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Green Batteries: A Competitive Advantage for Europe's Electric Vehicle Value Chain?

Carole MATHIEU

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Ifri

27 rue de la Procession 75740 Paris Cedex 15 – FRANCE

Tel.: +33 (0)1 40 61 60 00 – Fax: +33 (0)1 40 61 60 60

Email: accueil@ifri.org

Website: Ifri.org

Author

Carole Mathieu is a Researcher and Head of European policies at the Ifri Centre for Energy & Climate. Her research areas primarily cover decarbonization policies and the transformation of energy systems, network regulation and security of supply. Prior to joining Ifri, she was a Policy Officer at the French Energy Regulatory Commission (2010-2014), in charge of access rules to cross-border interconnectors and investment procedures. Holding a Master's degree in Public Administration – Energy from Sciences Po Paris, Carole Mathieu has also studied at Boston College (Massachusetts, U.S.).

Executive summary

On 10 December 2020, the European Commission (EC) proposed a new Batteries Regulation setting out sustainability requirements for the whole life-cycle of rechargeable industrial and electric vehicle (EV) batteries, from the extraction of raw materials to end-of-life management. This pioneering initiative would kill two birds in one stone: ensuring that the massive roll-out of EVs fits with Europe's climate neutrality and resource efficiency pledges, while giving European new entrants a better chance to challenge the leadership of Asian incumbents on the basis of green differentiation strategies.

The wave of investments in battery cell manufacturing projects suggests that the worst-case scenario of Europe subsidizing massive battery cell imports will not materialize. Cell manufacturers have a direct commercial interest in setting up operations closer to the European automakers' EV assembly factories, and Member States can provide an additional argument for local cell production with their large financial support for EU-based industrial projects. However, strategic autonomy remains a distant dream, as most confirmed projects are being developed by non-EU stakeholders. In addition, Europe has not yet managed to attract corresponding investments in the manufacturing of battery cell components, while its very limited control on raw material supply chains does not match its political aspirations.

The lack of consensual calculation methodologies makes it almost impossible for manufacturers to substantiate their green claims, especially with regards to carbon footprints. Yet, the life-cycle assessment (LCA) literature points to cell and active material manufacturing as key climate hotspots. Efforts should concentrate on reducing energy consumption for these critical production steps and covering incompressible needs with grid-based or contract-based low-carbon electricity, provided the latter option guarantees the additionality of renewable electricity supplies. In addition, the extraction and refining of raw materials offer the second largest and mostly untapped potential for green differentiation, especially when combining climate and local environmental impact considerations.

Ultimately, manufacturing green batteries does not require locating all production steps in Europe, but European players may have a competitive edge thanks to their expertise in measuring and improving the sustainability of their operations. In addition, reducing the environmental footprint of products requires a holistic view of supply chain management, which pleads for building closer ties between industrial stakeholders.

Should the Batteries Regulation retain an ambitious timeframe for information and labelling requirements, it could be a game changer for the European EV market. The methodological and practical challenges should not be underestimated, but the best way to obtain robust implementation rules is to engage the industry in the drafting process. If the EU legislator confirms that customers should be able to compare the environmental performance of EV batteries as of 2023, companies should see the urgency of sharing their knowledge with the EC, and Member States will allocate appropriate resources to enforcement procedures. Likewise, the political signal will encourage EU automakers to place greater focus on sustainability in their ongoing supplier selection processes, instead of waiting for future industrial cycles. The Batteries Regulation is not just about the EV value chain, it is an opportunity to demonstrate the high potential of Europe's green industrial policy, delivering consumer trust, jobs, and strategic autonomy.

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Introduction

In the EU, 2020 will be remembered as the year when sales of plug-in EVs finally took off. Despite the pandemic hindering the automotive supply and distribution chains, and though the passenger car market contracted by a record 23.7%, combined registrations of battery electric vehicles (BEV) and plug-in hybrids (PHEV) jumped from 387,808 units in 2019 to 1,045,831 units in 2020 (+117.4% for BEVs, +262.3% for PHEVs).[1] In terms of market share, the EV segment reached 10.5% of volume sales, compared to just 3% the year before, suggesting that the coming years will finally see a massive switch from the internal combustion engine (ICE) to electric powertrains.

The stars are fully aligned for European customers to embrace electric mobility. Over the past years, the global industrial race has brought EVs closer to cost-competitiveness, while advances in energy density and fast charging capability have eased range concerns, without compromising the safety and durability of battery products. From 2020/2021, the EU has applied a sharply reduced fleet-wide emission standard of 95 gCO_2/km (grams CO_2 per kilometer), leaving conventional automakers no other choice than to undertake massive investments in electric mobility, to roll out dozens of new models and market them effectively. On top of this, post-COVID 19 green recovery strategies have emerged, with generous purchase incentives for zero-emission vehicles and large investment support for public charging infrastructures. From the customer perspective, the EV option has become increasingly attractive at a time when the owners of ICE cars face growing taxation and access restriction in urban areas. With the EU recently committing to reach a net emission reduction of -55% by 2030, a new decarbonization push is on the political agenda and more stringent post-2020 CO_2 standards will follow. The EV revolution is now bound to pick up pace.

But in this rosy outlook, the main challenge for the EV industry could be to preserve customer trust with regards to the genuine environmental performance of their products. Independent research does confirm that using EVs in the EU saves on average 55% of CO_2 emissions compared to gasoline ICEs on a life-cycle basis (-75% in Sweden and -17% in Poland), and that the overall environmental

1. ACEA, "Statistics – Registration Figures", accessed February 1, 2021, available at: www.acea.be.

impact – including resource use in production – is less significant.[2] Yet, there is persistent confusion in the public debate, partly resulting from car manufacturers' isolated attempts to slow down electrification and push for alternative solutions,[3] and partly from non-governmental organizations and media investigations warning about the rise of a new dependance on mineral raw materials extracted in unethical and environmentally unacceptable conditions.[4] In this controversial debate, the only valid conclusion is that EVs have a better overall performance compared to ICEs; but – as with most products we use – they do have a harmful CO_2 impact, and they do imply a significant use of mineral and metal resources. Their carbon footprint mainly results from one stage of the product life-cycle: manufacturing. For example, for a Polestar 2 EV model powered by the average EU28 electricity mix, the production phase accounts for 62.4% of total CO_2 life-cycle impact.[5] If the EU's ambition is to decouple growth from resource use and achieve climate-neutrality,[6] then the next imperative is to improve the sustainability of battery manufacturing and end-of-life management.

The EU is taking up this challenge by introducing the first-ever product legislation with sustainability requirements covering the whole life-cycle of rechargeable industrial and EV batteries. Published in December 2020,[7] the new Batteries Regulation proposal covers four interrelated environmental and social challenges: the responsible sourcing of raw materials, the carbon footprint of battery products, their performance and durability, and finally their repurposing and recycling. Innovative in scope, the new legislation adopts a careful step-wise approach, starting with the mandatory declaration of key metrics (e.g. carbon footprint, durability, recycled content) for all batteries sold into the EU market. This framework will be completed with EC delegated acts introducing performance classes and obligatory thresholds, leaving enough time to solve the remaining methodological challenges and ensure the sufficient buy-in from the industry.

2. Ricardo Energy and Environment, *Determining the Environmental Impacts of Conventional and Alternatively Fueled Vehicles through LCA*, Final report to the European Commission, July 1, 2020, available at: https://op.europa.eu.

