TRENDS
ROAD TRANSPORT

Metals, the precious fuel for the automotive market in the race to electrification

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The upsurge in new vehicle sales observed in 2021 features an acceleration in purchases of electric models. The high concentration of strategic mineral resources and battery production sites means that car market players are in stiff competition, both to secure their supplies and to take up position on the new low-carbon services that accompany the development of electric vehicles. Whether it concerns opening lithium mines, recycling batteries, or building gigafactories, industrial competition is taking on a whole new dimension. Nevertheless, the success of electric vehicles has had no impact on another strong market trend: the rocketing rise in SUV sales.

DATA OVERVIEW

Electric car sales still outpaced by the growth of SUVs

After a historic 9% drop from 2019 to 2020 due to the pandemic, global greenhouse gas (GHG) emissions from the road transport sector shot up by 7.1% in 2021, although still below pre-Covid levels (5.5 $GtCO_2$ compared to 6.1 $GtCO_2$).[1] This recovery can be attributed to the gradual pickup in activities for both passenger and goods transportation by road, which concern 75% of global emissions related to transport.[2]

The growth in global sales of new vehicles in 2021 brought to an end three years of successive decreases, accelerated by the pandemic. 82,684,788 new vehicles were sold, which is 4.9% more than in 2020, but still far below the pre-crisis figure (-9%), according to data from the International Organization of Motor Vehicle Manufacturers (OICA). The European market has remained relatively stable (+1%), while the American (+6%) and Asian (+6%) markets have risen sharply. Africa, where the new vehicle market is smaller, has seen a very high growth rate (+24%). The Chinese automobile market has been relatively unaffected by the crisis, and in 2021 was already 2% higher than 2019. Countries like Chile (+61%), Ukraine (+23%), Saudi Arabia (+23%) and Pakistan (+91%) have also clocked up bigger sales volumes than in 2019, while major car-making countries like Germany (-9%), Japan (-3%) and South Korea (-9%) have continued their decline.[3] The downward trends of these countries can be explained by supply chain difficulties following product bottlenecks due to lockdown inactivity, the dispersion of maritime freight capacities **(SEE "MARITIME TRANSPORT" TREND)**, the rocketing demand for electric vehicles, and especially, the hike in oil prices which has brought down sales of internal combustion enging (ICE) vehicles.

In this highly contrasting picture, the market is still pursuing the same two-way trend involving contradictory emissions impacts: the electrification of vehicles on one side, and the shift towards SUVs and heavy vehicles on the other. Global sales of electric vehicles

(EVs)[a] have doubled in the space of a year, reaching 6.6 million units and 10% of the global market. In the first quarter of 2022, sales were already 2 million units, which is 75% more than during the first quarter of 2021.[4] China (3.3 million sales) has overtaken Europe (2.3 million, +65%) as the leading global market, far ahead of the USA (630,000 units). EVs have also benefited from the slump in the conventional market caused by the oil crisis to take a bigger share of the market: one car in five sold in China and Europe[5] is now rechargeable electric (BEVs and PHEVs). In India, two-wheelers, the dominant mode of transport, are undergoing their own "electric revolution": sales of electric two-wheelers shot up by 132% in 2021,[6] and multiplied by five in the first quarter of 2022, to reach 3.6% of the market.[7] However, two- and three-wheelers with ICEs still represent 84% of vehicle sales in the country.[8] The shift to electric for heavy vehicles, like trucks and buses **(SEE "URBAN TRANSPORT" TREND)**, is growing fast but remains marginal and is mainly concentrated on the Chinese market. Nevertheless, the International Energy Agency (IEA) points out that electric vehicles currently represent only 1% of the world's automobile fleet. And traditional hybrid (non-rechargeable) vehicles are no exception, since their market share amounted to 22.6% in the EU in the first quarter of 2022.

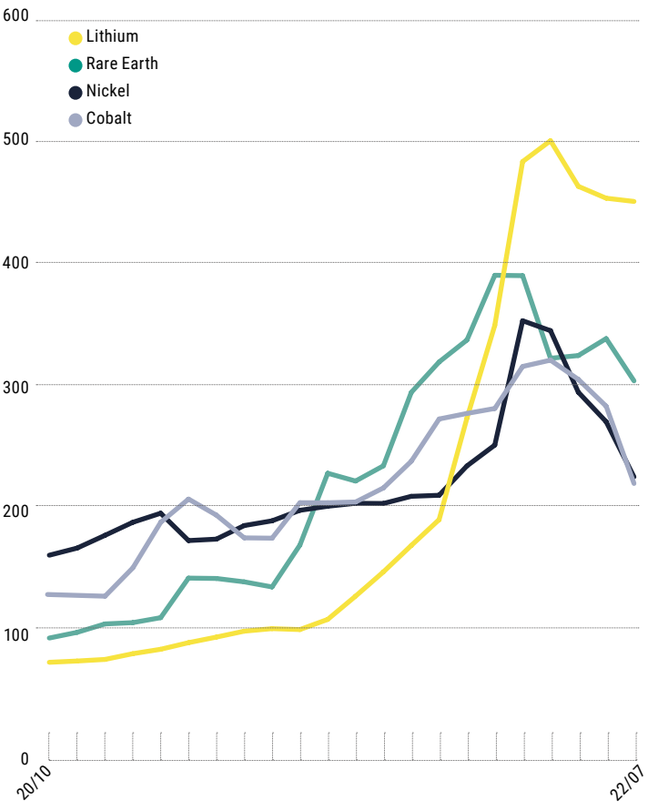
The emission gains achieved thanks to the electrification of vehicles are offset by sales of Sport Utility Vehicles (SUVs). These vehicles, which are much heavier and consume more fuel than average, now represent 45.9% of global vehicle sales.[9] According to the IEA, SUVs, were the second largest cause of the increase in GHG emissions from 2010 to 2021, behind electricity production and ahead of heavy industry, while emissions from traditional vehicles are decreasing. The more than 35 million SUVs that entered the market in 2021 will generate 120 $MtCO_2$ of emissions a year. As the Observatory pointed out in 2020, the enthusiasm of carmakers and consumers for SUVs also concerns the electric vehicle market. Although they do not yet make up the majority of sales, 55% of electric vehicle models on the market in 2021 were SUVs according to the IEA. While the electrification of SUVs is now following the same pace as the rest of the market, 98% of the 320 million SUVs in circulation in the world are still ICE vehicles.[10]

