



EUROPE IN THE GLOBAL RACE FOR ELECTRIC BATTERIES

Carole MATHIEU

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Summary

The future looks bright for electric battery technologies. They can meet the constraints of electricity grids taking an increasing share of intermittent renewable energies. At the same time, they can open the way for reducing the carbon footprint of transport activities through their electrification. In recent years, significant progress has been made in terms of performance and manufacturing cost for batteries, due in particular to the rise of portable electronic equipment and the development of lithium-ion solutions. The prospects for a large expansion in the client base of the energy and car sectors are leading to massive investments in manufacturing capacity. Economies of scale and pressures on margins should in turn improve the profitability of batteries, helping their deployment independently from public support mechanisms.

A race to massive development is now on, but it is mainly taking place in Asia and to a lesser extent in North America. In both these regions, public authorities are proactively encouraging domestic manufacturers, in a global market that is surely promising but still highly risky in the short-term. Without a quick response, the European Union (EU) could see its domestic demand captured by non-European giants. The EU has undeniable academic and industrial strengths, yet risks being excluded from these new mass markets if it does not act in a concerted way to support Europe's battery production industry. Two issues are at stake: benefiting from potential job and wealth creation, but also preventing major technological dependence.

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Introduction

Assuming that the threat of global warming is now taken seriously, then everything suggests that electricity will be the energy of the future. Two main considerations support this hypothesis. First, electricity generation is a major source of carbon emissions worldwide (42% of CO₂ emissions stem from electricity generation according to the International Energy Agency (IEA, 2016).¹ Given existing and new technologies, it is not surprising that efforts for reducing greenhouse gases are being deployed primarily in the electricity sector. Helped by the spectacular cost reductions observed in recent years, renewable energies thus accounted for 55% of new generating capacity installed globally in 2016 (BNEF, UNEP, 2017). If this trend is confirmed, then it will become possible to use carbon-free electricity to meet a very large variety of our energy needs, especially in transportation, so far dominated by the combustion of petroleum products which represented 23% of global emissions in 2015 (IEA, 2016a).

However attractive it may be, the prospect of an “all-electric” future including a significant share of intermittent renewable energy will have to rely on storage. The possibility of converting electricity into a “storable” energy, which can be converted back to electricity at will, would reconcile the intermittent nature of renewable energies with the imperative of continuous supply. At the same time, it would make electric vehicles a non-carbon credible alternative to thermal vehicles. The challenge is both technical and economic. The potential of different storage solutions needs to be improved and their production costs reduced for large-scale adoption to occur.

Storage therefore appears as a first order industrial and strategic issue for any government seriously engaged in the transition to a low carbon economy. Ensuring mastery of solutions which are set to be central to energy systems and mobility is primarily a necessity in terms of technological independence, but also an opportunity for creating jobs and wealth. France and the European Union are especially concerned by this issue, given their long-term commitment to preserving the climate and the promises made to European citizens of using the low carbon transition as a springboard for the European economy.

1. Some countries are an exception to this, for example France with its hydro-nuclear power mix.

The parallel with the solar power industry based on using photovoltaic panels is a warning to Europe. This industry was strongly encouraged by the introduction of a pro-active European policy to sustain demand, employing various mechanisms and subsidies. The attractiveness of the European market played a key role in the initial dynamics of this industry. But it is clear today that Asia dominates the production of solar panels: in 2016, of the world's top 10 producers, nine were Asian, including six which were Chinese (PV Tech, 2017). To be sure, photovoltaic technology has thus become more affordable and the sector remains an important employer in Europe, especially in distribution and maintenance. But European producers of solar panels are now marginalized, in the absence of effective innovation and demarcation strategies.

In the case of storage, and especially for lithium-ion batteries – electrochemical solutions which are expected to develop massively – the initial context is different because Asia already dominates the industry. This is especially true for battery cells. Indeed, Asia supplies most portable electronic devices, which have been the main outlet for lithium batteries since the start of the 1990s. Electric vehicles and stationary storage are now new drivers of growth. 43% of lithium-ion battery cells produced in 2016 were for electric mobility, compared to 40% destined for electronic appliances (Avicenne, 2017). The battery industry should therefore change in scale and potentially in structure. An industrial turning point is taking place and provides Europe with a window to react, to take advantage of an expanding market, and above all to avoid dependence on imported technologies in order to ensure the future of its energy and car industries.

The aim of this memorandum is to question the positioning of the EU and its Member States in the race for electric batteries. The main strategic options are assessed here, with respect to the outlook for demand, the international competitive environment, public policies implemented in Asia and North America, and the European industrial context.

Observing the Battle or Taking Part: Time to Make Industrial Choices

The storage of electricity in electrochemical form is not a recent discovery. As early 1800, the Italian Alessandro Volta established its principles by bringing two different metals into contact – electrodes – and a conducting substance – the electrolyte – which led to the invention of the first electric cell. Then in 1859, the first rechargeable lead battery was developed by the French Gaston Planté. Electric vehicles subsequently appeared, and actually accounted for one third of vehicles in the United States in 1900, before disappearing entirely due to competition from the internal combustion engine.

The technology has therefore been known and mastered for a long time. However, the generalization of batteries remains subject to reducing their production costs, combined with improving their performance, especially in terms of the energy density per mass (per kilo) and per volume (per liter), their calendar lifetime as well as their life cycle in terms of the number of possible charging and discharging cycles possible before their materials degrade substantially, or before the speed of charging and discharging deteriorates. Different batteries have different compositions and so specific properties, better fitted for one purpose or another. To date, lead batteries still dominate the car market, even if their energy density and lifetime are relatively poor, as their production costs are quite low. They still constitute the technology of choice for starter batteries in transport or emergency supplies, but they do not meet the requirements of portable electronics.

An important turning point occurred in 1991 with the commercialization of the first lithium-ion battery (li-ion) by the Japanese company Sony. Though more expensive initially, li-ion batteries have a far higher energy density so that they became the privileged means for accompanying the massive development of portable computers and then mobile telephones. Japanese companies were the early leaders, but were progressively overtaken by their Korean competitors in the 2000s, before

China became the world's top producer of li-ion batteries for electronic appliances in 2013.² China produced about 55% of the world's lithium-ion batteries in 2016.³ These developments in portable electronics have led to significant progress in the cost and performance of li-ion batteries. The technology has become much more mature in the last 25 years, so that new usages are henceforth credible and are attracting investors.

The outlook for electric battery demand

The electric battery industry is today concentrating on two new areas of growth: electric vehicles and stationary storage which are both benefiting from growing government support.

The rise of electric vehicles

The figures are clear: sales of electric and rechargeable hybrid vehicles have been growing strongly in recent years.⁴ In 2016, nearly 750,000 units were sold (IEA, 2017), compared to only a few thousand in 2010. Consumer interest is growing, with 45% of German buyers, 30% of American buyers and 23% of Chinese buyers today considering purchasing electronic vehicles as a possible option (McKinsey, 2017). Tesla has recorded nearly 500,000 pre-orders for its "Model 3", confirming this trend and even establishing a record in the history of the car industry.

The market share of electric and hybrid vehicles nevertheless remains modest, and was just 1% in 2016. They only represent 0.1% of all light vehicles on road. Forecasts are equally mixed, although they all see a clear expansion and so far annual revisions have always been upwards.

2. H. Sanderson, "Electric Cars: China's Battle for the Battery Market", *Financial Times*, 5 March 2017, available at: <https://www.ft.com>.

3. J. Ryan, "China Is about to Bury Elon Musk in Batteries", Bloomberg, 28 June 2017, available at: www.bloomberg.com.

4. A rechargeable hybrid vehicle is equipped with a thermal engine as well as an electric motor. They are used alternatively to optimize energy consumption (the vehicles are rechargeable from the grid, in contrast to "simple" hybrid vehicles for which petrol or diesel continue to be the exclusive carbon energy source). The "pure" electric vehicle only uses a battery system. The term "electric vehicles" used in international statistics often tends to cover both categories.