3. P. Ward, "New Report Questions Government's 2030 Ban", *Autocar*, November 27, 2020, available at: www.autocar.co.uk.

4. O. Balch, "The Curse of 'White Oil': Electric Vehicles' Dirty Secret", *The Guardian*, December 8, 2020, available at: www.theguardian.com.

5. Polestar, *Polestar 2 LCA report*, September 2020, available at: https://about.polestar.com, Volvo, *Carbon Footprint Report – Battery Electric XC40 Recharge and the XC40 ICE*, July 2020, available at: https://about.polestar.com.

6. European Commission, *The European Green Deal*, Communication COM/2019/640 final, December 11, 2019, available at: https://eur-lex.europa.eu.

7. European Commission, "Proposal for a Regulation Concerning Batteries and Waste Batteries, repealing Directive 2006/66/EC and amending Regulation 2019/1020", COM(2020) 798/3, December 10, 2020, available at: https://ec.europa.eu.

A lot is at play with this new Batteries Regulation, on both the environmental and industrial fronts. As identified in the 2018 Strategic Action Plan on Batteries,[8] incentivizing sustainability along the value chain is also an opportunity to reshuffle the cards in market competition. Implicitly, the EU has high hopes that the environmental requirements will come with an economic co-benefit, as the attractiveness of batteries produced locally and/or by green-minded EU manufacturers should be improved. Looking further ahead, the EU may also claim to set the trend, spread its norms at a global scale and thus give EU players a prime-mover advantage. The bet is audacious because side-effects may also include hampering innovation or increasing manufacturing costs to such an extent that it would affect sales dynamics and slow down the decarbonization of road transport.

In the context of the Green Deal negotiations, this study looks at how Europe competes in the global EV battery industry and assesses progress made since the launch of the European Battery Alliance in 2017. The second chapter assesses how the quest for sustainability can impact industrial projects targeting the European EV market, while the last chapter identifies under what conditions the legislative proposal can best contribute to both the environmental imperative and the successful renewal of the EU's industry strategy.

8. European Commission, "Strategic Action Plan on Batteries, Annex 2 to the Communication Europe on the Move", May 17, 2018, available at: https://ec.europa.eu.

Confronting political aspirations with industrial realities: how European is the EV battery value chain?

The shift to electric mobility catalyzes most of the EU's strategic concerns with regards to the transition to climate neutrality. Failing to secure Europe's position in the EV value chain could mean putting at risk the 2.7 million direct manufacturing jobs the automotive sector currently provides[9] and accelerating further the EU's industrial decline. Moreover, replacing ICEs by EVs may lead to substituting a dependency on imported fossil fuels with a dependency on lithium-ion battery cells. These make up to 70% of the battery pack price, which itself accounts for 30-40% of the EV price. This sector is currently dominated by an oligopoly of Asian competitors, with Chinese CATL, Japanese Panasonic, Korean LG Chem and Chinese BYD accounting for 75% of the battery cell market at the end of 2020.[10]

In addition to technology dependence, Europe would also run the risk of being excessively exposed to a raw material supply chain largely controlled by Chinese mining and refining operators. For instance, China is responsible for around two-thirds of global natural graphite supplies, and the processing of graphite into battery grade products is almost entirely performed in China.[11] With regards to lithium, China is only the third largest producer (7% of global capacities), but its domestic companies account for 23% of global lithium production and are currently investing in 20 lithium mining projects abroad, while China accounts for 80% of the world's lithium hydroxide production.[12] Likewise, China controls 40% of the cobalt production in Democratic Republic of Congo (DRC), which provides 70% of global supplies, while China is also responsible for 80% of the

9. ACEA, "Statistics – Direct Automotive Manufacturing jobs in the EU, by Country", August 1, 2020, available at: www.acea.be.

10. S. Inagaki, Yano Research Institute, "Presentation at the European Conference on Batteries", December 10, 2020.

11. Deutsche Rohrstoffagentur, *Supply and Demand of Natural Graphite*, July 2020, available at: www.deutsche-rohstoffagentur.de.

12. *Mining.com* Editor, "China's Grip on Battery Metals Supply Chain", May 7, 2020, available at: www.mining.com.

global output for cobalt sulphate and oxide.[13] While the EV race raises concerns over potential supply shortages of battery metals and in particular nickel, Chinese companies are also by far the most active players in overseas mining investment projects, especially in the top-two nickel producing countries, Indonesia and the Philippines.[14] Eventually, these structural weaknesses on the supply side undermine the relevance of Europe's financial support on the EV demand side.

EV batteries: an experimental field for Europe's industrial policy 2.0

Back in October 2017, the EC decided to address these concerns and launched the European Battery Alliance (EBA) with the very clear ambition of putting Europe on the map of the global EV battery industry. Under the direct leadership of Commission Vice-President Maroš Šefčovič and with unanimous political support from Member States, the 2018 Strategic Action Plan on batteries has followed a fast-track implementation procedure. The EU is shifting from a sectoral to a value chain approach and the political stakes are high because the EBA is seen as an opportunity to showcase Europe's 21st century industrial policy. If successful, it could provide a ready-to-use blueprint for other strategic industries in the low-carbon and digital transitions.

The EBA has achieved remarkable results in promoting industrial partnerships along the value chain and most importantly in mobilizing public funding to trigger investment decisions, with a clear focus on cell manufacturing capacities. To date, close to €10 billion of grants and preferential loans have been awarded to both European and non-European project promoters, including American Tesla or South Korean LG Chem. Further progress is required in strengthening the availability of relevant skilled workforce in a context in which Europe has a limited background in battery manufacturing and no experience of scaling up high-volume manufacturing. Founded in 2017, Swedish battery company Northvolt employed 50 people at the end of 2020 and it plans to have 500 employees to start operating the Skellefteå factory at the end of 2021, 1500 in 2023 and 3000 in 2025.[15] To bridge the competitiveness gap with Asian incumbents, another pressing challenge is to facilitate access to raw materials at reasonable costs, knowing that material costs contribute to least 60% of the total costs of cathodes for

13. Roskill, *Cobalt Market Outlook 2030*, October 2020, available at: https://roskill.com.
14. J. McBeth, "China Building Indonesia into an EV Powerhouse", *Asia Times*, February 4, 2021, available at: https://asiatimes.com.
15. K. Borstedt, Northvolt, "Presentation at Albatts Battery Cell Manufacturing Workshop", January 2021, available at: www.project-albatts.eu.

example, the most expensive component of the battery cell.[16] Such concern is expected to grow as the supply-demand balances of battery metals have tightened considerably over the last year.[17] While established battery component manufacturers have already secured long-term deals for their raw material supplies, the surge in market prices may create an additional barrier to entry for potential new entrants. On both the skills and raw material fronts, the EU initiatives date back to only 2019/2020, and the efforts are likely to pay off in a couple of years, at best.