With its continued move towards heavier vehicles with higher material footprints, the automobile market is vulnerable to price swings in mineral raw materials and fossil fuels. The average weight of an EV on the market is 1,940 kg: one third are heavier than 2,000 kg, and more than half are between 1,500 and 2,000 kg.[11] That figure is much greater than the average weight of new vehicles in France (1,240 kg),[12] and even the United States (1,857 kg),[13] while the energy efficiency of an electric car tends to decrease as its weight increases.[14] Electric cars also require six times more rare metals than their conventional alternatives,[15] and the price of most cobalt, lithium and nickel, the main three metals contained in batteries, has been subject to very high inflation since the second half of 2020 **(FIG. 1)**.

FIGURE 1

EVOLUTION OF A SELECTION OF METALS PRICES INDEX FROM OCTOBER 2020 TO JULY 2022

Source: IMF Energy Transition Metal Index, 2022



The move towards heavier vehicles featuring more raw materials exposes carmakers, states, and consumers to structural risks caused by the unprecedented rise in global demand for strategic metals. As a result, a major trend in the automobile market this year is massive investments in the regionalization of battery production, metal supply security, and the vertical integration of the value chain.

THE OBSERVATORY'S LENS

The automobile market's mad scramble for electric batteries

Policies favouring electric vehicles

One of the main drivers of the market according to the IEA is the doubling of public subsidies and incentives for EVs in 2021 ($30 billion), such as purchase bonuses. At the same time, consumer expenditure is close to $280 billion. Combined with the drop in the cost of batteries **(SEE BELOW)**, the lever effect of

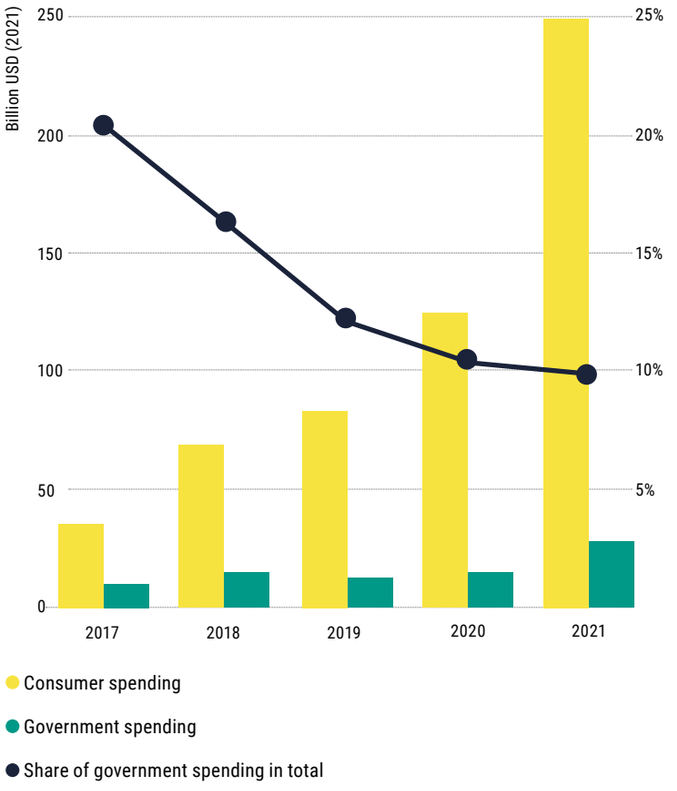
a EVs comprise vehicles with "100% electric batteries" (Battery Electric Vehicle – BEV) and those with rechargeable batteries (Plug-in Hybrid Electric Vehicle – PHEV). PHEVs are not the same as traditional hybrids (Hybrid Electric Vehicles – HEV).

public expenditure is therefore obvious, since the share of government expenditure in total investments in electric vehicles constantly dropped, from 21% in 2017 to 10% in 2021 **(FIG. 2)**.[16]

