ELECTROMOBILITY IN THE AUTOMOTIVE INDUSTRY: A TECHNOLOGICAL AND GEOPOLITICAL SHIFT

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Abstract
At the beginning of 2021, the very worrying shortage of Taiwanese semiconductors from TSMC and UMC for the industrial sector, and in particular the automotive sector, highlighted the crucial role of these electronic components. If we tend to consider automobiles as a chassis-engine assembly, the 1990s introduced on-board electronics as a series for reasons of safety, electro-mechanical management and comfort. This interdependence between raw materials and data has become particularly crucial in electromobility, because it manifests itself in the midst of the industrial transition of the automotive sector, which is also in geopolitical transition from West (Atlantic zone) to East (Pacific zone). The countries that hold the systemic approach will be the masters of the mobility of the future.

Keywords: *electromobility, electric vehicle, semiconductors, transition, automotive*

1. Introduction

Since early 2021, major automakers around the world are forced to cut back, or worse, to shut down production lines due to a persistent shortage of semiconductors.

In a press release, the Alliance for Automotive Innovation (www.autosinnovate.org, 2021), a federation of industrialists present on American soil, strongly urged the 29th March 2021 the public authorities to take into consideration strategic supplies, including critical metals and electronic components: “We offer the following specific policy recommendations to encourage and incentivize investment by manufacturers and suppliers: Promote national security and economic security enhancements through the development of U.S.-based supplies of critical minerals (extraction, processing, recycling), battery and fuel cell manufacturing, and other critical components, including semiconductors.

The real reason for this concern is the awareness that Americans, like Europeans, have become prisoners of an industrial reality profitable to the Asian powers.

The advent of electromobility is a phenomenon the acceleration of which is disrupting many players and practices in the mobility sector that have existed for many decades. It is also part of an indirect geopolitical perspective, with the supply of equipment and components, and more and more direct, with the delivery of finished products by mainly Asian private entities often benefiting from discreet state support.

The latter have been able to invest and impose their know-how, their vision and their industrial power by further weakening the former proponents of the sector, mostly European and American, obliged in order to survive to ally themselves, to merge, to transform or to disappear.

The Asian grip on the nerve cogs of large-scale electrification is one of the least visible but most active facets of the pivotal world domination from the Atlantic zone to the Pacific zone, of which Tesla is the tree that hides the forest.

Electrification has also accelerated a trend visible since the 1990s: the increasingly critical use of electronic components. Cars have thus become over the years “computers on wheels” that it is necessary to supply millions of lines of codes because of the ECUs (Electronic Control Unit) placed inside them. If we often insist on the fact that electric vehicles (EV) are less demanding in mechanical parts, on the other hand they are very demanding in electronic parts. To understand its importance, we must consider the three layers of cyberspace: the electronic part is the physical layer (hardware) which allows the logical layer (software) to interact to end up in the social layer (information).

This trend is the result of a triple demand: more safety (active or passive); more comfort (e.g., infotainment, heating, seat position); more optimization (mobility) (European Commission, 2019). This demand is based on a double requirement: more raw materials and more data. And electromobility consequently reinforces this double requirement. Both for legal reasons (imposition by European law[i] of security systems such as ESP, ABS, eCall), for marketing reasons (electromobility must appear modern and have the latest technology with optional options billed at the high price) and finally for maintenance reasons (access to OBD2 / EOBD).

Basically, an electric vehicle requires two key elements: the motor and the battery or the fuel cell. Because it is not enough to extract and/or assemble raw materials, it is also necessary to master the technology of electromobility. The battery and the motor are condensed technologies whose efficiency is intrinsically linked to the presence of electronic components. However, few international automobile producers have invested since the year 2000 in this mobility sector, except Asian ones and the American Tesla… till 2015.

2. The big turning point of 2015

As a result of national incentive and / or restrictive policies (conversion aid, bonus / penalty system, traffic zones prohibited for thermal vehicles, CO^2 emission thresholds, etc.), the global electromobility market is displayed in boom despite the coronavirus crisis and an overall very gloomy automotive market: according to the figures for 2020, sales of electric vehicles thus recorded + 137% in Europe, + 12% in China and +4 % in the United States while overall sales fell by -28% according to EV-Volumes figures (Roland, 2020).