Table 1: Main EU-led initiatives to support sustainable battery production in Europe

Build-up of a European ecosystem	**EBA250**	**Managed by EIT InnoEnergy, the EBA250 collaborating network gathers more than 500 members involving industrial, financial, academic stakeholders and public authorities.**
	EBA Business Investment Platform	Online platform launched by EIT Innoenergy to accelerate transactions between European investees and investors along the battery value chain.
Research and Innovation (R&I)	Horizon 2020/Europe	In 2020, the EU R&I program dedicated an overall budget of €132 million to the development and production of next generation batteries in Europe. This came after a similar call of €114 million launched in 2019.
	Battery 2030+	Based on a long-term research roadmap,[18] the implementation of the Battery 2030+ initiative started in Sept. 2020, focusing on 7 projects benefiting altogether from a €40.5 million Horizon Europe support over three years.
	ETIP Battery	Supported by the EC, the European Technology and Innovation Platform (ETIP) has drawn on industry expertise to define a strategic agenda for short to medium-term R&I actions in established research programs (Strategic Energy Technology Action Plan & Strategic Transport and Innovation Agenda).[19]
Financing	EIB	The European Investment Bank (EIB) committed to increase its backing of battery-related projects to more than €1 billion of financing in 2020, which includes a €480 million loan for LG Chem's battery cell and module plant in Poland, a €125 million loan for Umicore's cathode plant in Poland and a €350 million loan for Northvolt's battery cell plant in Sweden.
	EBRD	The European Bank for Reconstruction and Development (EBRD) is also providing preferential loans for battery manufacturing (LG Chem cell plant & Johnson Matthey cathode plant) and recycling projects (Elemental) in Poland.

16. M. Wentker, M. Greenwood and J. Leker, *A Bottom-Up Approach to Lithium-Ion Battery Cost Modeling with a Focus on Cathode Active Materials*, *Energies*, February 5, 2019, available at: www.researchgate.net.

17. F. Els, "EV Metal Index Beats Record by 54% as Electric Cars Reach Tipping Point", *Mining.com*, February 10, 2021, available at: www.mining.com.

18. BATTERY 2030+, *Battery 2030+ Roadmap*, March 27, 2020, available at: https://battery2030.eu.

19. European Technology and Innovation Platform on Batteries – Batteries Europe, *Strategic Research Agenda for Batteries*, December 4, 2020, available at: https://ec.europa.eu.

	IPCEI/Approved State aids	In line with EU State aid rules, two Important Projects of Common European Interest (IPCEI) have been approved by the EC: • 1st IPCEI approved in Dec. 2019,[20] coordinated by France and involving seven Member States providing up to €3.2 billion in public funding to 17 participants, including battery cell manufacturer ACC. The non-confidential version of the EC decision has not been published to date, so the exact distribution of funding is not public knowledge. • 2nd IPCEI approved in Jan. 2021,[21] coordinated by Germany and involving 12 Member States providing up to €2.9 billion in public funding to 42 participants, including battery cell manufacturers Northvolt and Tesla. The non-confidential version of the EC's decision has not been published to date, so the exact distribution of funding is not public knowledge. Overall, Germany is the largest financial contributor (€1.25 billion for the 1st IPCEI + €1.6 billion for the 2nd IPCEI), while France is second (€960m for the 1st IPCEI). In addition to IPCEIs, additional State aid measures targeting the battery industry have been approved by the EC, including: • €36 million Polish investment aid to LG Chem for the launch of its battery cell plant, approved in Jan. 2019. • €46.5 million Hungarian investment aid to Toray for its battery separator film plant, approved in July 2020. Other State aid measures have been notified by Poland for Johnson Matthey cathode manufacturing plant (PLN 42.7072 million) and SK Innovation separator plant (PLN 47.5668 million), but the EC's approval is pending. Finally, the EC has opened investigations on two state aid packages notified by Poland for the extension of LG battery cell plant (€95 million) and by Hungary for the extension of Samsung SDI's battery cell plant (€110 million). In both cases, the EC has raised doubts about the existence of a real viability gap between the projects' location and the non-EU alternative.
Skills	ALBATTS	4-year program launched in 2020, co-funded by the Erasmus+ Programme and aiming at better coordinating the demand and supply side of skills/competences relating to batteries.
Access to raw materials	ERMA	Launched in Sept. 2020 and funded by the EU, the European Raw Material Alliance (ERMA) is a new collaborative network gathering over 300 partners from industry, research, government and civil society. Mirroring the EBA approach, its objective is to identify barriers, opportunities and investment cases to build EU capacity at all stages of the raw material value chain, from mining to waste recovery. The first two clusters will focus on rare earth magnets & motors and materials for energy storage and conversion.

20. European Commission, "State aid: Commission approves €3.2 billions publics support by seven Member States for a pan-European research and innovation project in all segments of the battery value chain", *Press release*, December 9, 2019, available at: https://ec.europa.eu.
21. European Commission, "State aid: Commission approves €2.9 billions publics support by twelve Member States for a second pan-European research and innovation project along the entire battery value chain", *Press release*, January 26, 2021, available at: https://ec.europa.eu.

The business case for investment in battery manufacturing in Europe

To date, the substantial investment in cell manufacturing capacity is the main achievement in Europe's quest for strategic autonomy in EV battery technology. By the end of 2020, the EU had reached an operational cell production capacity of around 50 GWh/yr (gigawatt hours per year), located mainly in Poland (LG Chem) and Hungary (SK Innovation & Samsung SDI). This capacity accounts for a mere 6.8% of the global 741.8 GWh/yr,[22] but still represents a slight improvement compared to the 3% share registered in 2017.[23]

Before the EU takes legislative action on sustainable manufacturing, the localization trend is already becoming a reality in the EV industry. Non-European EV manufacturers are setting up EV production lines in Europe to reduce their distance to customers, save costs and shorten delivery times. After Hyundai, Tesla decided not to launch its Model Y in Europe until the vehicle can be manufactured at its Berlin Gigafactory, set to start operation in mid-2021. EVs imports from non-EU countries (such as South Korea and the United-States) are thus expected to decline, and so are battery module and cell imports. Previously shipped from South Korea to Europe within a six-week delay, the cells used for Renault's ZOE and Audi's e-tron are now manufactured by the same player, LG Chem, but in the Wroclaw factory in Poland. And this option was also favored by VW for the launch of its ID.3 model in September 2020.

Table 2: Location of the key battery manufacturing steps for the top-5 EV models sold in Europe in 2020

	Battery pack	Module	Cells	Cathodes
Value added per step[24]	~30%	~25%	~50%	~40%
Renault ZOE	Renault, France	LG Chem, Poland	LG Chem, Poland	LG Chem, South Korea/Umicore, South Korea & China
Tesla Model 3	Tesla, California	Tesla, Nevada	Tesla-Panasonic, Nevada	Sumitomo Mining, Japan
Volkswagen ID.3	Volkswagen, Germany	Volkswagen, Germany	LG Chem, Poland	LG Chem, South Korea/Umicore, South Korea & China

22. Benchmark Mineral Intelligence, *Megafactory Tracker*, available at: www.benchmarkminerals.com.
23. M. Steen et al., *EU Competitiveness in Advanced Li-ion Batteries for E-Mobility and Stationary Storage Applications – Opportunities and Actions*, Joint Research Centre, 2017, available at: https://publications.jrc.ec.europa.eu.
24. V. Sharova *et al.*, *Evaluation of Lithium-Ion Battery Cell Value Chain*, Hans-Böckler Stiftung Working Paper, January 2020, available at: www.econstor.eu.