FIGURE 2

CONSUMER AND GOVERNMENT SPENDING ON ELECTRIC CARS, 2016-2021

Source: IEA, 2022



The gradual global shift away from ICE vehicles is also gaining ground. Thirty-nine countries, sixty local and regional governments, and thirteen automobile manufacturers signed the COP26 Declaration on accelerating the transition towards "100% zero emission" cars and vans by 2040.[b, 17] Since then, the State of California has voted to phase out sales of thermal vehicles by 2035, along with a 35% sales target for "zero emission" passenger vehicles (BEV and hydrogen) by 2026.[18] This initiative should have an automatic knock-on effect in the States of Washington and Massachusetts, which have linked their regulations to California's. Oregon and the State of New York are also expected to follow suit.[19] Canada has presented an emissions reduction plan for 2030, aiming at sales of 100% electric passenger vehicles by 2035.[20] In its national strategy for electric mobility published in October 2021, Chile is aiming at 100% sales of electric light- and medium-duty vehicles and urban public transport (buses, taxis, etc.).[21]

The European Parliament's vote to prohibit the sale of ICE cars by 2035 is a major milestone in the electrification of the market.[22] This new goal supplements the European regulation aimed at reducing CO_2 emissions from new vehicles that came into force on 1 January 2020 (regulation EU 2019/631)[23], in place for the third consecutive year. However, this is the first time that performances are being measured in line with the new WLTP standards.[c]

BOX 1 • **KEYS TO UNDERSTANDING**

EU REGULATION ON EMISSION STANDARDS FOR NEW VEHICLES

The EU regulation 2019/631 does not establish sale targets for electric vehicles, but rather sets emission limits that must not be exceeded by individual carmakers. The limit of 95 gCO_2/km set for all new vehicles sold in 2020 was not extended when the WLTP system was adopted. Instead, specific targets have been set for each car manufacturer, based on the average weight of their vehicles measured in 2020 and 2021, and the WLTP/NEDC emissions ratio measured in 2020. The principle is the same: it is still possible to produce and sell units above this limit if those sales are compensated by sales of less-emitting vehicles.

There are several ways of getting around the rules. Carmakers can gather into manufacturer pools, such as Fiat-Chrysler, which got together with Tesla to bring down its average level, in return for a $1.8 million payment over three years, before merging with Peugeot in the Stellantis group. Moreover, the emissions limit takes cars' weight into account, so that the CO_2 target set by carmakers that sell heavier than average cars can be brought down, which gives no incentive to reduce the weight. A bonus system is also applied to electric cars, which are counted more than once in the average emissions calculation, making the emissions limit more flexible (1 EV counted for 2 vehicles in 2020, then 1.67 in 2021). Lastly, automobile manufacturers can obtain eco-innovation CO_2 bonuses by equipping their vehicles with innovative technology.[24] However, in 2021, the provision that allowed carmakers to only present 95% of their fleet for evaluation was withdrawn. Following these various adjustments, the emissions limit allocated to each carmaker by the EU can be significantly different: ranging from 100 gCO_2/km for Kia, Hyundai and Renault-Nissan-Mitsubishi group, and up to 133 gCO_2/km for Volvo in 2022.[25]

In 2021, average emissions by car manufacturers amounted to 115 g/km in Europe, compared to 131 g/km in 2020 (12%). After applying the flexibility mechanisms, exemptions and bonuses allowed by the European standard **(SEE BOX 1)**, the

b Leading carmakers (Toyota, Renault-Nissan, Volkswagen, BMW, etc.) and major economies (France, Germany, China, USA, etc.), which nevertheless have individual targets to transition towards electric vehicles and/or phase out thermal vehicles, did not sign the agreement.

c The global vehicle standard *Worldwide Harmonized Light Vehicles Test Procedure* (WLTP) replaced the *New European Driving Cycle* (NEDC) in 2021, whose shortfalls came to light during the Dieselgate crisis. Consequently, WLTP values are higher than NEDC values. In the 2021 Global Synthesis Report on Climate Action by Sector, the figures given are still based on the NEDC standard; the level of the results presented here is therefore different, but the trend from one year to the next remains downward.

average drops to 113 g/km. All carmaker groups reached and exceeded their targets with variable margins: from a margin of 1 gCO_2/km for Renault-Nissan-Mitsubishi (109 g/km, for a target of 110) to 96 gCO_2/km for Tesla-Honda-Jaguar Land Rover, which attained 33 gCO_2/km for a target of 129.[26] Honda and Jaguar Land Rover benefit from the results of Tesla, which only sells BEVs, just as Fiat-Chrysler, which is now part of the Stellantis pool, did last year. The transaction cost paid to enter this group has not been disclosed. Overall, these positive results demonstrate the further penetration of electric vehicles in the fleets of vehicle manufacturers.