Table 1: Forecasts of the Share of Electric and Hybrid Vehicles in the Light Vehicle Fleet

	2030	2035	2040
AIE			8 %
BNEF			25 %
BP		6 %	
ExxonMobil			6 % *
OPEP			12,6 %
Statoil (Reform Scenario)	12 %		

* Forecasts by ExxonMobil also include hydrogen powered vehicles.

Sources: IEA, *World Energy Outlook, 2016*; BNEF, *New Energy Outlook, 2016*; BP, *Energy Outlook, 2017*; ExxonMobil, *Outlook for Energy – A view to 2040, 2016*; OPEP, *World Oil Outlook, 2016*; Statoil, *Energy Perspectives – Long-term macro and market outlook, 2017*.

The differences in forecasts can easily be explained by the diversity of factors which determine the attractiveness of electric vehicles. First of these is the more or less advantageous nature of public policies and their capacity to compensate current high purchasing prices. National and local demand depend especially on taxes and emission standards applied to thermal vehicles, subsidies for purchases, tax exemptions and other facilities provided to electric vehicles. But demand also depends on the availability of recharging infrastructures. In 2016, 95% of electric vehicle sales were concentrated in 10 countries (China, United States, Norway, the United Kingdom, France, Japan, Germany, the Netherlands, Sweden and Canada), which had all adopted ambitious policies to support demand (IEA, 2017).⁵ In 2010, China identified “new energy vehicles” as one of the seven “strategic sectors” for the future of the country’s economy. Since then it has implemented an especially favorable regulatory framework, so that China has become by far the world’s leading market for personal electric

5. The purchase of electric vehicles is supported by public authorities because electrification stands out as a key solution in the energy transition of transport. As noted by ADEME (2016), electric vehicles have an energy consumption similar to diesel vehicles throughout their product life, but emit far less greenhouse gases (9t CO₂-eq compared to 22t CO₂-eq for a thermal vehicle under the same conditions) and contribute to improving air quality.

vehicles, accounting for 40% of sales in 2016. It should also be noted that the enthusiasm for electric mobility also concerns public transport, as well as two-wheelers, both of which are supported by public procurement and financial incentives. In 2016, 200 million two-wheelers and 300,000 electric buses were sold, again largely in China (IEA, 2017).

The support measures have contributed to closing the persisting competitiveness gap between electric vehicles and conventional thermal vehicles. Estimates in 2015 show that a vehicle with a 35 kWh battery had an average total cost of ownership that was \$10,000 greater to a comparable thermal vehicle. Cost parity is not reached yet, even when taking the assumption that electric vehicles are used to cover more than 20,000 km per year (IRENA, 2017a).⁶ Given that public subsidies are assumed not to last indefinitely, it must be admitted that sales growth can only rise if the operating costs of electric vehicles improve. This assumes that production costs for batteries will continue to fall, as these are estimated at about a third of the cost of producing an electric vehicle.

By contrast, it should be noted that batteries which were initially destined for electric vehicles but which have lost part of their autonomy over time can probably see their life cycle extended by use in stationary storage. This opens up the possibility of sharing costs between primary and secondary users and so strengthening the attractiveness of electric vehicles. Their profitability will also depend on the future sales price of conventional fuels compared to electricity prices, as well as on parallel improvements in the consumption of thermal motors. The definition of a “breakeven point” is therefore hazardous, even if a price of \$100/kWh for batteries is often presented as the objective to reach in order to guarantee parity with thermal vehicles, excluding incentives. In 2016, the actual sales price of batteries was \$273/kWh, still very far from the objective. However, the 73% fall in prices observed since 2010 provides good grounds to be optimistic (BNEF, 2017).

The development of stationary storage

Storage is so far relatively little developed in electricity grids, although there are some big disparities between regions. In 2015, total storage capacity only stood at 149 GWs, about 2% of global electricity output. Furthermore, nearly 95% of this storage capacity was hydroelectric, in pumped storage hydroelectricity (PSH) stations, and these continue to

6. To give an order of magnitude, on average a vehicle in France covers about 13,000 km per year (SOeS, 2014).

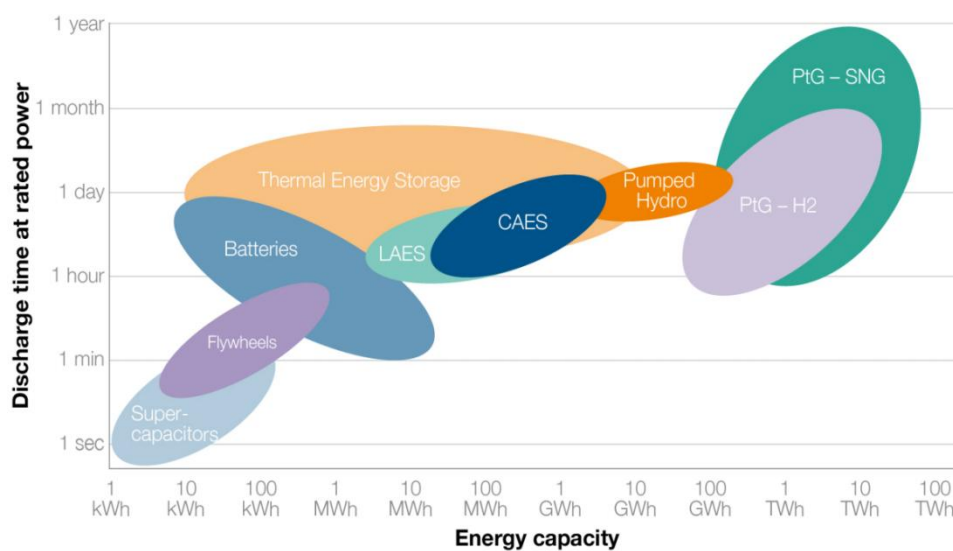
represent most storage projects, especially in emerging countries where unexploited potential still exists (IEA, 2016b). A growing interest in electric batteries, which provide a different type of service compared to PSH, can however be observed (see below). For large-scale installations (>1 MW), the contractualized capacity to be put into service in the next two years will be greater than the cumulative capacity installed before 2016 (French Ministry of Economy, 2017). As with electric vehicles, forecasts of future development have very large ranges, but some predict that stationary storage with batteries could reach 325 GW in 2030, compared to only 0.8 GW in 2014 (IRENA, 2017b). Even if other chemical compounds, such as sodium-sulfur, lead acid and nickel cadmium are sometimes used by operators, lithium-ion tends today to dominate existing projects. The energy density argument is less relevant in the case of stationary storage, but the number of cycles remains important, as do lower costs. These stem from developments in electronics and now transport and strongly favor the attractiveness of lithium-ion technology in the area of stationary storage. In 2015, lithium-ion accounted for 90% of all large-scale battery projects put into service (BNEF, 2016a).

Interest in stationary storage is progressing as intermittent renewable energies are becoming more important in the electricity mix, even though needs are not evolving in a linear fashion with the penetration rate of renewables. In fact, the massive development of production subject to weather variations is raising the need for flexibility of electricity systems and new tools need to be made available to ensure equilibrium between output and consumption at any moment. Storage is a possible response, but not the only one. National and cross-border interconnections, intelligent demand management and production modulation, especially via combustion turbines or peak shaving, are also part of this competing and complimentary package of options. The technical-economic attractiveness of battery storage will depend both on the penetration of renewable energies, and on their competitiveness compared to other flexibility devices. In the short term, needs will be greater in isolated areas, like island systems, and should occur later in densely interconnected continental networks, such as the European continental grid.

Furthermore, different stationary storage solutions (pumped storage hydroelectricity, compressed air, hydrogen, flywheels, batteries, etc.) each

provide a combination of parameters, especially in terms of power and discharge time, and thus meet different system needs.⁷

Graph 1: A Classification of Different Stationary Storage Technologies as a Function of their Capacity and Discharge Time



Source: World Energy Council (2016), *E-storage: Shifting from cost to value*.