Hyundai Kona Electric*	Hyundai, Czech Republic (since March 2020)	Hyundai, Czech Republic	SK Innovation, Hungary	EcoPro, South Korea
Audi e-tron	Audi, Belgium	Audi, Belgium	LG Chem, Poland	LG Chem, South Korea/Umicore, South Korea & China

*Out of the 48,500 Kona Electric vehicles sold in Europe in 2020, 30,000 were manufactured in the Czech Republic factory, while the remaining 18,500 continued to be shipped from South Korea.

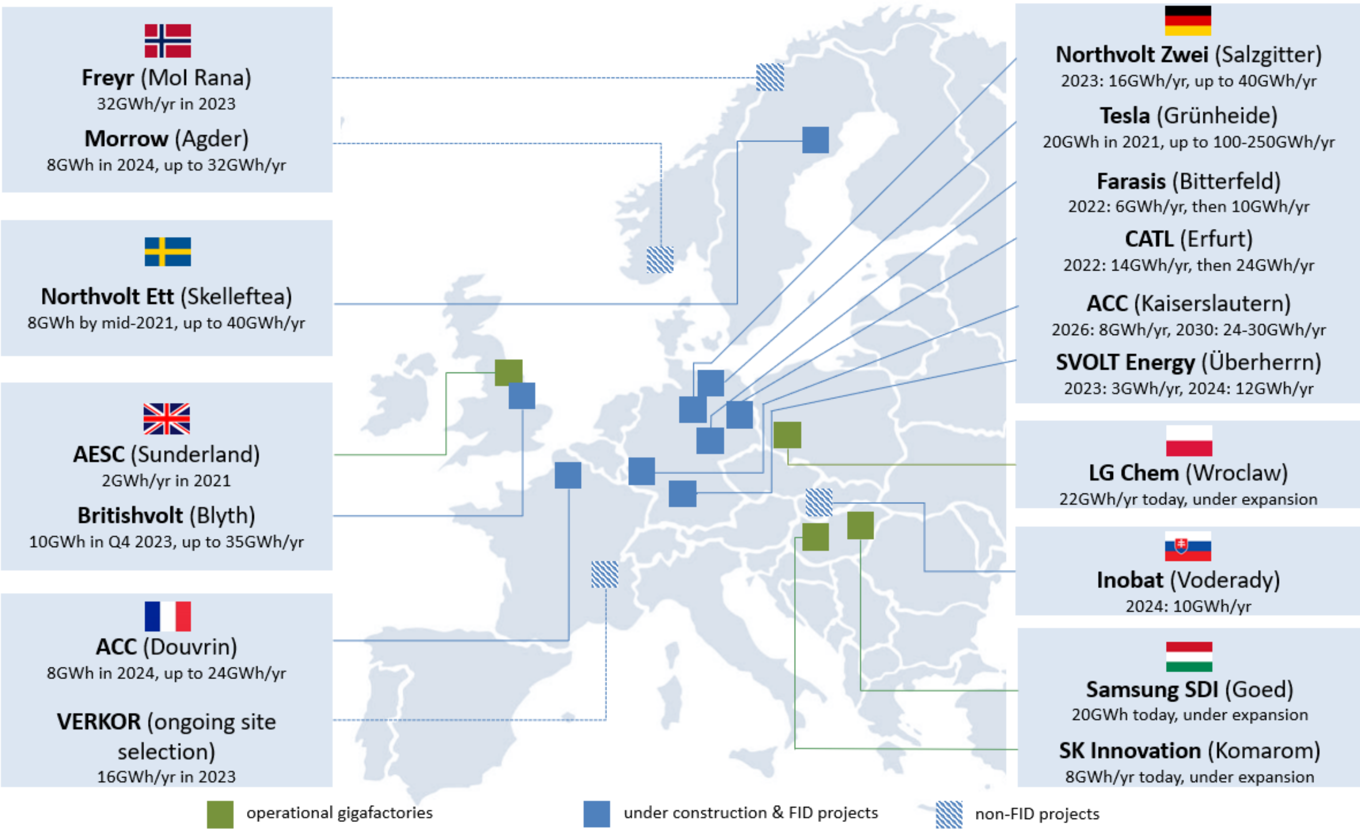
Source: Ifri, based on company announcements.

EVs are becoming so central in the strategies of automakers that considering battery cells as a simple commodity is not a viable strategy anymore. In this booming market, a precondition to gain market share is to secure timely, cost-competitive, and high-quality supplies of cells. This mindset shift seems even more relevant after the disruption caused by the recent shortage of semiconductors, providing a telling example of the fragility of automotive supply chains.[25] Here, economic rationale favors bringing cell/module suppliers closer to EV factories and the client base of original equipment manufacturers (OEMs), and of building closer business relationships, in the form of long-term off-take agreements, R&I partnerships and joint-ventures.

In Europe, two joint-ventures have been established to date: ACC, formed by French battery manufacturer Saft and PSA-Opel (participant in the 1st IPCEI), and Northvolt Zwei, formed by Swedish battery manufacturer Northvolt and Volkswagen (participant in the 2nd IPCEI). In addition, many of the leading Asian cell producers are currently developing large-scale cell manufacturing in Europe, including Chinese CATL, Farasis and SVOLT, while Tesla is also building its European Gigafactory in Germany. Meanwhile, established players, LG Chem, SK Innovation and Samsung SDI, are also expanding their production lines. More recently, other Europe-based companies, such as Norwegian FREYR, Finnish Morrow or French Verkor have announced plans to develop battery cell production by 2023-2025 and they are now in the process of securing the industrial partnerships and financing. Not all projects will be completed and/or meet the announced timelines and capacity targets. But a conservative assumption is that Europe will have a 350 GWh/yr production capacity by 2025. This would still represent only 14.9% of the global capacity forecast then,[26] but it would be enough to power 6.7 million EU-made EVs[27] and create around 22,000 direct jobs[28].

25. R. Diamond, "Opinion: With EV Future Ahead, Secure Crucial Supply Chains for Producing Them", *The Detroit News*, February 1, 2021, available at: https://eu.detroitnews.com.
26. Reference data from Benchmark Mineral Intelligence, *Presentation at ALBATTS workshop*, January 2021.
27. Calculation based on the assumption of an EV battery capacity of 52 kWh (compact cars).

Map 1: EV battery cell manufacturing projects in Europe



Source: Ifri, based on company announcements.

Taking stock of these investment flows, Vice-President Šefčovič claimed that the EU would likely be self-sufficient in battery cells by 2025,[29] but this will not be enough to guarantee the EU's strategic autonomy. What remains to be seen is whether European companies succeed in their unprecedented scale-up effort and manage to dispute the incumbents' leadership despite their lack of experience. A second open question is whether the localization trend will go beyond the level of cells. The next step for Europe is to move further upstream in the value chain, to cover the manufacturing of cells' subcomponents (cathodes, anodes, electrolytes and separators), and ultimately the raw material refining and extraction stages.