BYD outstripped Tesla to become the leading producer of electric cars in the first six months of 2022. The Chinese carmaker sold a reported 641,000 vehicles, which is an increase of 300% in one year, compared to 564,000 for Tesla. Tesla appears to have particularly suffered from the lockdown in Shanghai, where BYD does not have a factory.[27] However, most BYD vehicles are PHEVs, which always partly use a thermal engine. Even more remarkable, BYD has overtaken LG as the world's number two producer of batteries, behind a Chinese company called Contemporary Amperex Technology (CATL). BYD and Shell have signed a strategic cooperation agreement in Europe and China. In Europe, the two companies will form a pan-European Mobility Service Provider (MSP) to provide BYD's private and commercial clients with subscriber access to a network of Shell electric charging stations. In China, a joint venture is due to be launched to equip the city of Shenzhen with over 10,000 electric charging stations.[28]

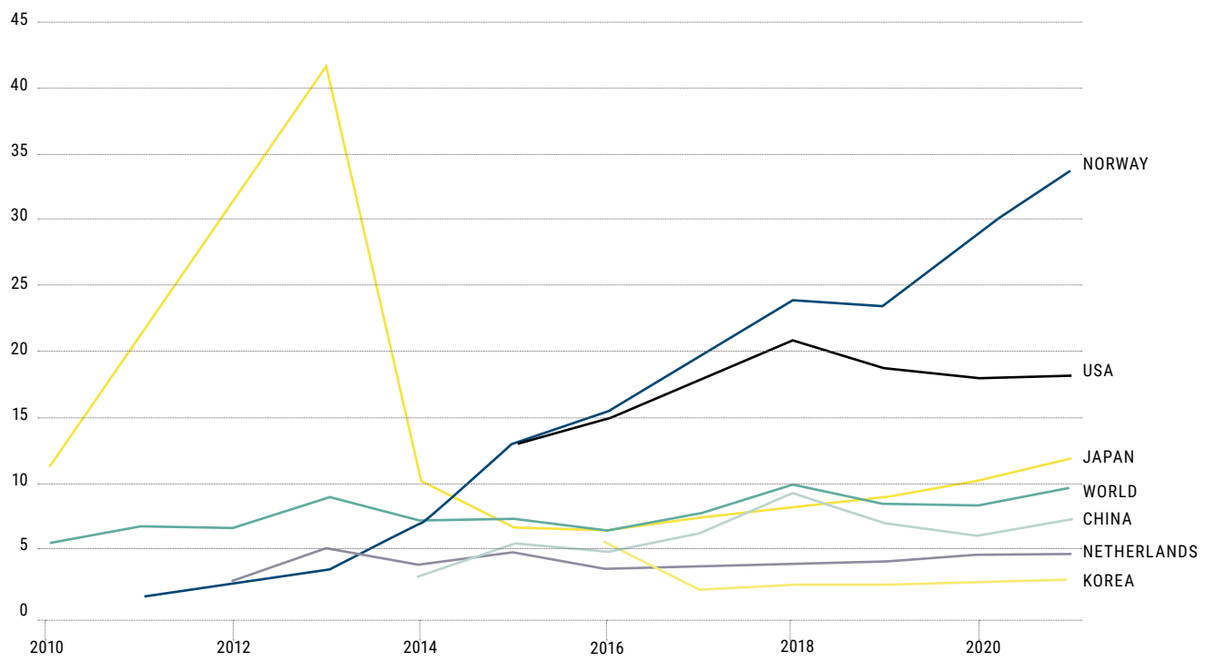
Electric vehicles are increasingly popular as company cars. The Corporate Electric Vehicle Alliance is an initiative run by Ceres and gathers companies committed to accelerating the electrification of their corporate fleets. In early 2022, Ceres presented major carmakers with the results of a survey of its members: companies like Amazon, Best Buy, DHL, Hertz, Schindler Elevator and T-Mobile confirmed that they were ready to order 330,000 EVs in the next five years in the United States.[29] In 2021, 31 new companies joined EV100, an initiative launched by the Climate Group to make company fleets electric. The initiative now covers 98 markets in the world, with a total commitment to 5.5 million electric vehicles. In 2021, EV deployment in corporate fleets grew by 42%; 53,361 EVs had been integrated, taking the number of operating electric company cars to 209,654. EDF has the biggest EV fleet (6,331 units) among EV100 members, and recorded the highest growth in 2021, followed by E.ON and BT Group.[30]

The ride-hailing sector is shifting more slowly towards electric vehicles. Yet market leaders Uber, Lyft and Didi Chuwing, as well as some local governments like California, have made formal commitments to ensuring 100% electric fleets by 2030. In Brazil, the e-hailing app 99, Uber's main competitor in the country, has moved into a partnership with BYD to test the deployment of EVs in Sao Paulo.[31] However, the electrification of ride-hailing fleets in Europe, the United States, and Canada is slower than the rest of the market, according to a study by the World Resource Institute (WRI).[32] The authors identify three major obstacles to ride-hailing electrification: the high cost

FIGURE 3

ELECTRIC LIGHT-DUTY VEHICLE PER CHARGING POINT IN SELECTED COUNTRIES, 2010-2021

Source: IEA, 2022



of purchasing an EV for drivers; the lack of rapid charging solutions that are inexpensive and easily accessible at night; and insufficient information and awareness of drivers about electric vehicles. Although Uber pays its drivers an extra $1 per hour for driving an EV, last year Bloomberg identified reports of late payments. The partnership signed by Hertz in October 2021,[33] which aims at making it easier for drivers to rent Tesla vehicles, is also out of reach for a large number of drivers.[34] Some cities stand out as exceptions. In Amsterdam, where over 6.5% of Uber vehicles are electric, the installation of charging stations corresponding to user requests has made it easier to equip different areas of the city to meet drivers' requirements. In London, where Uber works closely with the municipality, the Californian firm claims that nearly 90% of new drivers use 100% electric cars.[35] To meet its target of 100% electric activities in the British capital by 2025, Uber recently extended its "Uber Green" service from Zone 1 to cover the entire city of London.[36] In India, Delhi has become the first territory in the country to make electric cars obligatory for some new taxis (in particular two- and three-wheelers), and numerous start-ups are taking part in this burgeoning market: with 1,000 electric four-wheelers, BluSmart is the biggest 100% electric ride-hailing company in the country.[37]