However, behind this success of artificially assisted electromobility, it hides a less perceptible but nevertheless a reality: the great battle for the mobility of tomorrow. Because if the European and American manufacturers have outrageously dominated the world automobile market (with the notable exception of the Japanese brand Toyota) the last decades, this situation seized up after 2015.

The Dieselgate affair revealed by the EPA (United States Environmental Protection Agency) has emphasized the growing criticism towards diesel in particular, then against all internal combustion vehicles, known as thermal: struck by all ills, these became quickly the target of taxes and traffic restrictions for the benefit of electric or hybrid vehicles (Harrel, 2019).

This “industrial earthquake”, on the other hand, was a bonus for promoters of electromobility, very few in this niche market when the affair occurred. One of its main representatives is Tesla Inc., which had remained confidential in the segment since its creation in 2003, under the initial name of Tesla Motors.

We can infer that this confidentiality allowed this young manufacturer to avoid the chance of this ambitious but unfortunate entrepreneur of the 1940s that was Preston Tucker (Pearson, 1988), target of the Detroit Big Three (General Motors, Ford and Chrysler) well aware the danger of a large-scale fourth American brand.

This turnaround in mobility can be considered as a revenge more than a hundred years apart where the heat engine definitely took the upper hand technically and economically over its electric counterpart in the 1920s (Wakefield, 1994).

We have to remind that at the turn of the 1900s, almost all of New York's taxi fleet was powered by electricity fairy as evidenced by the dynamism of the Electric Vehicle Company.

Be that as it may, in 2021, it is the automaker Tesla with more than $ 580 billion in market valuation that dominates the market, far ahead of Toyota with its 244 billion or General Motors with its 78 billion.

We still have to be careful about this craze for electromobility which sometimes precedes a sudden contraction of the market associated with the reduction, or even elimination, of certain aids to electromobility (like China or France which have decided to reduce the related tax benefits in stages in 2021 and 2022): the example of the return of the vehicle registration tax to Hong Kong in April 2017, which caused the collapse of purchases of electric vehicles previously exempted by this measure, is to be contemplated.

3. A technological shift accompanied by a new deal in raw materials

If electromobility is not recent, on the other hand the use of new technologies makes its return to favor more plausible. The real technological evolution does not lie in the engine but in the energy supplier. It is the lithium-ion revolution, liquid for the moment and solid in a more or less near future. This electrochemical accumulator thus makes it possible compared to its lead acid counterpart (PowerTechSystems, 2020) to have 100% of the power available (50% for the lead acid battery), to offer a longer service life with a minimum of 2 000 cycles (vs 500 for the lead acid battery) and with faster charging process.

The principle: two electrodes immersed in a conductive element (electrolyte) and isolated from each other by a separator allowing only ions to pass to one side or the other as the battery charges or discharges. There is a negative electrode (anode) and a positive electrode (cathode). The materials used in the composition of the anode, cathode and electrolyte influence the potential of the battery, at equal volume, to deliver energy with more or less power.

While the risk of thermal runaway was real on lithium-cobalt-oxide batteries, the predominance of lithium-nickel-cobalt-aluminum batteries and especially lithium-iron-phosphate ones has reinforced electrochemical safety.

Electromobility makes it necessary to understand the phenomenon from another angle: the needs for raw materials (Académie des Sciences, 2017). Of course, the first essential material (for the electrolyte) is lithium. For the cathode, cobalt or nickel are used and for the anode, graphite is usually used, which can be replaced by silicon.

The future could belong to solid (composed of odium, zirconium and phosphorus) and sodium-ion batteries. This will depend both on technological maturity but also on cost (extraction and refinement).

The success of the new generation of different battery models and their alternatives must be based on five criteria: Availability of elements, Cost of elements, Durability, Energy efficiency and Security (Figure 1).