A long list of Asian electrolyte producers (Mitsubishi Chemicals, Tinci, GTHR, Central Glass, Soulbrain, Enchem and Capchem) have already established site in Europe (in Poland, Hungary and Czech Republic), for the precise reason that long-distance transport would

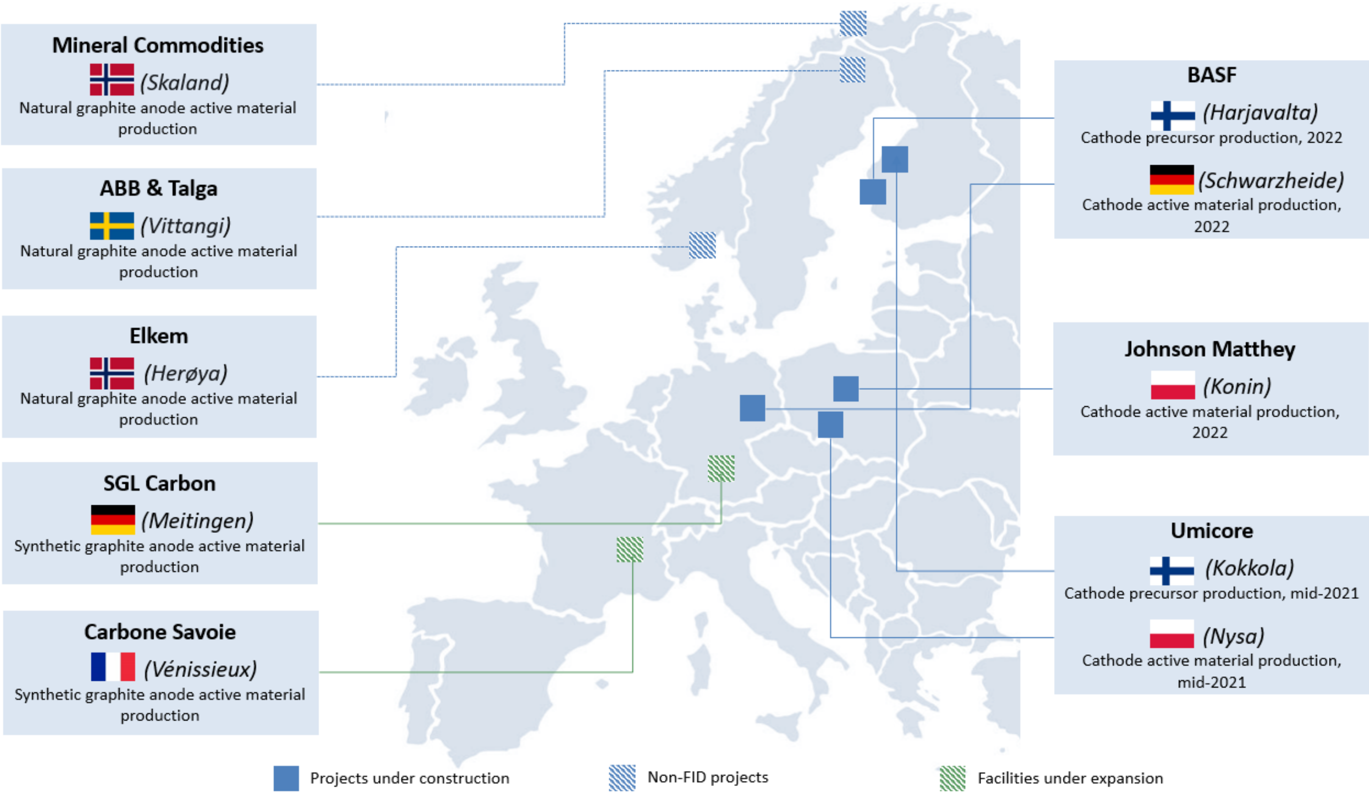
28. Calculation based on the assumption that operating a cell production capacity of 8 GWh/year requires 500 direct jobs.
29. K. Abnett, "EU Says It Could Be Self-sufficient in Electric Vehicle Batteries by 2025", *Reuters*, November 24, 2020, available at: www.reuters.com.

cause significant degradation to their products.[30] Separator producers such as SK ie technology, Toray and Shenzhen Senior Technology have followed the same path, not because of practical hurdles but to be able to respond quickly to their customers, the cell manufacturers.

With the ramp up of cell production volumes, cathode and anode manufacturers should be the next ones on the list to open factories in Europe and so avoid the six-week shipping period and associated costs. However, anodes and cathode active materials are the main metal-rich components of the battery cell, meaning that the advantage of proximity to market must be weighed up with the advantage of proximity to mineral sources. To date, only Belgian Umicore and German BASF, both participants to the 1st IPCEI, and British Johnson Matthey, recipient of Polish State aid and an EBRD loan, have announced investments in cathode manufacturing in Europe. Umicore's Polish plant will open by mid-2021 and it will use the cathode precursors manufactured in Umicore's newly acquired facilities in Finland, which also includes cobalt refining activities. Likewise, BASF's German plant will open in 2022 and it will use the cathode precursors that BASF will manufacture in Finland, on the doorstep of its refined nickel and cobalt provider Nornickel. Johnson Matthey has not yet unveiled the supply chain arrangements for its Polish cathode plant scheduled for 2024. While encouraging, these developments on the cathodes front will not be enough to meet the needs of the fast-growing cell production. And the outlook is not better for anodes, as no final investment decision investment has been reported yet. However, feasibility studies are on the way for at least three projects: Elkem is building a pilot plant in Norway and is currently assessing the prospects for a large-scale production unit (Northern Recharge), NMRC is also working on manufacturing project in Norway, close to existing graphite mining and refining facilities in Skaland, and ABB & Talga are jointly developing a third project in northern Sweden, where graphite mining and refining activities would also be developed. In addition, two manufacturers of synthetic graphite anode materials (Carbone Savoie and SGL Carbon) have received IPCEI public funding to expand their production base in France and Germany and serve the fast-growing EV battery market.

30. S. Inagaki, Yano Research Institute, "Presentation at the European Conference on Batteries", *op. cit.*

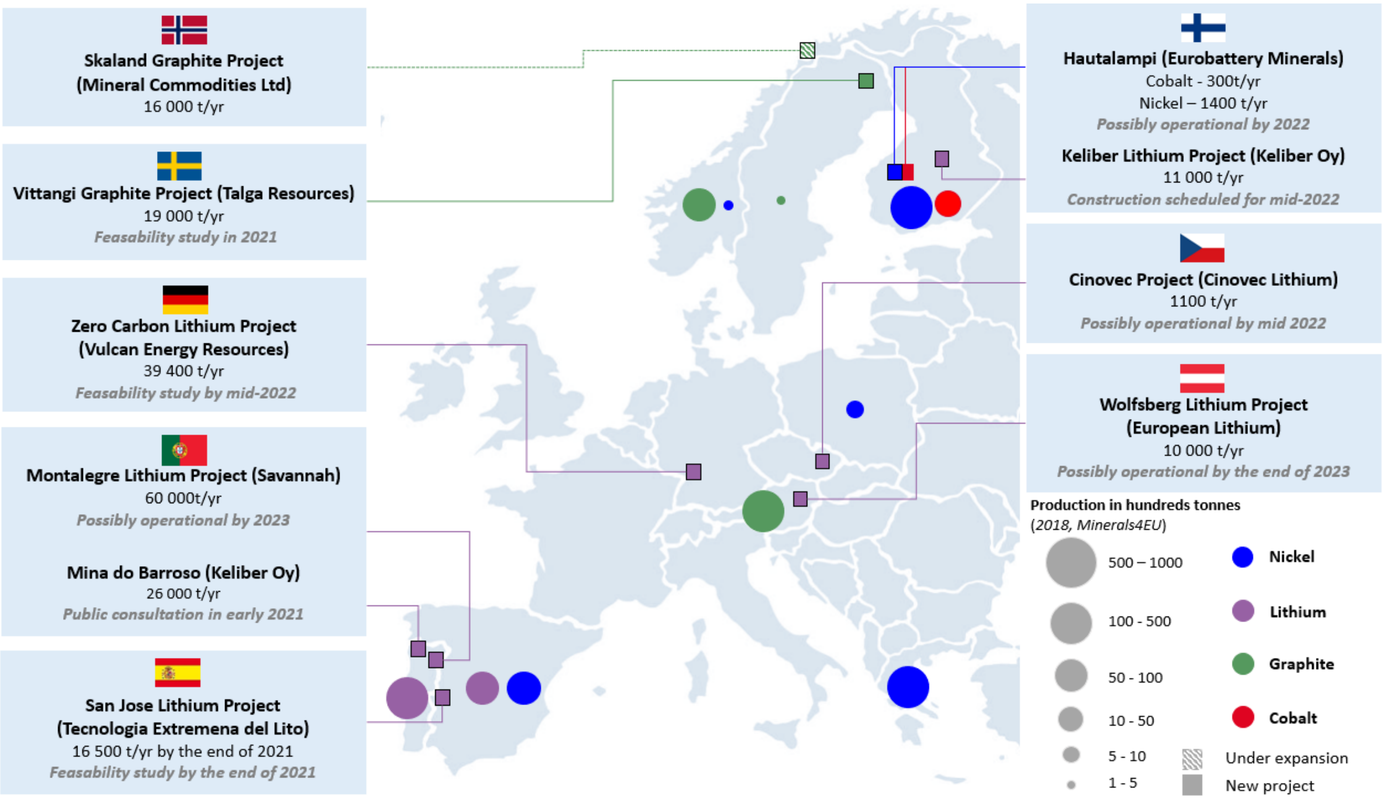
Map 2: EV battery cathode and anode active materials manufacturing projects in Europe