The number of electric charging stations accessible to the public went up by 40% in 2021, which is 500,000 new stations installed in the world.[38] 85% of these charging stations are located in China. On a global scale, the International Energy Agency observes that the EV/public charging station ratio tends to drop as the proportion of BEVs in the automobile fleet rises (**FIG. 3**). In China, Korea, and the Netherlands, this ratio has remained relatively stable since 2015, indicating that the charging network is developing at a similar pace as the EV market. In Norway and the United States, where the number of individual houses with garages is very high, the ratio is greater than average and on an upward trend due to the predominance of home charging stations. The European Union, which in 2014 established in its AFID (Alternative Fuel Infrastructure Directive) an objective of one charging station for ten electric vehicles by 2020, has not reached its goal (1/14 in 2021).[39] The revised EU Energy Performance of Buildings Directive could make it obligatory to install charging stations in carparks in new buildings. At COP26, then prime minister Boris Johnson announced a plan to make the installation of electric charging plugs obligatory in all new housing featuring private parking starting from 2022.[40]

In the United States, cities are starting to restrict and even prohibit the construction of new gas stations. Petaluma, a city with 60,000 inhabitants in California, was the first town in the world to change its building code to ban not only the construction of new gas stations, but also the extension of existing ones. In contrast, state senators in Raleigh, North Carolina, introduced a bill to remove free electric charging stations unless gasoline and diesel are also offered at no fee. The Infrastructure Investment and Jobs Act passed by Joe Biden in November 2021 establishes an investment of $7.5 billion to support the installation of electric charging stations with the aim of reaching 50% sales of electric vehicles in 2030, compared to 2% currently.[41] The Inflation Reduction Act, which was finally voted by the House of Representatives in August 2022, establishes a new tax credit of $ 7,500 for the purchase of an electric vehicle. The aim is not just to accelerate sales and the transition of the automobile fleet, but to initiate a shift towards national supply chains: only vehicles assembled in the United States qualify for the tax credit.[42]

In fact, following the trend of 2021, electrification of transport is not just motivated by climate and energy targets; states and non-state actors are also keen to establish strategic autonomy, involving domestic battery production and a secure supply of critical resources.

Europe and the United States move towards local battery production

Global battery production grew by 83.4% in the space of a year, to reach 122.9 GWh between January and April 2022. China alone was responsible for 77% of the lithium-ion batteries produced in the world in 2020.[43] Asian producers largely dominate the market: the Chinese company CATL (33.7% market share) is ahead of the Korean LG Energy Solution (12.8%) and Chinese carmaker BYD (12.1%). Despite the pandemic and temporary factory closures, like the Tesla Gigafactory in Shanghai, each of these companies has doubled, sometimes tripled, its annual battery production.[44] The average price of a battery continues to drop, reaching $132/kWh at the end of 2021, compared to $140/kWh in 2020 and $1,200/kWh in 2010.[45]

However, the ten-year downward trend of the cost of electric batteries took a remarkable U-turn during the second half of 2022 due to the combined effect of increased demand and the inflation of raw materials that has put a strain on supply chains. The cost of Li-ion[d] batteries went from $105/kWh in 2021 to $160/kWh in April 2022.[46] On average, the prices of batteries produced in the United States and Europe are 40% and 60% higher than in China, according to BloombergNEF, which monitors annual trends. Yet the price of the battery represents 40% to 60% of the cost of an electric vehicle.[47] With the high growth of the global electric vehicle market, this sudden inflation is spurring manufacturers and states to find ways of bringing battery production closer to automobile manufacturing sites.

In order to get away from this double exposure to the domination of Asian actors and the pressure of inflation in a high-demand situation, Europe and the United States have launched into a veritable race to produce electric batteries. These projects are the result of joint investments involving automobile manufacturers, electronics companies, and public support. As part of the Infrastructure Investment and Jobs Act voted in November 2021 by the US Congress, $7 billion were earmarked to help companies develop projects to produce and recycle electric batteries in the country.[48] Since 2017, the European Battery Alliance (EBA) has allocated public funds and