We know, for example, that Lithium-Iron-Phosphate (or LFP-LiFePO4) technology is more secure, that the materials are cheaper and more available, and that the lifespan is very good. On the other hand, energy efficiency is less good than its Lithium-Nickel-Cobalt-Aluminum (or NCA) variant.

Fuel cell vehicles are evolving just like battery vehicles, but their low distribution (937 units sold in the United States market amongst 322 422 electric vehicles in 2020) does not facilitate economies of scale. This aspect slows down the development of more efficient and less expensive technical solutions.

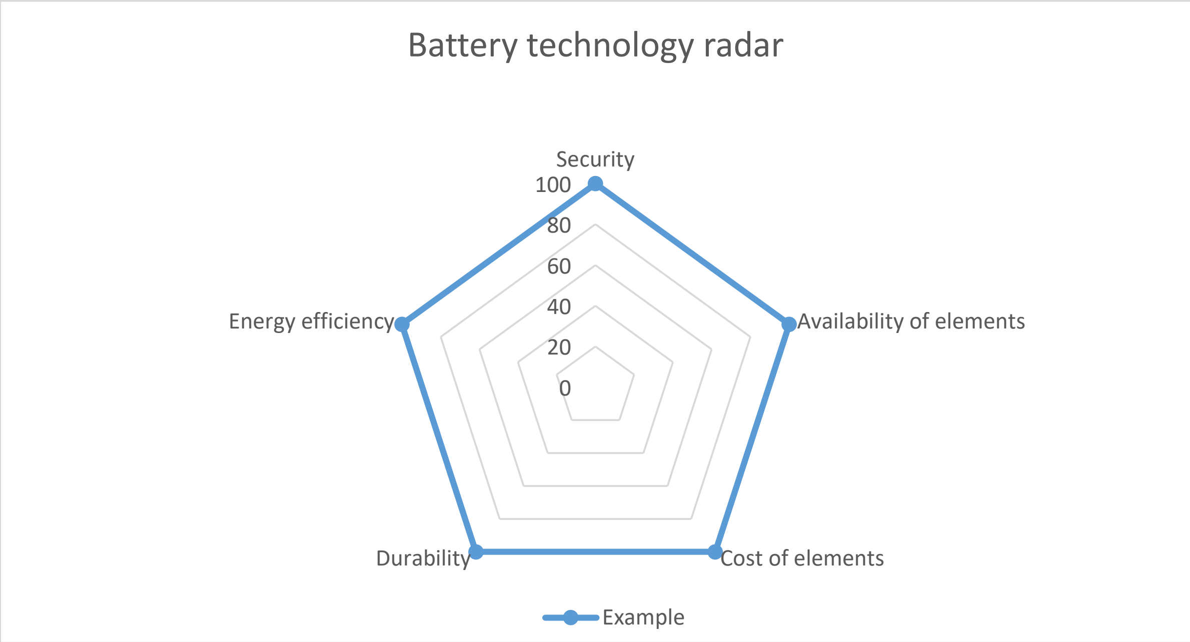

Figure 1. *Battery Technology Radar - Credits to YH*

If we consider that the automobiles of tomorrow will be 3.0, that is electric, autonomous and connected, then we must recognize the predominance of Asian technologies in this area. The massive investments in disruptive technologies in the decade 2000-2010 have been evident for several years: whether in the field of 5G or batteries, the reality is ruthless, American and European manufacturers are either lagging behind or forced to cooperate so as not to be left behind in the technological race. In the field of mobility, and unlike thermal vehicles, the engine is less critical in electric vehicles than batteries (mostly lithium-ion).

This is all the more so as the mechanical elements making up an EV are extremely small (the reduction being up to ten times their number compared to a so-called "conventional" automobile). In return for this limitation of parts, certain elements become all the more essential for electromobility, this is primarily the case of lithium-ion battery cells. We can also add the fuel cell for hydrogen vehicles which are also EVs.