Source: Ifri, based on company announcements.

Most investments in cathode and natural graphite anode active materials are based on strategies to source the raw materials locally, at least partially. This approach means including the diversification potential that European raw material supplies can offer in the value proposition, as well as the environmental gains stemming from the application of more stringent local environmental regulations.

Map 3: Battery raw material production and investment projects in Europe



Source: Ifri, based on data from Minerals4EU[31] and company announcements.

31. Minerals Intelligence Network for Europe, "Minerals4EU Knowledge Data Platform", available at: http://minerals4eu.brgm-rec.fr.

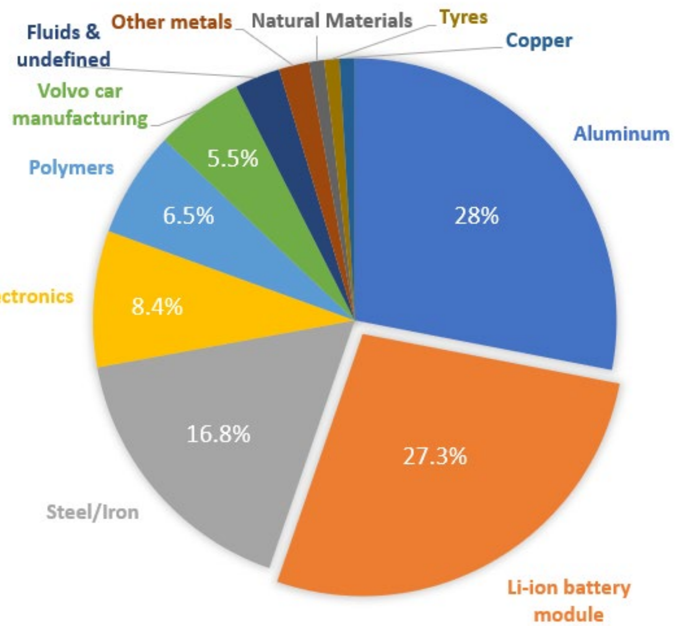
Localization and climate performance are not necessarily the perfect match

(Re)localizing production is widely seen as one of the best ways to improve environmental performance. Yet, this is not *a priori* the case for EV batteries. Thanks to the efficiency of maritime shipping, the long-distance transportation of active materials, cells or modules are considered to have a negligible environmental impact compared to the other factors.[32] In addition, unless we assume that the raw materials are sourced in Europe or come from European recycling activities, long-distance transportation in the production cycle is not avoided but rather shifted upstream. In fact, what makes Europe an attractive location for sustainable battery manufacturing projects is the availability of low-carbon energy sources and the application of a more stringent legislation on local air, water and soil pollution, waste management, biodiversity and landscape protection, as well as on workers' exposure to hazardous substances (etc.).

Focusing on the CO_2 footprint, Swedish Volvo and Polestar BEV manufacturers have provided the most comprehensive and publicly available assessment to date. Volvo's calculation shows that the lithium-ion battery module accounts for 27.3% (7 tCO_{2e} – tons CO_2 equivalent) of the embedded carbon emissions of its XC40 Recharge model, almost on par with the contribution from its aluminum content (28%).[33] However, the battery module remains a 'black box' in the EV LCAs. The suppliers (LG Chem and CATL) have performed their own analysis following Volvo's methodological guidelines, but only communicated the aggregated result with no details on the sub-steps of module production.

32. RECHARGE, *Product Environmental Footprint Category Rules for High Specific Energy Rechargeable Batteries for Mobile Applications*, February 2018, available at: https://ec.europa.eu.
33. Volvo, *Carbon footprint report – Battery Electric XC40 Recharge and the XC40 ICE*, April 20, 2020, available at: https://group.volvocars.com.

Graph 1: Distribution of the embedded CO_2 emissions of the Volvo XC 40 Recharge battery EV



Source: Ifri, based on Volvo LCA data.

In terms of per kWh of battery capacity, the carbon footprint will depend on the amount of energy used and its emissions-intensity, when considering all production steps of all components. The latest LCA literature review conducted in 2020[34] concluded that from 'cradle to gate' (excluding the use and end-of-life phases), lithium-ion battery packs for BEVs currently have a median carbon footprint value of 120 $kgCO_{2e}$ per kWh (25%-quantile–75%-quantile: 70–175 $kgCO_{2e}$/kWh). However, existing industry-average estimates face very strong limitations because they are based on scarce data from real operation and make a large use of modelling and proxy values that are quickly outdated in a rapidly changing industry.[35] Two thirds of the 50 publications covered in the 2020 review did not include any form of relevant primary data. The lack of accurate data makes it very complex, if not impossible, to compare the climate performance of individual battery cell/module manufacturers with benchmark players. This said, the LCA literature already provides reliable insights on which production steps should be given the greatest attention from a climate perspective. More precisely, available studies conclude that the manufacturing of cathodes, anodes and battery cells are the key

34. C. Aichberger and G. Jungmeier, "Environmental Life Cycle Impacts of Automotive Batteries Based on a Litterature Review", *Energies*, December 2020, available at: www.mdpi.com.