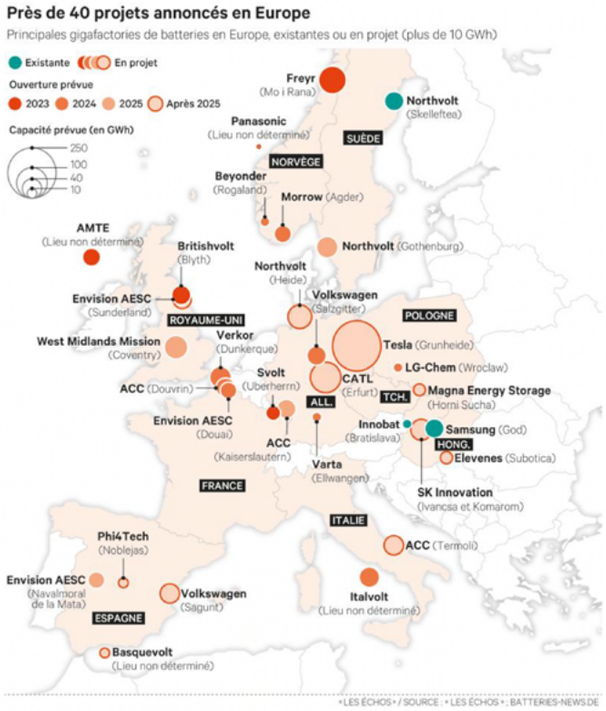
d Lithium-ion batteries are generally produced for electromobility, unlike lead batteries. This family includes Nickel-Manganese-Cobalt (NMC) batteries, which are the most common because they have the best energy density, and Lithium-Fer-Phosphate (LFP) batteries, which are more stable and have higher storage capacities.

authorized state aid for the development of battery-related projects; in a press release in February 2022, the EBA listed 111 projects developed around Europe amounting to a total investment of €127 billion throughout the entire value chain.[49]

Close to 1,400 GWh of "Gigafactories" are planned in Europe **(FIG. 4)**, which is enough to equip about 17.5 million vehicles a year in 2030.[50] Overall, close to forty Gigafactories have been announced. To date, only three factories manufacturing batteries for electric vehicles are operational in Europe: a small pilot and R&D factory opened by InoBat in early 2022 in Slovenia; a factory operated by Samsung since 2017 in Göd, Hungary (40 GWh); and in particular Northvolt Ett, in Sweden. In December 2021, this Gigafactory with a capacity of 60 GWh announced the very first lithium-ion battery cell to be designed, developed and assembled by a European company.[51] Northvolt has already secured supply contracts worth the equivalent of $50 billion with carmakers like BMW, Scania, Volkswagen, and Volvo, and made its first commercial deliveries in June 2022.[52] In 2022, Northovolt announced the opening of two new sites in the next few years, in a former paper mill close to Gothenburg in northern Germany.

FIGURE 4

EXISTING OR PLANNED BATTERY GIGAFACTORIES IN EUROPE (OVER 10 GWH) - *Source: Les Échos, 10/07/2022*



The latest projects include one by Volkswagen, which holds 20% shares in the Northvolt Ett factory. The carmaker announced the creation of a new company, "PowerCo", which will develop five Gigafactories in Europe, the first of which is planned in Salzgitter, Germany. In total, the automobile group plans investing €20 billion and creating almost 20,000 jobs.[53] Also in Germany, Tesla opened the biggest Gigafactory in Europe in spring 2022, in Grünheide, near Berlin. With a capacity of 100 GWh, the factory is due to start manufacturing in the second half of 2022 – initially 30,000 units for the first six months, and eventually up to 500,000 cars per year.[54] In the United States, the Energy Department has reported thirteen Gigafactory projects due to start operating in 2025.[55] Recently, Stellantis and Samsung announced their intention to invest €2.3 billion to construct and operate a new Gigafactory in Indiana,[56] while Honda has teamed up with LG Energy Solution to invest $4.4 billion in a new 40 GWh factory.[57]

BOX 2 • **KEYS TO UNDERSTANDING**

THE CRITICALITY OF METALS IS ALL RELATIVE

The "criticality" of metals depends on two factors: the risks related to its supply (geological availability, concentration of extraction and production, political stability of producing countries, etc.), and how important it is for economies. Different appreciations of these factors result in different evaluations of how critical metals are, depending on the economic area, context, and period: the latest list produced by the European Union in 2020 qualifies 30 materials as "critical", compared to only 14 in 2011, while the United States list 35, Japan 34, and China 24. These lists feature metals that are rare from a geological point of view along with abundant metals subject to high pressure from anticipated demand (copper, bauxite, and even "rare earths") or the political and environmental contexts involved in their extraction when they are very geographically concentrated (e.g., cobalt in the Democratic Republic of the Congo – DRC).

Sources: BRGM, 2018; Commission européenne, 2020; Interior Department of the United States, 2019; Andersson, P., 2020

The relocation of strategic minerals comes up against local opposition

Apart from battery production, another significant imbalance affects the top of the value chain: the concentration of capacities to produce, refine and process critical metals **(SEE BOX 2)**. The Democratic Republic of Congo for example extracts 70.9% of the world's cobalt, China 59% of rare earths[e] and 67.1% of graphite, and Australia 52.3 % of lithium. The DRC also features 51.4% of global cobalt reserves, while China, Brazil and Russia have 68.4% of the world's rare earths, and the sub-soil

e "Rare earths" are a group of 17 metals that are not rare in the true sense of the term, but whose concentrations in the Earth's crust are very low, which makes them costly to extract in terms of energy. They have remarkable catalytic, magnetic, electric, chemical, optical and heat-resistant properties, making them indispensable for numerous technologies such as smartphones, LCD screens, low-energy bulbs, lasers, permanent magnets in wind turbines, particularly offshore, and weapons.

of Chile and Australia harbours almost three-quarters of the lithium available in the world.[58] The distribution is even more impressive further down the value chain, with China alone concentrating the vast majority of capacities to refine and process all of these metals,[f] and a very high proportion of global production capacities.