However, the top three suppliers of vehicle batteries in the world are, in order, the Chinese CATL (24.2% market share), the South Korean LG Chem (22.6%) and the Japanese Panasonic (19.2%) according to SNE Research. Next on the list, the fourth and fifth positions are occupied by South Koreans Samsung SDI and SK Innovation and not Western structures (Figure 2).

It should be noted at this stage that the control of the battery monopoly can be based not only on the control of its own extractive and manufacturing sector but also via investments (in the form of shareholding, partnerships or technological assistance) in regions third parties where certain mineral resources are intensively or strategically exploited (e.g., Tianqi Lithium which has invested a total share of 25,86% in Sociedad Quimica y Minera de Chile in Chile (en.tianqilithium.com).

As for the hydrogen car, although projects are bursting up in Europe and the United States, only the Toyota Mirai (Japan) and Hyundai Nexo (South Korea) models have exceeded, to date of publication, the concept stage to become an industrial reality. Once again, Asian entities have taken a step ahead of their Western counterparts.

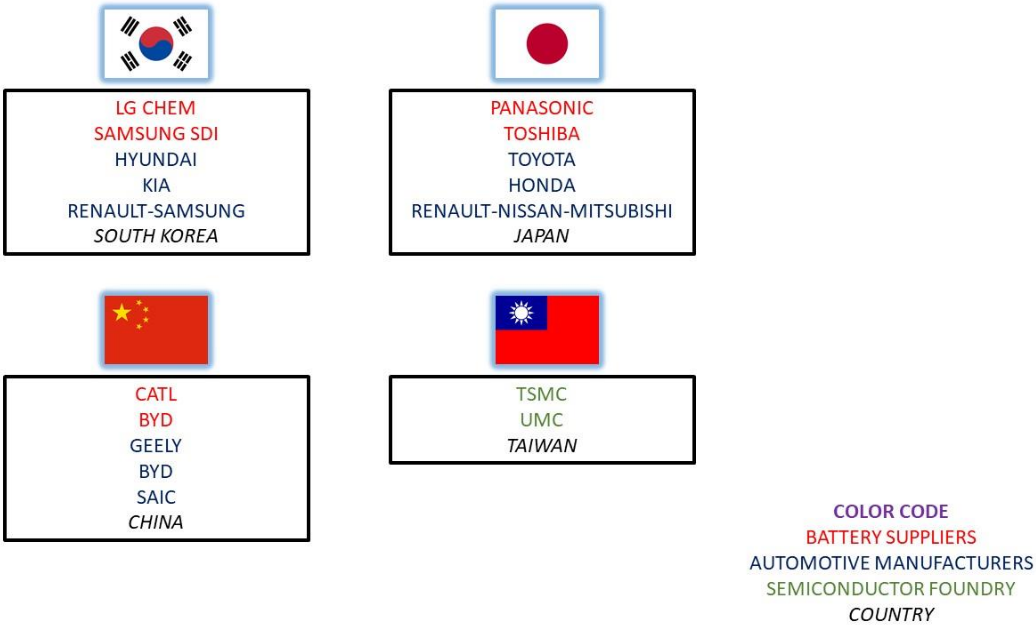

Figure 2. *Asian powers in Electromobility - Credits to YH*

The American entrepreneur of South African origin, Elon Musk, was crowned the richest man in the world in January 2021 thanks to the very strong stock market valuation of the company Tesla, created in 2003, granting him a personal fortune estimated at 195 billion dollars, beyond the 187 billion of Jeffrey Bezos, head of Amazon.

The man is a business survivor having touched bankruptcy on several occasions due to its unusual and expensive nature. Elon Musk has over time entered the mobility landscape as a visionary (Valentin, 2020), both in space with SpaceX and on earth with Tesla.

Yet, on closer inspection, this industrial success is more fragile than it appears due to increasingly fierce competition with Asian firms in a tense geopolitical context. The case of Tesla is emblematic of this ongoing struggle for mineral, digital and technological sovereignty, the stake of which will be the monopoly of the mobility of tomorrow.