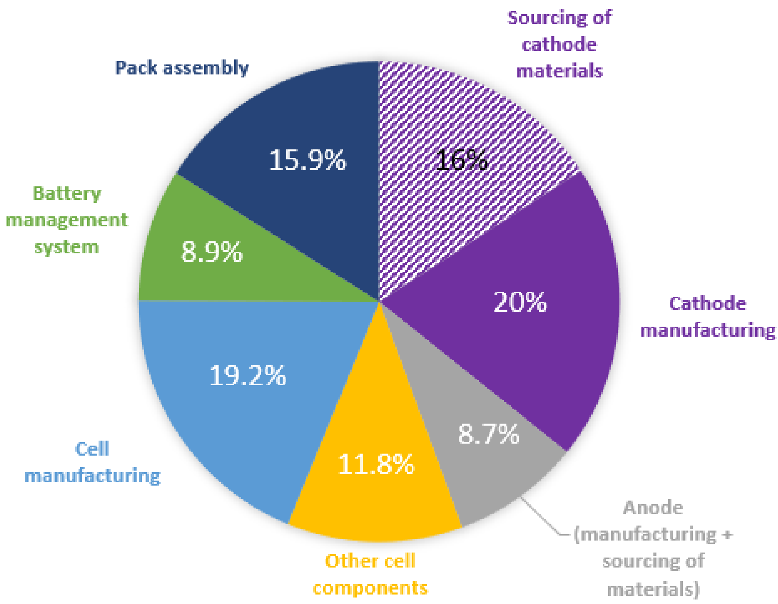
35. H. E. Melin, *Analysis of the Climate Impact of Lithium-ion Batteries and How to Measure It*, Circular Energy Storage, Transport and Environment, July 2019, available at: www.transportenvironment.org.

climate "hot spots" because of the large amounts of heat and electricity consumption required in the industrial processes.

Manufacturing green battery cells and active materials by minimizing energy consumption and favoring low-carbon electricity

In Argonne's 2018-2019 LCA study conducted for an NMC111 battery and based on data from real operation,[36] the cell production process itself represented 19.2% of the total energy used to manufacture the battery. Looking at the cells' subcomponents, the co-precipitation and calcination steps required to produce the NCM111 powder (cathode material) accounted for 20% of the total energy used to manufacture the battery, while the sourcing of the upstream cathode materials accounted for 16%. The production of the anode was found to contribute to another 9% of the total energy used, but the Argonne study gave no information on the relative weight of the sourcing step (mining and refining of graphite).

Graph 2: Distribution of energy consumption among the different steps of battery pack manufacturing



Source: Ifri, based on data from the Dai et al. *2019 study for an NCM111 battery pack, 2019.*

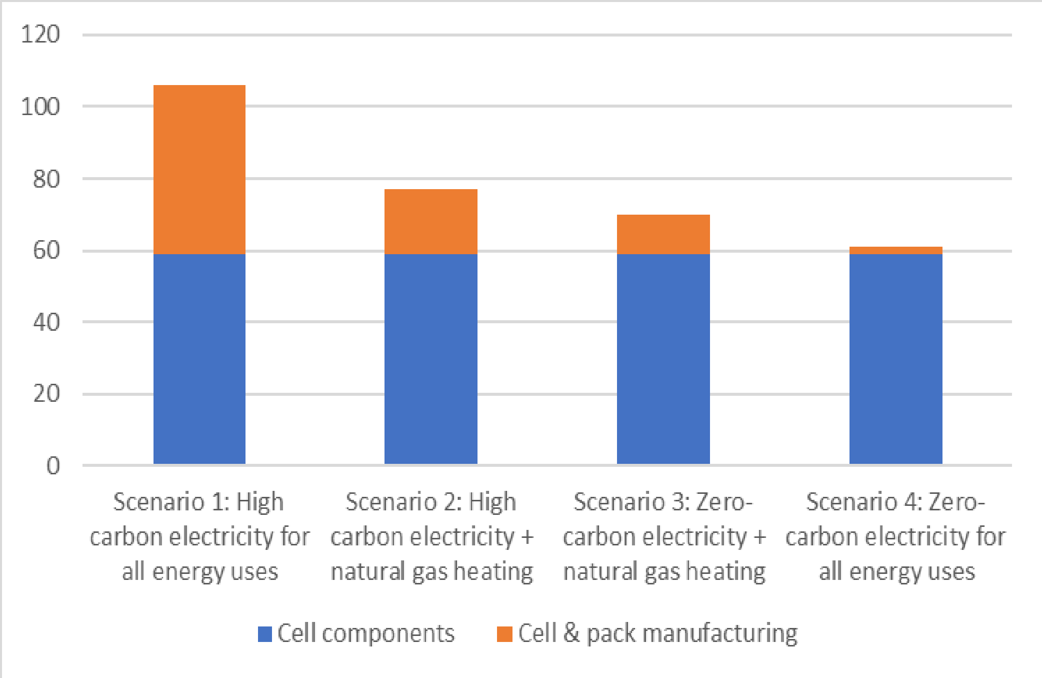
36. Q. Dai, J. C. Kelly, L. Gaines, M. Wang, *Life Cycle Analysis of Lithium-Ion Batteries for 13 Automotive Applications. Batteries*, Argonne National Laboratory, June 2019, available at: www.mdpi.com.

Irrespective of their locations, cell, cathode and anode manufacturers have a direct competitiveness incentive to reduce their energy consumption and judging by companies' announcements, significant improvements can be achieved. The scale-up trend is already highly beneficial as more products are manufactured in the same rooms, with no or limited impact on the drying and heating needs, thus leading to stable energy consumption levels for larger output. Beyond scale, one recent example of climate-relevant process innovation is Tesla's announcement that it is about to commercialize dry coating of electrolyte onto cathodes. This would mean eliminating the coating's wet process step, thus skipping the very energy-intensive drying step and also avoiding the use of hazardous solvents. More broadly, the drive to operational excellence should lead to building factories that are increasingly energy-efficient, for example by leveraging big data analysis to optimize energy management systems[37] and improving the logistics to reduce scrap.[38] This means that cost competition is already pushing down the energy consumption and the carbon footprint of battery manufacturing, even before the introduction of climate performance incentives and requirements.

Once energy consumption is reduced to a minimum, it is necessary to focus on the energy supply strategy, and at this stage climate change considerations may run counter to competitiveness imperatives. The most optimal climate solution would be to use low-carbon electricity for all energy needs, including heat, which for example is said to account for 80% of the energy used for cell production (140 MJ – megajoules – out of 170MJ/kWh according to the Dai *et al.*, 2019). If heat production is not electrified but rather comes from cheaper fossil fuel resources, then the climate benefit of securing low-carbon electricity supplies is significantly reduced, considering the carbon footprint of the whole battery pack.

37. ACC, "Presentation at Lyon Batteries Event", October 2020.
38. Northvolt, "Presentation at Battery Forum Germany", November 2020.

Graph 3: Carbon footprint calculation based on different energy supply scenarios for cell and pack manufacturing (in $kgCO_{2e}/kWh$)



Note: the high-carbon electricity is estimated at 1 $kgCO_{2e}/kWh$.

Source: Ifri, based on data from the Dai et al. *study of a NCM111 battery pack, 2019.*

Finally, when it comes to securing access to abundant low-carbon electricity, locating the manufacturing projects in areas with highly decarbonized electricity mixes is the most straightforward option. Sweden, where Northvolt has established its first cell factory, is the European country with the lowest emission-intensive electricity mix (only 8 gCO_{2e} per kWh generated in 2019), thanks to its large hydro, nuclear and wind capacities. Likewise, France, where ACC is developing the Douvrin gigafactory, has an electricity emission factor of only 52 gCO_{2e} per kWh. Yet, the largest share of cell manufacturing (and cathode manufacturing) projects will be located in Poland and Germany, two countries with emission factors above the EU average (719 gCO_{2e}/kWh for Poland, 338 gCO_{2e}/kWh for Germany 2019).[39] This means that other arguments have prevailed in the site selection process, such as geographical proximity to customers (OEMs' EV factories), tax legislation and investment incentives, access to skilled workforces, availability of land or the possibility of converting existing facilities, and the level of complexity and length of local authorization procedures.