Batteries are adapted to short-term storage, from a fraction of a second to several hours, but they are not appropriate beyond that. They are a favored means for intra-day transfers, because their costs are mainly fixed costs. They improve by being diluted across one or several charging/discharging cycles per day. Aside this primary characteristic, batteries stand out as being easy to deploy, or “versatile”. Indeed, they can be installed at any point in a grid, their construction not presenting *a priori* any major problems of social acceptability. Generally, installation only takes a few months and their capacity can be increased or decreased gradually. These assets are currently being highlighted in California, where the challenge is to compensate the sudden unavailability of gas turbines which was caused by the closure of the underground gas storage site at Aliso Canyon, following a leak which occurred in 2015-2016. In July 2016, the regulator approved the emergency installation of 100 MW battery storage capacity to be deployed by December 2016. This express ruling

7. See for example the report by the ITRE Committee of the European Parliament (2015), or the WEC report (2016) for a detailed comparison of storage technologies as a function of the different needs of the electricity system.

applying to the operator Southern California accelerated projects under study and contributed to demonstrating the interest of batteries to meet situations of tension rapidly. On the basis of this success, the battery industry is henceforth well-positioned to propose solutions in South Australia, a State in which wind and solar power account for 43% of installed capacity (AEMO, 2016) and which recently experienced repeated blackouts. Elon Musk, the emblematic boss of Tesla, has even boasted of being able to solve this supply security problem within 100 days.⁸

Aside such emergency situations, batteries are able to provide different services to electricity systems, but this raises the question of their valuation (WEC, 2016), especially in liberalized electricity systems.⁹ Battery systems can find a business model once prices enable a proper valuation of the services they provide. This assumes lifting pre-existing barriers, such as double grid tariffs (for storage and injection), and authorizing storage installations to participate in different energy markets and system services.

The “historical” business model for storage is based on arbitration. PSH is generally specifically constructed to store baseload electricity output, which is abundant and cheap, in order to feed it back into grids during peak periods, when production is scarcer and more expensive. In theory, this perspective will be extended with renewables, even if the predictability of spikes is reduced. Nevertheless such arbitrage revenues are currently low in Europe as a whole, where overcapacity has depressed prices. Arbitrage is only interesting when price spreads are significant. This assumes that a system actually has little storage capacity and experiences the strong development of intermittent energies, or that it is subject to strong CO₂ taxes. Moreover, as mentioned above, batteries continue to be expensive when discharge stretches out for more than 10 hours.

Currently, the most attractive market segment for stationary batteries is for system services, especially frequency regulation. The aim here is to have reserves available which can be used rapidly, to ensure that electricity frequency does not vary beyond security margins. Batteries are henceforth an attractive solution with respect to traditional production means. At the last call for tender in the summer of 2016, held by the British operator

8. E. Hunt, “Elon Musk: I Can Fix South Australia Power Network in 100 Days or It’s Free”, *The Guardian*, 10 March 2017, available at: www.theguardian.com.

9. A rough economic analysis would take wholesale electricity market prices (spot and futures markets) as the primary source for calculating valuations. But “market failure” and “regulatory failure” distortions mean that such calculations should be taken with caution. The challenge is to avoid the presence of both entry barriers and undue subsidies given to storage.

National Grid to constitute primary reserves, 61 out of 64 projects submitted involved battery storage.¹⁰

Moreover, installing batteries can also be seen as a way for easing congestion by shifting electricity flows, and so permitting the deferral or even replacement of investments in physical power lines. This solution is all the more interesting given that battery capacity can be easily modulated, and so adapted quickly to changing constraints. This is echoed in France with the pilot project of virtual lines (RINGO)¹¹ managed by RTE and under discussion currently with the regulator. It could lead to the installation of 100 MW in storage capacity in five sites, by 2020. However, the question of the regulatory framework is essential since grid operators should not upset the functioning of the wholesale electricity markets when withdrawing or injecting current with their batteries. The regulatory challenge is to define the role of the different players, and especially grid operators, in terms of the ownership and operation of storage infrastructures which is today at the centre of European discussions on the new Clean Energy Package (Cruciani, 2017).

Finally, the expansion of storage “behind-the-meter” could contribute to maximizing the self-consumption of renewable energy. Again, the success of residential storage will depend on price signals consumers face, as well as on societal demands. In Germany, where battery installation is supported by the public investment bank with a 30% investment aid as well as cheap loans, residential storage associated with solar production has not yet reached “grid parity”, the profitability threshold with respect to electricity provided by the grid.¹² That said, the German household storage market is booming, and 50,000 installations were already in place at the end of 2016 (GTAI, 2017). Lastly it should be recalled that small capacity batteries may also support the electrification of isolated areas, especially in sub-Saharan Africa and South Asia (Desarnaud, 2016).

In volume terms, the market for stationary storage has less potential for the battery industry than mobility. Worldwide demand for lithium-ion batteries in 2016 was 20 GWh for electric vehicles, compared to 1.6 GWh

10. National Grid, “National Grid Brings Forward New Technology with Enhanced Frequency Response contracts”, press release, 26 August 2016, available at: <http://media.nationalgrid.com>.

11. RTE, “Voyage au cœur du réseau de demain”, Dossier de présentation of 7-8 March 2017, available at: www.rte-france.com.

12. The term “grid parity” commonly refers to the socio-economic profitability of solar panels or photovoltaic-battery solar packs for the final consumer (the “self-consumer”), and not necessarily for the community. It may reflect a disguised form of subsidy for these technologies if the saving in electricity bills for the “self-consumer” overestimates the savings actually made by the electricity system (or underestimates the costs of supply guaranteed by the grid).

for stationary storage. Even by 2024, sales for stationary storage are not expected to be more than 10% of those for transportation (BNEF, 2016a). Electric vehicles dominate order books and hence the performance and cost paths of electric batteries. Stationary storage will be mainly driven by this momentum, but it will also provide battery producers with a means for diversifying their outlets, and optimizing factory production planning.

Production capacities: the race to gigantism

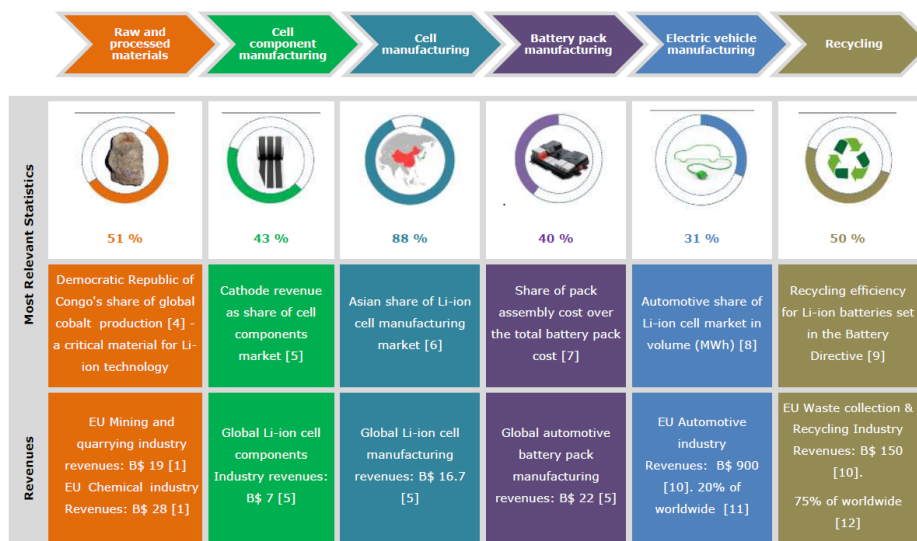
These promising markets have stimulated the interests of a wide range of manufacturers coming from the electronics, car and energy industries. Batteries are indeed creating connections between sectors that were previously partitioned, and encourage all companies concerned by their use to seek an appropriate position in the value chain. In the example of the car industry, some carmakers consider that they must invest themselves in the production of batteries in order to master this key element of vehicles and avoid the risk of shortages. This integrated strategy is favored by the American firm Tesla, and the Chinese one BYD. Others, such as General Motors, prefer to run such risks and benefit from competition between companies specialized in electrochemistry. In reality, the choice is not purely binary as the production of batteries involves several stages: the transformation of raw materials into chemical components, the manufacture of cells, the assembly of cells into modules and lastly battery intelligence including different management systems (electric, thermal, etc.), as well as communication with loaders and vehicles. Car producers like BMW or Renault-Nissan¹³ have opted to concentrate on this last stage of manufacturing, which is the least standardized. Indeed, the objective is to produce a battery with no security risks, and which can be managed according to the specific characteristics of the vehicle. The electric battery industry is therefore expanding and diversifying, implicating actors with increasingly varied histories and priorities.