Against the background of the American-Chinese economic confrontation that began under the former mandate of Donald Trump and then converted into competition under the new mandate of Joe Biden, can the American manufacturer able himself be free from the Asian monopoly on the new generation of mobility? At the very least, that is his ambition.

On September 22, 2020, Tesla's keynote was held, called Battery Day, where the brand's strategic perspectives for the coming years were outlined. Many commentators were disappointed by the lack of booming news. However, in detail, this communication exercise revealed Tesla's whole approach to countering its sector competitors and limiting its dependence on Asian suppliers.

First of all, Tesla presents itself as a future conglomerate where EVs are only part of the company's offering: this is a systemic approach. Thus, the production, conservation and distribution of energy are clearly identified as the three other pillars of a global strategy in the electrification market (as evidenced by the production and marketing of its PowerPack and PowerWall as storage units coupled with the installation of its Solar Roof photovoltaic panels or the presence of Superchargers on the roads). Just as its investment in the mining sector in the United States is perfectly correlated with the desire to get rid of dependence on Chinese mineral resources.

Elon Musk sets its pace on the automotive industry in the process of electrification: so, he no longer wishes to mention an annual battery production capacity in Gigawatts but now in Terawatts (or 1000 Gigawatts) for the next decade. To have an order of magnitude of the growth of the industrial tool that this prospect would require, a Gigafactory Tesla currently produces 0.15 Terawatts / hour.

In short, this is a truly comprehensive strategy that Tesla is putting in place for its value chain, employing gradual end-to-end internalization while pursuing vertical integration.

However, Tesla, like other emerging players (we think of the Automotive Cells Company, Verkor and Northvolt), still remain heavily dependent on raw materials and / or components of Asian origin.

The very recent Taiwanese-origin semiconductors shortage from TSMC and UMC, also called the “Global Chip Crisis”, which crippled all major automakers in the first half of 2021, is a further warning after the Chinese embargo on rare earths intended for Japan in September 2010.

Because the automotive sector is terribly greedy in raw materials as in electronic components, the closure of mines in Europe and the United States as well as the industrial relocations of these in recent years have provided the foundations of industrial strength for booming Asian powers such as China, South Korea, Japan, Taiwan and Singapore.

This is why Tesla is part of this systemic logic although it is still obliged to deal with its foreign suppliers, in particular with its historical partner, the Japanese Panasonic, for the supply of its new generation of battery cells or even the South Korean Samsung for some microprocessors.

This is not, however, dramatic in the sense that the aim is to reduce dependence on third-party supplies and not to produce in an autarkic way. Its strategy is clearly thought out from well to wheel with a very industry 4.0 approach (i.e., scalable automation and response to demand in real time).

4. Which strategy for the European EV Sector?

The Covid-19 crisis in 2020 cruelly highlighted the lack of health resources for Europeans in the face of a pandemic impact, even paralyzing the traditional logistics circuits. The industrial land transport sector, already in a weakening phase with an electrification process imposed by the public authorities, for its part found itself severely hit with the effects of the pandemic.

However, this command of excessive electrification of mobility by the national and European authorities has increased dependence on non-sovereign technologies (example: connecting the batteries to the 5G electrical network (Fortune Editors, 2019)) and supplies of specific materials (example: silicon and germanium semiconductors) undermining traditional manufacturers, forced to rethink their production chains and make more use of crucial external elements.

This imposed policy is already leading to job cuts, mergers between weakened players, skills losses and worsened dependence on third-party products and technologies (cf. figure 3).

