stay competitive by offering all the motorizations at the same time. The winner could be the carmaker that invests in doubling the performance and reducing the weight of the batteries, especially if it develops a new automobile architecture capable of revolutionizing the design, the industry, the economy, the supply chain, and the use of the automobile.

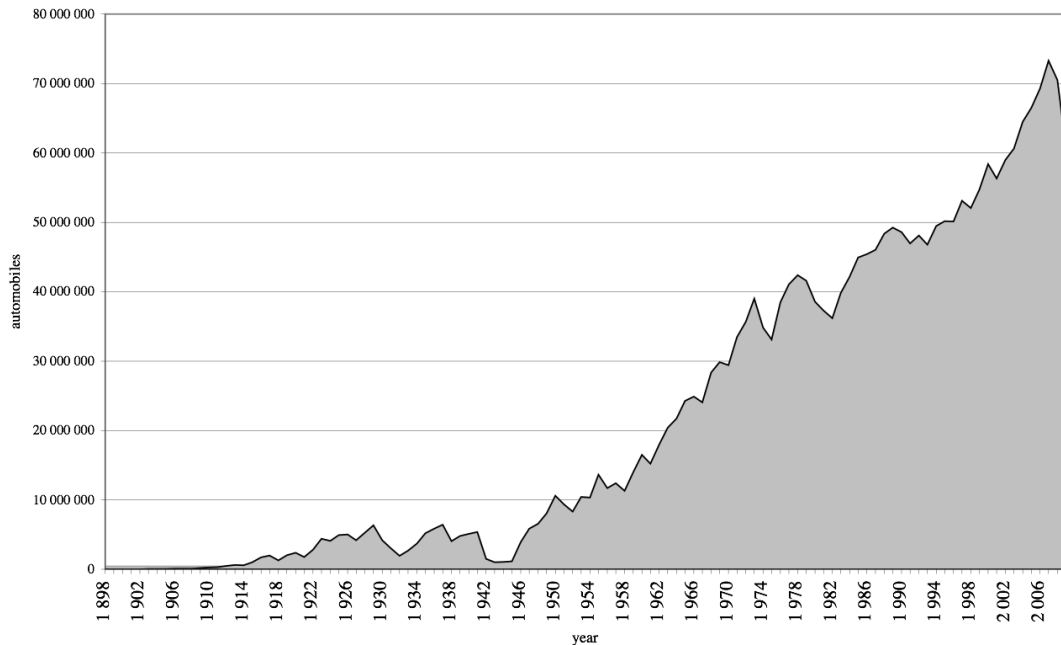
In fact, the electric motor would make it possible to design and produce cars in a radically new way for two reasons. First, it would be possible to install an electric motor in each wheel, known as the “wheel motor” system, this innovation has been successfully tested by Michelin and several start-up companies. That approach would free up almost the whole of the car’s interior space as well as substantially improve its driving performances. The designers would be able to design vehicles that meet even more specific and changing needs and invent new uses for the car. Second, the car potentially would become truly modular because the interfaces between units could be standardized. The vehicle production and maintenance processes would change completely and it would be possible to develop the automation of assembly lines. Ultimately, it might even be possible to create a new profit strategy that reconciles “volume” with “innovation” (Boyer, Freyssenet, 2002).

The situation today can be described as the beginning of the third stage of the innovation process, in which no clear choices have yet been made and the formation of coalitions is still under way. However, the formation of a dominant coalition will not be enough to ensure the rapid generalization of the adopted solution. In addition, a fourth stage needs to be taken into account, that of the national income redistribution policies, which may or may not favour the expansion of the market for cleaner cars.

4. Macro-economic decisions and public policies for the adoption and generalization of the solution

The graph (Figure 6) of worldwide automobile production since 1898 shows clearly the massive and continued surge in petrol car purchases starting the second half of the 20th century.

Figure 6. Worldwide Automobile Production, 1898-2009



Main sources: WMVD, SMMT, JAMA, IRF, CCFA, OICA.

Elaboration Freyssenet M., 2004. Updating april 2010

That surge can be attributed to the adoption in the main industrialized countries of a far less uneven national income distribution policy than that of the pre-war period. Thanks to the new post-WW2 policy enacted by the governments, which no longer wanted to risk a similar build-up of the events –increasing social inequalities, economic crises, and the exacerbation of nationalisms– that led to the outbreak of the war, a growing number of households now had the spending power to buy a new car. The current crisis of the American auto industry had also shown that without regular, nationally coordinated and moderately hierarchical growth of purchasing power of households, automobile sales would falter, penalizing the long-term profitability of the carmakers.

Today, the same question arises albeit in a less dramatic way. In those countries where motorization has reached saturation point, young couples and the middle-classes are forced increasingly to purchase used vehicles that are more polluting and, in the long run, more expensive than the new vehicles. The emerging markets will be able to continue to push the worldwide car production, but only if the countries and governments in question adopt new policies to share their national revenue and reduce the current gaps in income distribution.

Conclusion

Although much uncertainty surrounds the political effort to fight global warming, there is no such uncertainty on the tendential increase in petrol prices, also driven by the exponential needs of BRIC. As a result, the long-term motorization of BRIC can be pursued only through the use of alternative energy sources and the adoption of new types of automobiles. That constraint and the electric car translate into major opportunities for Chinese carmakers to become economically and technologically independent from the historical carmakers. The only uncertainty is not the future

growth of BRIC but the insufficient distribution of national revenue to the people of these countries, which factor can slam the brakes on the future demand for new vehicles.

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