The falling costs observed in recent years are primarily linked to this industrial craze, and not to a specific technological change. Improvements in industrial processes and economies of scale are today the key drivers for competitiveness in the sector. Factory size conditions the capacity of manufacturers to negotiate good prices with their raw material suppliers,

13. Nissan is presently holding negotiations with the Chinese fund GSR for the sale of its stake in the company AESC, which has to date made lithium-ion cells for the Nissan-Leaf and other electric models of the Renault-Nissan alliance.

and even the terms for setting up plants with local authorities. To prevent competitors from emerging and reaping the benefits, it is necessary to increase production capacity as quickly as possible. This has led to a race to gigantism, which has in turn brought on the proliferation of new factory projects. Global production capacity of lithium-ion cells increased by nearly 40% between 2014 and 2016, to reach 104 GWh for all applications (EC, 2016). It could easily reach 273 GWh by 2021, if all projects put forward are completed.¹⁴ The concept of a Gigafactory, launched by Tesla and Panasonic in 2013, illustrate this trend most clearly. This huge factory, set in the Nevada desert, should achieve a production of 35 GWh in cells and a total of 50 GWh in lithium-ion batteries (i.e. with 15 GWh being imported), as of 2018. According to recent declarations by Elon Musk, 2 to 4 new projects for Gigafactories, in the United States and elsewhere, should be officially launched by Tesla in 2017.¹⁵ The Asian giants are just as fervent in this race. The Chinese producer CATL for example tripled its production capacity in 2016, and aims to cross the 50 GWh/year threshold by 2020.¹⁶

Table 2: Segments of the Battery Value Chain for Electric Vehicles



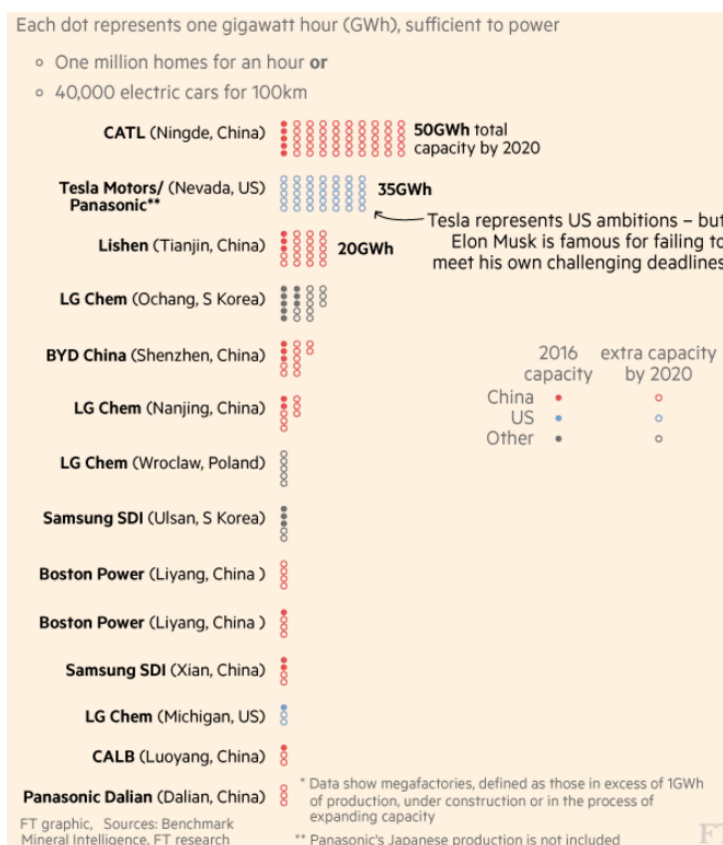
Source: European Commission (2016), *Lithium-ion battery value chain and related opportunities for Europe*, JRC Science for Policy Report.

14. J. Ryan, "China Is about to Bury Elon Musk in Batteries", 28 June 2017, Bloomberg, available at: www.bloomberg.com.

15. TED Talks - Elon Musk, "The Future We Are Building", April 2017, available at: www.ted.com.

16. J. Spring, "Power Surge: Chinese Electric Car Battery Maker Charges for Global Market", Reuters, 25 December 2016, available at: www.reuters.com.

Graph 2: Projects for Extending Production Capacity of Lithium-ion Batteries through to 2020



Source: *Financial Times*, based on data from *Benchmark Mineral Intelligence* and *FT Research*.

This bet on the future requires mobilizing colossal financial resources, without being bound by short-term profitability constraints. For example, the costs of constructing the Tesla Gigafactory were estimated at \$5 billion in 2013. As a result, several actors involved in this industrial war are currently facing significant financial losses. In the first quarter of 2017, Tesla recorded a net loss of \$330.3 million, despite an increase in turnover of 76.5%.¹⁷ Along with these gross operational results, Tesla is stressing the imminent launch of its mass market vehicle, the Model 3, with the aim of reassuring investors about its capacity to meet the rise in demand for electric vehicles without delay.

However, profits may not materialize in the expected proportions, if current investments lead to sustained global overcapacity,¹⁸ as was

17. Tesla, First Quarter 2017 Update, see: <http://files.shareholder.com>.

18. The factories are already over-sized in relation to current needs as in 2016, production capacity of cells was estimated at 104 GW while actual production was 60 GW. The question is whether this situation is temporary (anticipating needs) or structural.

previously the case in the solar panel industry. The risk would be for prices to fall more quickly than production costs, especially if Chinese manufacturers flood the market or if world demand has been over estimated. Some analysts, such as Morgan Stanley, have specifically pointed to the possibilities of a Chinese bubble, especially given the prospects of a gradual fall in subsidies for the domestic market of electric vehicles (a cut of 20% from 2017 to 2018, and a new cut of 20% from 2018 and 2019), as well as a more active fight against fraud. In this context, pressure on margins will be strong for cell manufacturers, as their products are weakly differentiated and as entry barriers are relatively low (Morgan Stanley, 2016).

The risks of a mismatch between the supply and demand of batteries are also a factor contributing to higher production costs. The lack of visibility concerning order books prevents manufacturers from optimizing the use of their factories, or easily obtaining finance to plan expansion. Long-term contracts, especially between carmakers and parts suppliers, are therefore an important factor in determining the competitiveness of battery manufacturers (BNEF, 2016b).

In short, investments must be undertaken at the right point in time, neither too early with respect to demand, nor too late with respect to competitors. Matching industrial strategies and market realities is a subtle process and bankruptcies are numerous, as shown by the failure of A123 Systems in 2012. In 2009, this pioneering company benefited from subsidies by the American Department of Energy (DoE) running to nearly \$250 million, to support construction of two battery factories for electronic vehicles in Michigan. Three years later, the company declared bankruptcy as it was unable to build up a solid client base. A123 Systems had entered the battle too early and went into Chinese ownership in 2013. The recent failure of the US start-up Acquion Energy is another example of the weaknesses of business models. Created in 2009, the company raised \$190 million of finance with its promise to revolutionize stationary storage thanks to the exemplary performance of a technology based on the electrolysis of salt water. The firm was still listed in the 2016 MIT ranking of the 100 Smartest Companies, but was unable to face off competitors using lithium-ion. It thus declared bankruptcy in the spring of 2017.¹⁹ Batteries are therefore a promising sector but with high risks. Public policies can hence play a determining role in managing these risks and aiding the rise of domestic industrial champions.