In an ultimate symbol of the convergence between the issues of environmental transition and geostrategic independence, in early March 2022 President Joe Biden invoked the Defense Production Act dating from the Korean War era to free up additional credits to accelerate the production of strategic metals for the country's energy transition.[59] The United States currently only has one rare earth mine (Mountain Pass in California), but numerous other projects are under development.

The production of strategic minerals kindles economic nationalism, including in emerging countries that want to take advantage of their raw materials to integrate value chains and improve added value. In Mexico, President Andres Manuel Lopez Obrador announced in April 2022 the creation of a state company, Litio para México, to explore and exploit lithium and control the value chain.[60] One year earlier in April 2021, the Korean LG Energy Solutions (LGES), which dominates the rechargeable battery market, signed a memorandum of agreement with four Indonesian state companies to form the Indonesian Battery Corporation.[61] The prohibition of nickel exports decided in January 2020 by the government has reportedly already boosted domestic investments.[62] Once refined, nickel sulphate is an essential element used to make cathodes in domestic batteries and li-ion batteries used in electric vehicles. The ambition of the Indonesian president Joko Widodo is to develop an integrated national economic industry, from mining to battery production, rather than only export raw materials. In the Democratic Republic of the Congo, in February 2022, a court withdrew the control of one of the biggest cobalt mines in the world from China Molybdenum, suspected of tax fraud.[63] The Congolese government intends to take back control of cobalt production through its state company Gécamines, bolstered by an anticorruption campaign and a rapprochement between President Tshisekedi and his American counterpart Joe Biden, concerned by Chinese control of the supply chain.[64] With a view to strengthening its dominating position, China has authorized a merger between China Minmetals Rare Earth Co, Chinalco Rare Earth and Metals Co, and Ganzhou Rare Earth Group, to form a single group under the authority of central government, the China Rare Earth Group, which will control 70% of the national production of rare earths.[65]

But this ambition to open new mines is coming up against opposition from a civil society that sometimes turned the page of its mining history years ago. In January 2022, the Serbian government ended up revoking the operating license of the Anglo-Australian group Rio Tinto to open one of the biggest lithium mines in the world in the Jadar Valley. The mining giant, which had planned to invest $2.4 billion, came up against strong opposition from local inhabitants and politicians.[66] In Portugal, the project to open a lithium mine by Savannah Resources in the Barroso region, which is a world agricultural heritage site located 150 kilometres northeast of Porto, has also stirred up protests.[67] The mine could have the capacity to provide lithium for 500,000 EVs over almost ten years. In France, in the Finistère area, 600 people carried out a "preventive" demonstration against any plans to extract lithium in a Natura 2000 area, after the *Bureau des Ressources Géologiques et Minières* published a map showing the region's potential.[68] In Indonesia, increasing numbers of activists have been arrested since the 2020 revision of the mining law: in 2021, 53 people faced criminal charges for opposing mining projects.[69] A last example is in the United States, were native American peoples are joining forces to combat the Thacker Pass project, destined to become the biggest lithium mine in the country, and constructed by the Lithium Nevada Corporation. During the project's 41-year lifespan, the mine is expected to produce 80,000 tonnes of lithium carbonate a year, which is the equivalent of a fifth of global production in 2020.[70]

Manufacturers and suppliers join forces in their quest for supply security

Throughout the entire market, manufacturers are tending to move closer to suppliers by signing contracts to supply strategic metals. The Stellantis group (PSA/ Fiat-Chrysler) signed a lithium supply contract with Vulcan Energy for its European factories. This young Australian company is developing a project called "Zero Carbon Lithium" in Germany, aimed at employing geothermal energy to produce lithium hydroxide from brine. It has agreed to supply Stellantis with a minimum of 81,000 tonnes of lithium hydroxide for five years starting in 2026. The project is similar to and in competition with an initiative developed by Eramet in the Alsace region of France **(SEE ASLACE CASE STUDY)**. Renault and battery manufacturer LG have also signed supply contracts with the Australian firm.[71] On the US market, Stellantis has secured an agreement with Controlled Thermal Resources (CTR) to supply it with lithium hydroxide produced in California. CTR will therefore provide 25,000 tonnes a year to the carmaker during the next ten years, in order to manufacture batteries in North America.[72] On its side, Ford has announced that it has secured supplies to produce 600,000 EVs starting from 2023; for example, via a recent joint venture with Ioneer Ltd, a lithium producer soon to open up a base in Nevada.[73] Taking advantage of a diplomatic trip by German Chancellor Olaf Scholz to Canada in August 2022, Volkswagen and Mercedes-Benz signed agreements with the Canadian federal government to secure their supplies of lithium, nickel, cobalt and graphite, which are abundant in Ontario.[74]