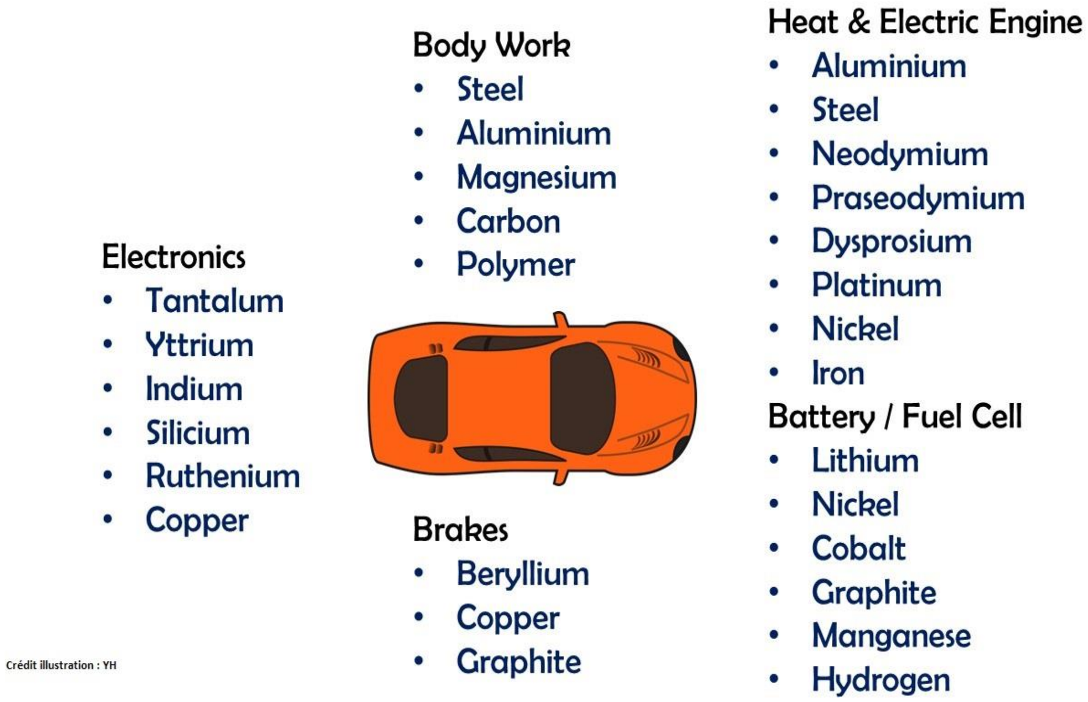

Figure 3. *Raw Materials for EV and IEC vehicles - Credits to YH*

A collateral consequence annoying the fragility of the European ecosystem in the sector by its recent boom, positive discrimination in favor of battery-powered vehicles favors for easier entry of Chinese vehicles (South Korean and Japanese to a lesser extent) on the European market , directly through their brands (Lynk & Co or Aiways) or indirectly through investments in various European brands (Volvo, MG or Lotus) or even by the manufacture of vehicles in their territory (Dacia Spring or BMW iX3).

Formerly unsuccessful for both security (EuroNCAP accident test) and environmental (greenhouse gases and atmospheric pollutants) reasons, Chinese electric vehicles now pass these two pitfalls without a hitch, or almost, to the European market: as mentioned in a chapter previously. It is quite logical that billions of yuan spent on this technology gives Chinese manufacturers a clear competitive advantage, reinforced by a highly competitive pricing policy. It is not logical, however, that national and European decision-makers outrageously favor a technological path rather than other promising ones to the point of slashing their own industrial tool (Collectif, 2020).

And the appetites unveiled at the beginning of 2021 of the BATXH (Baidu, Alibaba, Tencent, Xiaomi and Huawei (Riley, 2021)), presented as the Chinese counterparts of the GAFAM (Google, Amazon, Facebook, Apple, Microsoft) for electric and intelligent mobility, participate in this hunger for invest in the European market which is tending to become an economic peninsula on the Asian continent in terms of mobility.

Could the European Union offer solutions to save the European automotive industry? The Covid-19 crisis was a severe awareness as it has amplified an already present problem created by very restrictive legal conditions (European Commission, 2017 a). Thus, on September 3, 2020, the European

Commission published a communication serving as a strategy for the supply of raw materials for member states of the organization (Harrel, 2020).

The ten-point action plan can be summarized as follows: to be fully immune from further downfall, European industry must benefit from an incentive to relocate its factories, recycle raw materials and revival of the extractive sector. Although the term is never used, it does refer to industrial sovereignty and even more to mineral sovereignty. Especially when the for invest European Economic and Social Committee recalls that "85% of all batteries that we use in Europe come from China, Japan or Korea. European production represents a mere 3% of world production, with the USA accounting for around 15%." (European Economic and Social Committee, 2019).