19. E. Wesoff, "Acquion, the Advanced Battery Startup Funded by Bill Gates and Kleiner Perkins, Is Bankrupt", *Greentech Media*, 8 March 2017, available at: www.greentechmedia.com.

Polices for Supporting Domestic Industry

Most recently, specialized American media have expressed concerns about the electricity storage industry gradually escaping from their country.²⁰ By contrast, in India there are worries that if the government supports renewable energies and electric vehicles this could, over time, lead to a dependence on batteries imported from China.²¹ These various warnings always conclude with demands for rapid action by public authorities to defend domestic battery manufacturers.

The creation of an industrial sector depends above all on the development of local demand to fill order books and serve as a springboard for exports. This first stage is necessary but not sufficient if foreign competitors are better positioned to capture new sources of demand. The challenge then is also to support local supply, without falling into industrial protectionism. The aim is not to risk litigation before the WTO or face detrimental commercial reprisals in other sectors, nor to develop a poorly performing local supply base that is progressively protected from competition. Getting the mix right is delicate and requires above all good knowledge of practices in competing countries.

Japan and Korea: building industrial showcases for storage

The electrochemical industry has been a pillar of the domestic economy for Japan, and during the last decade for Korea. Their goal is therefore not to favor the emergence of new actors, but rather to encourage their major firms, especially Panasonic and NGK Insulators in Japan, as well as Samsung SDI and LG Chem in Korea, to expand their client base beyond portable electronics.

Furthermore, encouraging such developments in the area of stationary storage meets the needs of their respective electricity systems. The energy

20. "Energy Storage Is America's Industry to Lose", *EE News*, 20 March 2017, available at: www.eenews.net.

21. D. Sengupta, "Chinese Threat Looms Large over Indian Battery Makers", *Economic Times of India*, 16 March 2017, available at: <http://economictimes.indiatimes.com>.

situation in Japan is still strongly disrupted by the Fukushima disaster and the loss of nuclear production capacity. Restarting nuclear power plants has been longer than anticipated and the country is engaged in the rapid development of renewables, to the point of meeting serious problems in integrating these, which in turn led regional grid operators to oppose connecting new solar panel installations at the end of 2014. Korea for its part needs to meet the rapid rise in the demand for electricity, especially in industrial sector, while at the same time curbing its growing dependence on imported fossil energies. In both cases, the national grids are insufficiently dense and above all they do not have cross-border interconnections.

These situations easily justify the implementation of a regulatory framework favoring the deployment of stationary storage. As the world's leading market, Japan provides subsidies for behind-the-meter and utility-scale battery installation, in order to facilitate the absorption of output from renewables. In 2012, the Ministry of Economy (METI) published a "batteries strategy" setting out an ambitious goal for Japanese firms to provide 50% of global stationary storage market by 2020. Support by public authorities is reflected especially in financial aid to numerous demonstration projects. In September 2016 for example, 14 Japanese companies associated with the Kansai Electric Power operator launched a virtual power plant, thanks to the aggregation of renewable capacity and batteries. This initiative is set to be completed in 2020, and benefits from a subsidy of ¥3 billion, nearly €25 million.²² Seven similar projects were approved by the Japanese authorities in financial year 2016.²³

In Korea, support for stationary storage projects is more recent, but is expanding quickly. Wind farm manufacturers (since 2015), and solar panel producers (since 2016) installing storage capacity have been given rights to extra points in the system of renewable energy certificates, in which all suppliers participate. Moreover, the large public operator KEPCO has launched a vast program to deploy storage capacity in order to regulate electricity frequency. The aim was to achieve 500 MW of installed capacity by the end of 2017.²⁴ Several projects are being managed and implemented by LG Chem, Samsung SDI and above all Kokam. Also, the Korean State is supporting companies in their strategies to expand abroad, with cheap loan

22. "Japan to Test Virtual Power Plant for Renewables", *Asia Nikkei*, 14 July 2016, available at: <http://asia.nikkei.com>.

23. "Japan Is Keeping Itself Busy by Making Virtual Power Plants", *Asian Power*, 2 March 2017, available at: <http://asian-power.com>.

24. "In South Korea, an Energy Storage Bonanza", *Navigant Research Blog*, 14 October 2014, available at: www.navigantresearch.com.

programs for small and medium-size companies, as well as the organization of trade fairs promoting Korean products. In April 2016, the public operator KEPCO and Samsung SDI signed a protocol agreement of understanding to supply exports and reply to international calls for tender jointly.²⁵

In both cases, domestic firms benefit directly from such targeted support. Foreign competitors are not excluded *a priori* from these developments but may well find themselves poorly equipped to respect the demands for tenders, beginning with the need to bid in the national language. Lastly, while there can be no doubt that the bids by Japanese and Korean manufacturers are technically sound, economic patriotism in their favor cannot be ruled out in the various selection processes organized by public authorities.

China's advances in the markets for electric vehicles

In China, the government's proactive engagement mainly concerns electric vehicles. Given the size of its domestic market and the strength of public support, China already accounts for nearly half the global market in electric (and hybrid) vehicles: indeed sales volumes increased by a further 53% between 2015 and 2016.²⁶ These developments are fully coherent with the country's major priorities. First, the rise of electric mobility is one answer to the problem of atmospheric pollution in China's large eastern cities, especially if associated with a fall in the share of coal in its electricity mix. Second, it can contribute to reducing China's oil dependency, which is today close to 60%, half being due to the transport sector (Wang, 2017). Lastly, and above all, this sector offers new perspectives for China's manufacturing industries.

Chinese ambitions in the car market are long-standing. In 1994, the so-called "50/50 rule" was introduced which authorized foreign manufacturers to produce vehicles in China, and so access the Chinese market without paying customs duties, provided they established joint ventures in which Chinese partners had a 50% stake. Although this rule was backed up by demands to share know-how and technology, the development of Chinese players has not yet reached hoped-for levels. In

25. "Samsung SDI Joins Hands with KEPCO to Push into Global ESS Markets", *Business Korea*, 20 April 2016, available at: www.businesskorea.co.kr.

26. "After a Surge in Sales in 2016, What Can We Expect from China's Auto Industry this Year?", *Forbes*, 1 February 2017, available at: www.forbes.com.

this context, the shift to electricity is seen as a unique opportunity to close finally the competitiveness gap with global carmakers. Since he became Minister of Science and Technology in 2007, Mr. Wan Gang has perfectly manifested China's enthusiasm for electric mobility. Uniquely he was not a Communist Party member, in contrast to the large majority of ministers. Instead, he was appointed for his expertise as a former car engineer in the Audi group and as a coordinator of university research in electric vehicles.

Not surprisingly, China's objectives are especially ambitious. The aim is to reach 5 million electric (and hybrid) vehicles on road nationally by 2020.²⁷ At the same time, the goal is for Chinese companies to supply 70% of domestic demand by 2020, and 80% by 2025.²⁸ In conformity with these objectives, the Chinese battery and electric vehicle industries are growing quickly. The Vehicle Traction Battery Industrial Development Action Plan aims at achieving a national level of output of 100 GWh by 2020, stressing R&D efforts and the improvement of the quality of Chinese products. Indeed, even if China has already overtaken its competitors in volume terms, it still lags technologically when compared to Japanese and Korean manufacturers. This is an obstacle to exports.