Another way for manufacturers to guarantee their resources is to acquire a stake in companies located upstream in the value chain. For example, Stellantis, in addition to its supply contract, has also become the second shareholder of Vulcan Energy.[75] These strategies are not exclusive to large carmakers,

f From 35% for nickel to 50-70 % for lithium and cobalt, and up to 90% for rare earths, according to IEA figures. Source: IEA, 2021

and other midsize actors are asserting their strategic position in the value chain. Plastic Omnium, for example, global leader in the manufacture of bumpers and tank systems, is set to acquire Actia Power, a branch of the Toulouse-based group Actia, which specializes in the design and manufacture of embedded batteries, power electronics and electrification systems for the electric mobility of trucks, buses, coaches, trains and construction machines.[76]

Battery recycling, a value chain shortcut that is still a long way off

The new frontier of electric mobility is battery recycling, which introduces another geostrategic challenge into the international competitive context surrounding metal supplies.[g] According to IEA, global capacities for battery recycling in 2021 amounted to 180,000 t/year, half of it in China.[77] Japan, France and Germany offer most of the current and planned recycling capacities. Whatever the case, the global capacity for recycling is still far below what is put on the market, and remains the poor relation of industries' regionalization strategies. In the best-case scenario, the IEA deems that recycling could for example meet up to 12% of global cobalt demand and 5% of lithium in 2040. In the European Union, only 12% of aluminium, 22% of cobalt, 8% of manganese, 16% of nickel and almost no lithium is currently recycled.[78]

BOX 3 • **KEYS TO UNDERSTANDING**

HOW LI-ION BATTERIES ARE RECYCLED

The recycling process for li-ion batteries is broken down into four stages. The first stage is stabilization to discharge the battery pack, followed by pre-treatment, which involves dismantling the battery pack to isolate the modules. At the end of this stage, the modules are either dismantled or crushed before being separated into different materials. A "black mass" is then obtained containing hydrophobic carbon and hydrophilic metal oxides.

Two processes are used at this point to recycle lithium-ion batteries: hydrometallurgy and pyrometallurgy. Pyrometallurgy is the most common, and basically involves heating the battery to a high temperature to recover a metal alloy. This is a standard technique for recycling metals that has been adapted for electric vehicle batteries. Nevertheless, the operation has a limited yield, insofar as it is difficult to remove metals with high added value, such as cobalt, lithium, nickel and manganese, from the alloy. Hydrometallurgy is an emerging technique that involves dissolving the "black mass" in solvents (leaching), so that the different metals can be isolated. Hopes are pinned on employing this technique to put the strategic minerals found in batteries back into circulation.

Source: Culture Sciences Chimie, 2021

Quebec plays a pioneering role on the international scene for recycling li-ion batteries.[h] Thanks to an electric mix dominated by 95% hydropower, Quebec is well-suited to the electrification of uses, in particular transport, which represents 43% of the province's emissions. With its strategy to develop the battery industry, Quebec aims to position itself among global leaders at every stage of the industry, from mineral extraction from its rich subsoils to battery manufacturing, and including assembly and the manufacture of anodes and cathodes. The young Montreal-based company Recyclage Lithion receives support from the provincial government, which is one of its shareholders. A demonstration factory with a 200-tonne capacity was opened in 2020 in Anjou, a district of Montreal. The next step is a li-ion crushing site, due to open in 2023, with a capacity of 7,500 tonnes of batteries per year, or 25,000 EVs. Recyclage Lithion recently raised an additional CAN$125 million to feed into its investment plan of CAN$350 million over five years.[79] Li-Cycle, another Canadian company based in Toronto with a strong presence in North America, plans to open two battery recycling factories in Germany and Norway in early 2023, and to reach a recycling capacity of 65,000t/year by the end of 2023.[80]

Demand for recycled matter in Europe is growing with the opening up of new Gigafactories. Northvolt for example has committed to employing 50% recycled raw materials in 2030. French mining company Eramet and urban services giant Suez are planning a battery recycling factory project in France due in 2024,[81] at the same time as BASF in Germany.[82]

KEY TAKEAWAYS

The sharp rise in automobile sales in 2021 after the slump caused by Covid-19 continues the two-way trend from the last few years. While sales of new electric vehicles are picking up speed in Europe and China with: one vehicle in five sold in the world is now rechargeable electric (BEV and PHEV); SUVs are increasing their market share, pushing up the average size, weight and consumption of vehicles. One vehicle in two sold in the major economies is an SUV, and electric vehicles are no exception. The material result of this trend is an increased need for critical metals. Requirements for minerals indispensable for the production of electric batteries (lithium, nickel, cobalt) are intensifying international competition. Carmakers, battery manufacturers, mining companies, states and local governments are part of a mad race to secure their supply of raw materials, in a situation where value chains are highly concentrated between a few countries. In the United States and Europe, the regionalization and relocation of battery and critical mineral production is confronted with local opposition, which underlines the contradictions between creating low-carbon industries and preserving the environment. The same is true in emerging countries, where the vertical integration of value chains capitalising on mineral resources is being challenged. Finally, the concentration of value chains around a handful of dominant players upstream and downstream of the automotive sector is confirmed.

g For a detailed analysis of battery recycling capacities, see: "Recycling Lithium-ion Batteries, the New Frontier in the Electrification of Mobility", page 162 in Observatory of Non-State Climate Action (2021). Global Synthesis Report on Climate Action by Sector. *Climate Chance*

h Idem.

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