In the battery sector, the creation of a battery Airbus (European Battery Alliance) in 2017 was announced with a great deal of publicity, with the creation of a core of French and German skills to start research and production (European Commission, 2017 b), with the support of the European Investment Bank. Let's take the opportunity to wring our necks on a preconceived idea: batteries are subject to a minimum recycling rate imposed by a European directive (2006/66/EC), i.e., 45% since 2016, and the European Battery Alliance wishes precisely to create a virtuous circle, that is to say of circular economy. By recycling part of the materials that make up the batteries, the dual aim is to preserve these precious resources by thus limiting the use of its extraction and then shipping from third countries as well as being less sensitive to variations in prices.

Another change, the great hydrogen plan launched by the European Union (European Commission, 2020) is in this perspective of diversification since October 2020 with the European Clean Hydrogen Alliance, by promoting as the title indicates so well, the hydrogen is making a comeback in transport. It is also necessary to specify which hydrogen it is because it is categorized according to the origin of its production: black (carbon), gray (methane) blue (gas with CO2 retention), green (renewable energies) and yellow (nuclear).

The challenge for manufacturers will be to produce green hydrogen at an acceptable price (for the moment, the price of a kilogram of green hydrogen is four times higher than that of gray hydrogen massively used by energy companies). Europeans are betting on new industrial capacity, but Japanese advances in this area tend to demonstrate that the commercialization of large-scale solutions remains confidential and that not all forms of mobility are suitable for its use: heavy transport is thus largely favored by compared to individual vehicles.

Another solution put forward by several manufacturers, particularly Germans (Porsche, Audi and BMW), is to manufacture and to use synthetic fuels. These fall into two families: e-fuels (liquid fuels obtained from various compounds) and biofuels (second and third generation).

The latter solution is all the more strongly recommended as it would allow the investment of several decades of industrial research to be avoided by exploiting thermal engines, notwithstanding minor modifications.

The underlying idea is not to call into question electrification which promotes many advantages apart from its environmental aspect (movement silence, linear power torque, less use of mechanical parts, recovery of kinetic energy) but to offer a range of solutions capable of pursuing a logic of reducing greenhouse gas emissions (mainly CO2) released by vehicles as well as avoiding the disappearance of all European industrial know-how.

5. Conclusion

If the automobile company Tesla can boast of having been a precursor on the market of EVs sold in large series, it owes it to the precognition, to the financial and organizational efforts of its leader as well as to the benevolence of the federal authorities as of the State of California.

Its status and strategy allow it to create its own ecosystem in order to resist the inexorable progress of its Asian rivals in its domestic market. Just as by opening its Gigafactory in Shanghai, the American magnate wishes to probe the Chinese market with suitable models without too much risk taking due to its policy of specific and regular software and hardware updates including the nerve center, American home.

The same is not true in Europe, where Chinese consistency benefits from the European confusion resulting from drastic environmental policies, the adjustment variable of which has been precisely the industrial tool in general and the energy and automotive sectors in particular.

The Brussels executive now seems to be alert to the economic and social risk of this brutal practice, realizing the need for a more realistic, progressive, even sustainable, global systemic approach, as evidenced by the project for a carbon tax on borders of member states.

Despite the last decisions, the transition that began several years ago is painful and will leave several European actors bloodless or even slip away for a long or an indefinite time.

Because the Asian powers, led by China, are proving to be tough adversaries capable of paralyzing the supply of raw materials or components, such as flooding with low-cost vehicles of increasing quality capable of complying the normative requirements of the European market in medium term, and American in the longer term (the American domestic market is less tense and the more appropriate federal normative constraints make it possible to cushion the requirements, so General Motors does not plan to switch to all-electric until 2035).

The struggle for the electromobility market is a determinant of the geopolitical pivot that is taking place, slanting more and more sharply towards the Asian continent ... unless the Tesla model takes hold quickly.

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