As a result, the Chinese authorities today are seeking to encourage the consolidation of the battery industry, to avoid competition between small players in different provinces, to favor economies of scale, as well as to make production less polluting and less energy intensive. A new proposal for regulation published by the Ministry of Industry envisages multiplying the minimum production levels from manufacturers by 40. Henceforth, a production capacity of 8 GWh will be required to obtain governmental certification and so for electric vehicles equipped by manufacturers to benefit from different subsidy programs. To date only a few manufacturers – BYD, CATL, Lishen and perhaps Hefei Guoxan – easily meet this new criterion. It is especially restrictive for Chinese industrial companies, and is seen by some as an additional entry barrier for foreign companies. In the eyes of the Korean press, it even constitutes a form of Chinese retaliation following Korea's decision to authorize the deployment of US antiballistic missiles (THAAD) on its territory.²⁹

Suspicious about protectionism in China's industrial strategy are recurrent. Previously they concerned public support for the deployment of

27. The goal comes from the New Energy Vehicle Development Plan for the years 2012-2020.

28. These aims stemmed from the "Made in China 2025" strategy, published in 2015.

29. M. Herh, "Regulation on Batteries: Chinese Government Virtually Blocking Korean Batteries from Entering Chinese Market", *Business Korea*, 26 November 2016, available at: www.businesskorea.co.kr.

electric buses, and the obligation introduced in early 2016 to use lithium-iron-phosphate (LIP) batteries in order to obtain public subsidies. Nickel-manganese-cobalt (NMC) and nickel-cobalt-aluminum (NCA) batteries were temporarily excluded from this government measure, officially on grounds of safety. Such NMC and NCA batteries do indeed require more sophisticated packaging than LIP batteries to handle risks of overheating. However, it is also true that the Chinese industry, and especially its lead manufacturer BYD, are better positioned in LIP technology, while foreign competitors have focused on NMC/NCA technology for energy density reasons. One possible interpretation of the regulation is that the Chinese authorities have tried to protect the domestic market, allowing Chinese producers the time needed to catch up with NMC/NCA technology.³⁰

For the EU Chamber of Commerce in China, the “Made in China 2025” strategy is largely about import substitution, as it creates differences in treatment between domestic and international players, especially in the area of electric vehicles. As a result, the Chamber of Commerce is calling on the Commission and EU Member States to be more vigilant about possible violations of commitments made by China to the WTO, and also concerning the nature of Chinese investments in Europe (EU Chamber of Commerce in China, 2017).

A US catch-up strategy that mainly benefits Tesla

As in Europe, the United States lagged behind the moves by Japanese industry as of the 1990s. The US retained leadership in the lead battery segment but was forced to accept Asian domination in lithium-ion.³¹ However, compared to Europe, the United States has sought to correct this trend and started to rebuild its industrial potential as of the mid-2000s. The ARPA-E (Advanced Research Project Agency-Energy) agency was created in 2007 and has become a central component of US policy. It benefited from the Economic Recovery Plan adopted by the Obama administration in 2009, and then began participating directly in the financing of projects with high technological potential, though judged too risky when based only on private capital. The different programs supporting RND benefit especially batteries both for stationary storage and mobility (ARPA-E, 2016). The proactive determination of the federal

30. B. Einhorn and H. Kim, “Samsung and LG Have a Battery Problem”, Bloomberg, 31 March 2016, available at: www.bloomberg.com.

31. D. Ferris, “Energy Storage Is America’s Industry to Lose”, *EE News*, 20 March 2017, available at: www.eenews.net.

government has also focused on production capacity, as mentioned previously in the case of the A123 company.

Since Donald Trump came to power, US strategy has become more uncertain. On the one hand, lack of consideration for climate issues may create an unfavorable context and could even lead to the scrapping of the Clean Power Plan designed to accelerate decarbonization in the electricity sector, the possible ending of the ARPA-E program in the federal budget for 2018,³² and the removal of fuel economy standards (CAFE standards) for 2022-2025.³³ For the moment, the new president has also committed himself to “rebuild America’s infrastructure” and his transition team has indeed included a storage plant in California in its first list of priority infrastructure projects.³⁴ In addition, the plan to cut corporate taxes, and proposals to raise certain customs duties, could favor manufacturers who locate production in the United States.

Moreover, federal initiatives are usually complemented by policies at state level. Thus, sales of electric vehicles are encouraged by a federal tax credit of \$7,500 per vehicle, with California providing a further \$2,500 and New York state \$2,000 for example (Plug In America, 2017). In terms of stationary storage, the Federal Energy Regulator (the FERC) was a pioneer in adopting various regulations in 2011, to encourage the participation of batteries in the different markets of system services. Since 2016, the FERC has also launched studies and consultations to open wholesale electricity markets to storage installations. Again, this measure has been completed by state level regulations, for example the mandate given to three Californian operators to deploy 1,325 MW of storage capacity by 2024, in networks for transportation, distribution, and downstream of customer meters. Apart from creating an attractive domestic market, certain types of aid are even topped up when solutions are provided by local companies. This is notably the case for California’s Self Generation Incentive Program, which sets aside top-up aid of 20% when it is demonstrated that 50% of value-added associated with a storage system has been created in the State of California.³⁵ Lastly, the United States is seeking to encourage the establishment of battery manufacturing plants on its soil, by providing negotiated advantages. For its Gigafactory, Tesla was able to choose

32. G. Bade, “Trump Budget Would Slash EPA Funding 31%, Eliminate ARPA-E in DOE Cuts”, *Utility Dive*, 16 March 2017, available at: www.utilitydive.com.

33. “Trump Reopens Review of US Fuel Efficiency Standards”, *Financial Times*, 15 March 2017, www.ft.com.

34. “Trump Infrastructure Priority Plan Includes Transmission, Wind, Energy Storage”, *Utility Dive*, 25 January 2017, available at: www.utilitydive.com.

35. California Public Utility Commission, “Decision Revising the Self-Generation Incentive Program”, 23 June 2016, available at: <http://docs.cpuc.ca.gov>.

between the conditions offered by different States before selecting Nevada for its project, with the State providing Tesla \$1.3 billion in tax breaks, as well as land, a connection to the main road network and a preferential electricity price (Deslot, 2017).

Finally, the specificity of standards in the United States could benefit its domestic industry and enable it to seize the new opportunities in stationary and mobility storage in time. The car sector is historically very protected in United States, which has remained one of the few countries not to have signed the 1958 UN Agreement on the Mutual Recognition of Motor Vehicle Approvals. Foreign carmakers must therefore adapt their models significantly to meet American norms, which may dissuade market entry. In addition, storage solutions must respect American norms relating to the security of electric installations, notably the UL standards, if they want to supply products to the US market. However legitimate these standards may be, they may dissuade foreign competition.

In the three situations mentioned here, the public authorities seem to be fully aware of the strategic importance of the battery industry and are operating through various channels to favor the emergence of national champions. Although there is no trade war yet, accusations of protectionism are increasingly frequent. For Europe, it is important to take stock of the proactive policies of its competitors, so that it may adjust its own practices and serve its interests as well as possible.

Nurturing the European Battery Industry

Europe appeals to the large battery manufacturers both as a commercial outlet but also as a location for part of their production. After Korea and China, Samsung SDI chose Hungary to develop its output capacity. This project, estimated at €300 million, should allow 50,000 batteries for electric vehicles to be made each year, with production beginning in mid-2018. The other large Korean manufacturer, LG Chem, has invested a similar amount of money in building a site in Poland, with a target output of 100,000 batteries and production set to start at the end of 2018. Lastly it should be recalled that at the end of 2016, Tesla purchased the German engineering company Grohmann, which specializes in automated manufacturing systems. Tesla has also indicated it is looking for a location in Europe to set up a Gigafactory, along the lines of the plant in Nevada. By insuring their presence in the heart of the rapidly-expanding European market for electric vehicles, these companies will be able to meet demand rapidly, especially by reducing logistical constraints linked to the weight and safety of their products.

From this point of view, Europe can rejoice that these expansion strategies will create business and jobs on its territory. Nevertheless, it is necessary to examine the risks of not challenging Asian and American domination both worldwide and in Europe.

The risks of Europe's wait-and-see approach

There will therefore be some Gigafactories in Europe. But if they are managed essentially by non-European companies, their sustainability will be more uncertain. As noted above, the industry is currently characterized by excessive investment and a struggle for market shares. The risks of overproduction are clear and the battery industry could soon face consolidation. In such a scenario, it is reasonable to expect production sites outside the large companies' countries of origin to be first in line for restructuring, especially if production costs there are high. Ensuring European management of production centers is a better guarantee for the continuation of industrial activity.

Another risk of letting non-European battery producers prosper is that they will seek to move up the value chain progressively, especially in the car industry. Leaving aside direct competition from integrated players like Tesla and BYD, battery suppliers could also supply European carmakers for a while, ensuring their technological dependency, and then favor partnerships with car producers from their countries of origin with more favorable contract terms. The latter would then acquire a competitive advantage *vis-à-vis* European producers. In the field of stationary storage, the threats seem less immediate, as the short-term needs of the European electricity grid are moderate. By contrast, they will reveal themselves more fully in the decades ahead given Europe's targets for renewable energy generation. If these changes are not anticipated within a European industrial strategy, then technological dependency will be complete.

Yet, Europe's industrial fabric has a number of strong assets on which it can capitalize. First, European energy companies as well as car and component manufacturers are internationally recognized and can provide a base for the expansion of Europe's battery industry. To take just one example, the EDF group is currently developing several projects for battery storage to provide systems services, in particular with the operational facilities at McHenry in Illinois, as well as several projects in the UK and in the French island grids. Even if no European producer to date has the same size as the Asian giants, Europe's battery industry still employs 30,000 persons, it has 16 R&D centers and an annual turnover of €6.5 billion (EUROBAT, 2016). France too is very well positioned in the battery sector, specializing in high value-added lithium-ion and lithium-metal-polymer batteries (French Ministry of Economy, 2014). There are two major producers: the Saft company and the Blue Solutions subsidiary of the Bolloré group. There is also Forsee Power which is specialized in the integration of cells. Finally, Europe's industry can draw on cutting edge research in European centers, such as the CEA in France or the Fraunhofer-Gesellschaft in Germany. Nevertheless, if Europe does not find the means to expand industrial investment, then these assets will be underexploited, and the European battery industry may miss out on mass markets.

Possible strategies

Leaving aside a wait-and-see approach, different industrial options are now available to Europe, implying varying degrees of intervention by public authorities.

A first possibility would be to admit Asian domination of at least part of the value chain in battery production, namely the manufacture of cells. Given that the value for money provided by Asian suppliers today is hard to contest and that long-distance transport does not present a great difficulty, it may be wise to focus European priorities on assembly, integration and the second life or recycling batteries. This is the path which the German carmaker Daimler-Benz has chosen: in the presence of the German chancellor, the company has just celebrated the launching of the construction of what will be Europe's largest battery plant. This project has been made possible by an investment of €500 million, and aims at assembling batteries for Mercedes-Maybach vehicles, as well as household stationary storage, using cells provided by the Korean company LG Chem.³⁶ In justifying this choice, Daimler-Benz's CEO indicated in early 2016 that the market should reach such a level of overcapacity that cells today should be seen as simple commodities.³⁷ Nevertheless, this approach involves giving up on a non-negligible part of the value chain because even if the share cost of cells in batteries varies strongly depending on their use, it will nevertheless be about 60% for batteries powering electronic vehicles.

Another option would be to invest in the whole of the value chain, including cells, while focusing on differentiation. Lithium-ion technology should remain dominant at least until 2025 (EC, 2016). But improvements in materials used could be essential. From this point of view, it should be stressed that safety is becoming an increasingly important issue, especially since the problems which affected the Galaxy Note 7 smartphone developed by Samsung Electronics. Accordingly, a winning strategy could be to give even greater importance to this criterion compared to that of energy density, by focusing for example on solid electrolytes and organic solvents. Similarly, environmental criteria can be defended by improving the recyclability of batteries offered or even by guaranteeing a supply of low carbon electricity for factories producing European batteries. Over the longer term, the issue will be for Europe to position itself in technologies that can compete with lithium-ion, such as lithium-air, by actively supporting Europe's network of research centers and facilitating partnerships with industrial companies. In this case, the competitive race with other regions in the world shifts towards R&D.

36. M. Kane, "Daimler Breaks Ground on Tesla-Like Battery Gigafactory in Europe", *Inside EVs*, 23 May 2017, available at: <http://insideevs.com>.

37. C. Hetzner, "Daimler Declines to Invest in Battery Cell Production", *Autonews*, 25 February 2016, available at: <http://europe.autonews.com>.

Finally, Europe can opt for a genuine industrial ambition in the field of batteries and provide the means to compete fully with existing supply, by also encouraging investment in manufacturing capacity. Saft, which is currently Europe's largest manufacturer of lithium-ion cells, could aim at extending its activities into mass markets because since 2016 it has been supported by a new parent company, the Total group. The latter has sufficient financial resources to accompany the development of Saft and especially finance the expansion of its output capacities. Two former Tesla employees, Peter Carlsson and Paolo Cerruti, have also launched a construction project for what could be Europe's largest battery production plant, with an output capacity that will be 32 GWh by 2023. This project was announced in early 2017, and will go ahead if it manages to federate sufficient industrial and institutional investors. The official target is to raise €2 billion in equity to cover half the financing costs of the project. The other half will be provided by debt, including the issue of green bonds and possible support by the European Investment Bank. The young firm Northvolt based in Stockholm has already actively publicized the products and solutions it intends to offer, with the idea of getting contracts to supply volumes greater than 250 MWh/year. This would demonstrate the commercial solidity of its project. At this stage, the main constraint seems to be time, given that only €14 million in equity were collected by March 2017, while launching production in 2020 seems very ambitious for a new player in the battery market. This is especially so if indeed it is confirmed that Northvolt is not looking for a partnership with a cell manufacturer, along the lines of the Tesla-Panasonic or Daimler-Benz-LG Chem alliances. A similar initiative has also been launched in Germany, with the creation in the spring of 2017 of the Terra-E company, whose main shareholders include the German manufacturer of batteries BMZ. Terra-E aims to produce 34 GWh in cells by 2028 and should draw on the results of the "Giga-LIB" research program, supported by the federal government to the tune of €5 million. This program's aim was to establish a manufacturing model for lithium-ion cells which is fully automated and energy-efficient. Here again, finance remains the principal challenge for the actual implementation of the project.³⁸

38. E. Terra, "Terra E plant Bau von Giga-Fabrik für Lithium-Ionen Zellen in Deutschland", press release, 22 May 2017, available at: www.bmz-group.com.

The role of the EU and the role of Member States

Competition at the global level is strong, while Europe's supply possibilities are at the forefront especially for complex solutions and downstream activities in the battery sector. But, its position is incomplete and above all undersized to conquer the new mass markets of mobile electricity and stationary storage. The concept of an "Energy Airbus", which has regularly been defended by European politicians but so far remains inoperative, could find a welcome expression here. Indeed, the relative weakness of Europe's industrial base justifies concerted efforts, or even the structuring of a truly unified production chain at the EU level, bringing together know-how for the whole value chain. Yet, such a project is eminently complex to implement because industrial players and Member States may all fear that while consolidation is relevant to the Union, its advantages will be unequally distributed geographically. The key issue therefore is to define the right level of integration, ranging from the constitution of a simple network or European "eco-system" through to full industrial consolidation.

Even before deciding this issue, the EU should have a coherent strategy for deploying batteries across its territory. To be sure, the EU has for long financed research and development, with a total of 140 projects at different levels of the value chain having received support from the FP7 and Horizon 2020 programs (EC, 2017a). The 2006 Batteries Directive also defined common standards, especially in terms of recyclability, while the 7th key action of the new European Strategic Energy Technology Plan (SET Plan 2015) targets new improvements in performance and in costs to ensure the competitiveness of Europe's battery supplies. In addition, European legislators have urged Member States to develop the market for electric vehicles and related infrastructure, in particular through Directive 2014/94 /EU. Now they are actively seeking to facilitate the participation of storage installations in different energy markets and the services of the electricity grid, notably through the new Clean Energy Package. In this way, the EU is encouraging the creation of a sufficiently large pool of demand and promoting its coherence by limiting regulatory gaps. While welcoming these various initiatives, the European Battery Manufacturers' Association, EUROBAT, nevertheless considered it useful in February 2017 to call for the development of a genuine European strategy for batteries through to 2030 (EUROBAT, 2017). Two issues are at stake. First, it must be recognized that this technology creates bridges between the energy and transport sectors and so requires a cross-cutting vision. Second, the development of demand and the creation of sufficient European supply to

feed the European market and then use it as a showcase to conquer export markets should be considered jointly.

Awareness of the industrial issues at stake is gaining momentum among European decision-makers. In France, the *Nouvelle France Industrielle* initiative, which aims to help French companies position themselves in the markets of the future, has identified electrochemical batteries as one of 47 key technologies for 2020 (French Ministry of the Economy, 2016). At a time when this initiative is split up into different roadmaps, new orientations have been defined to support the French battery industry. For stationary storage, these include notably the adoption of a deployment target – the installation of 1.5 GW of storage in France by 2023 – but also the creation of a “French storage sector” label which could provide access to specific subsidies and constitute a competitive advantage in tendering, insofar as this label would be seen as a quality guarantee in terms of performance, recycling or safety (French Ministry of the Economy, 2017). In Germany, the “Giga-LIB” project mentioned above is part of a broader research program called “Battery 2020”. It has received €60 million in public aid and officially targets the improvement of materials and processes to establish an industrial base for manufacturing cells in Germany.³⁹ The United Kingdom is also intending to assert its leadership in the battery sector, which was identified as a priority in the new industrial strategy of Theresa May’s government published in January 2017 (UK Government, 2017). The creation of a new research institute is under consideration to ensure closer collaboration between the various academic and industrial players in the sector. Finally, at the European level, the “strategic interest” of batteries has been recognized and the Commission has expressed its intention to “support initiatives taken by industry to contribute to the creation of a complete value chain in the Union which can be used for mobility and other applications” (EC, 2017b).

The EU seems at last to be ready to discuss openly the various industrial options available to it, and the Union has every interest in organizing these exchanges as soon as possible, so that Member States do not proceed in a disorganized way. As mentioned above, the giants of the battery industry are all targeting the European continent for the installation of new production capacities. Enthusiastic about the potential for job creation, Member States are courting these major players by promising more favorable conditions than their neighbors. By going in for dumping or other protectionist measures strictly confined to national

39. Bundesministerium für Bildung und Forschung, “Forschung zu Batteriefertigung”, press release, 15 June 2015, available at: www.bmbf.de.

territories, European capitals could deprive themselves of a coherent European industrial strategy, which is equitable and which is also the only guarantor of their long-term interests.

Conclusion

Unsurprisingly, the launch of a global transition to low carbon is giving rise to new industrial battles. The climate constraint will require transforming whole sectors of the economy, leading to new needs and translating into new business opportunities. The race to electric batteries is even virtuous from an environmental point of view. States and industry seem to be convinced that the future lies in electric mobility and renewable electricity generation, so they consider it appropriate to engage now in the battle to capture a significant share of demand as it is materializing. This confrontation is useful insofar as these massive investments will lead to improvements in performance and costs, which in turn will facilitate the deployment of batteries that no longer depend on public support mechanisms.

Nevertheless, from citizens' point of view, it is also legitimate that the promise of a low-carbon transition which generates new wealth and new jobs is indeed fulfilled. If technological solutions are exclusively imported, then the low-carbon transition could lose its popular support. It could also lead to a new form of external dependence that would be synonymous with vulnerability. The most obvious temptation would then be to partition the national markets. Yet this risks slowing down the momentum of global innovation and fueling a trade war that seems unwelcome, given a geopolitical context which is already particularly tense.

Europe faces a major challenge. It must imperatively concern itself with the industrial dimension of its low-carbon transition, firstly by taking note of the efforts made by the competing regions seeking to provide the best opportunities to their industries and by aligning itself in part with these practices, if only by asserting environmental and safety standards that legitimately promote European supply capacity. In the battery segment, Europe's position in global competition very clearly favors concerted action, or even the pooling of efforts between Member States. Given the forecast of new manufacturing capacity, it already seems late to react. Nevertheless, the Union has strong assets, in particular its robust academic and industrial players in electrochemistry, energy and the automobile industry. They have the expertise to formulate jointly an effective response, if they are encouraged politically, but also from a regulatory and financial point of view.

Other competing regions in the world also have some weaknesses. Japan and Korea have much smaller domestic markets than Europe. China is impressive in terms of the dynamism of its demand and the very rapid growth of its production capacities. But it still lags behind in the quality of its products, which hampers its export potential for complete battery systems. Finally, the United States is going through a turbulent political period and its disengagement from the Paris climate agreement is sending its domestic industry a bad signal, even if individual states and cities are seeking to compensate the dismantling of federal legislation. At a time when European capitals seem to be more aware of what brings them together and distinguishes them from the rest of the world, the EU has a unique opportunity to be bold and break partially with its “market forces only” dogma, in order to encourage the assertion of genuine industrial leadership in the field of batteries.

Annexes

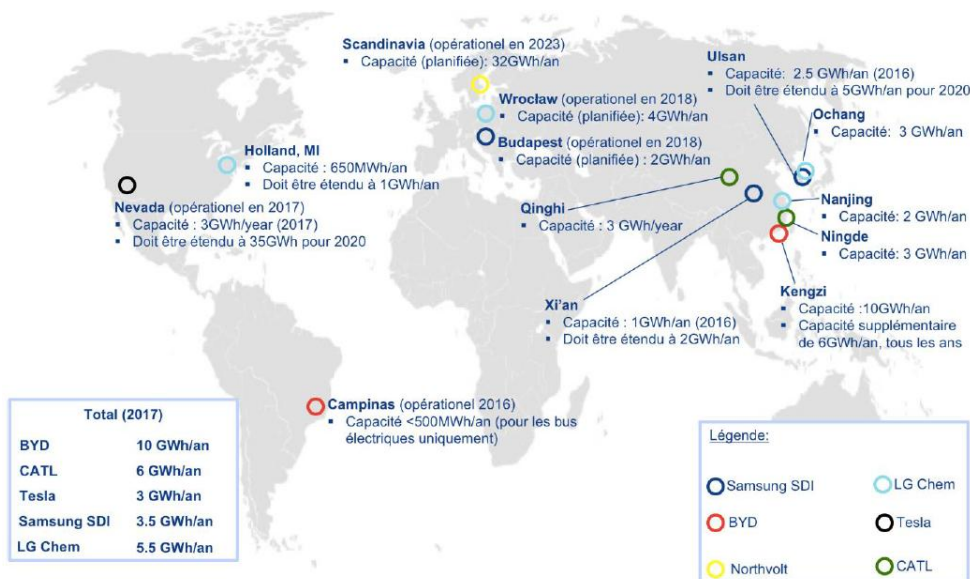
Annexe 1: Market Shares by Main Manufacturers of Lithium-ion Battery Cells in 2015

Company	Market volume in 2015, million cells	Company	Market value in 2015, million US \$
Samsung SDI	1376	Samsung SDI	3000
LG Chem	1008	LG Chem	2530
SONY	490	ATL	1490
ATL	465	Sanyo-	1125
Tesla	430	BYD	1120
Sanyo-	408	SONY	1040
Lishen	290	Tesla	970
Coslight	185	Lishen	850
BYD	180	NEC	520
Maxell	76	Coslight	450
BAK	67	GS Yuasa	210
Other	625	Other	3395
Total	5600	Total	16700

The left-hand column refers to sales volumes, and the right hand column to market value.

Source: European Commission (2016), Lithium-ion battery value chain and related opportunities for Europe, JRC Science for Policy Report, using data from Avicenne Energ.

Annex 2: Production Capacities of Lithium-ion Batteries for Electric Vehicles and Stationary Storage by Market Leaders



Source: French Ministry of Economy (2017), Plan Stockage de l'Énergie de la Nouvelle France Industrielle – Feuille de route stockage stationnaire pour les énergies renouvelables.

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