39. European Environmental Agency, "GHG Intensity of Electricity Generation – Data Visualization", December 8, 2020, available at: www.eea.europa.eu.

In addition, operating in an area where grid electricity is carbon-intensive is not viewed as an insurmountable obstacle, to the extent that project promoters can develop on-site renewable production or secure a power purchase agreement (PPA) with a renewable electricity producer, possibly at higher – but not prohibitive – costs. Green PPAs have already become common practice in the tech industry and the trend is likely to spread in the EV battery industry, especially if customers, employees, and financers pressure OEMs to commit to climate neutrality in a holistic way, by including the indirect emissions in their value chain (Scope 3).[40] For example, Daimler has recently announced the ambition of making its fleet of new cars completely CO_2-neutral by 2039, and one of its first actions will be to equip all its new EV models (EQ generation) with "CO_2-neutral" battery cells. To this end, Daimler entered "sustainability partnerships" with its two cell suppliers, Farasis and CATL, which are both developing manufacturing projects in Germany and are now committed to using 100% electricity from renewable sources.[41] The battery cell industry is predominantly considering that site location is not the only valid strategy to benefit from low-carbon electricity supplies. However, the reliance on green power purchases can lead to a risk of greenwashing if the contractual arrangements do not guarantee the additionality of renewable supplies in a given electricity market area (see Part III.).

Raw material sourcing strategies offer a large untapped potential for green differentiation

One last important take-away from the EV battery LCA literature is that a large part of the carbon footprint can be attributed to the extraction and refining of the mineral raw materials contained in the electrodes. The climate impact of upstream activities has not been rigorously investigated in available LCAs and there is also a chance that material emissions are often underestimated, due to process-based assumptions with very limited regionalized primary data.[42] Looking forward, a climate-conscious approach could lead to favoring battery cathode chemistries that make the most use of materials which can be produced with the lowest amount of energy. For instance, the 2019 Argonne study suggests that producing cobalt sulphate requires twice as much energy as producing nickel sulphate,

40. P. Sigal, "Valeo Joins Bosch, GM and Others in Pledge for Carbon Neutrality", *Autonews*, February 4, 2021, available at: https://europe.autonews.com.

41. Daimler, "Ambition 2039: Our path to CO_2-neutrality", available at: www.daimler.com.

42. C. Aichberger and G. Jungmeier, "Environmental Life Cycle Impacts of Automotive Batteries Based on a Literature Review", *op. cit.*

which would plead in favor of shifting towards more nickel-rich chemistries. When selecting raw materials producing countries, priority could be given to the resource types which can be extracted using the lowest amount of energy. This could mean for example giving priority to lithium sourced from brines in Chile, rather than lithium sourced from spodumene in Australia, because of the easier recovery process involved.[43] Another lever for improvement would be to select the mining and refining operators working in the most climate-friendly manner, by developing innovative concepts and making the most use of carbon-free energy. This is precisely how Vulcan Energy aims to grasp a share of the fast-growing lithium hydroxide market, by offering to harness geothermal energy to extract lithium from a deep brine source in the Upper Rhine Valley, in Germany.[44] Likewise, BASF intends to market cathode active materials that are 30% less carbon-intensive than benchmark players, and one of the key strategic moves to meet this goal will be to use nickel and cobalt refined by Nornickel in its Finish facilities, benefiting from low-carbon energy supplies (hydro, wind and biomass).[45] A final step would be to reduce long-distance transportation by increasing the geographical integration between mines and refineries, potentially suggesting a move away from the Chinese refining hub.

Another assumption is that the use of recycled content will bring significant climate benefits. Existing LCA studies conclude that recycling processes can reduce the battery carbon footprint by a median value of 20 $kgCO_{2e}/kWh$.[46] But these estimates should also be taken with caution because they require calculating the carbon footprint of recycling activities, which have not reached full scale, and comparing the result with the use of primary resources, which remains insufficiently investigated. Once again, the lack of robust knowledge is a major obstacle to defining climate-friendly raw material supply strategies, and the exercise becomes even more complex with the imperative of including other environmental and social impact categories.

43. Roskill, *Lithium's growing CO_2 footprint: An Analysis of Energy Consumption and Emissions Intensity from Global Lithium Supply*, White Paper, October 2020, available at: https://roskill.com.

44. Vulcan Energy Resources website, available at: https://v-er.com.

45. BASF, "BASF and Nornickel Join Forces to Supply the Battery Materials Market", *Joint News Release,* October 22, 2018, available at: www.basf.com.

46. C. Aichberger and G. Jungmeier, "Environmental Life Cycle Impacts of Automotive Batteries Based on a Literature Review"*, op. cit.*

Climate performance requires taking a holistic view of supply chain management

In sum, ensuring the local production of batteries and their components is no magic pill that, by itself, will guarantee the lowest carbon footprint. A wide range of levers can be mobilized to achieve a better climate and environmental performance and the only valid approach to make significant inroads is to take a holistic view of the value chain and to examine the impacts of all sub-steps with all suppliers. From this perspective, climate considerations provide an additional argument for moving beyond the 'buy-sell' relationship between the different industrial players of the EV value chain. Most likely, the quest for sustainable batteries will favor industrial partnerships and vertical integration strategies.

The resolve and know-how to make batteries greener will have a greater impact than the location. Yet, it can still play to the advantage of European companies because they are used to operating in a region with stringent environmental rules and have probably acquired more expertise in life-cycle thinking than the non-EU incumbents. A good illustration is that European project promoters are putting the environmental performance at the heart of their value proposition, by putting forward a CO_2 footprint target (e.g. Norwegian FREYR committing to achieve 15 $kgCO_{2e}$/kWh for its cell production as of 2025),[47] defining goals on the use of recycled content (e.g. Northvolt aiming to incorporate 50% of recycled materials in new cells by 2030),[48] or presenting responsible sourcing strategies (e.g. ACC committing to exclude cobalt from artisanal mines, nickel mined by companies practicing deep-sea tailings placement, lithium extracted in a way that contributes to water supply disruption, and minerals from conflict-affected areas).[49] They are taking a proactive position whereas the Asian market leaders seem to adjust their processes at the request of their European clients, as with CATL and LG Chem securing renewable electricity supplies for their respective cell factories in Germany and Poland.

47. Freyr, "Clean Battery Solutions for a Better Planet", Investor Presentation, January 2021, available at: www.freyrbattery.com.
48. Northvolt website, available at: https://northvolt.com.
49. ACC, *Dossier de concertation pour le projet d'usine de production de batteries de Douvrin/Billy-Berclau*, February 2021, available at: www.concertation-acc-batteries.fr.

In this sense, the new Batteries Regulation could turn out as a competitive advantage for European companies, not because of where they are operating but rather because they have already secured the necessary qualified resources to question and improve the sustainability of their operations. European new entrants may have a head-start, but the incumbents can catch up as well. For instance, Korean companies such as LG Chem and SK Innovation have recently committed to reaching climate neutrality by 2050 and are now working on concrete implementation strategies.[50] SK Innovation unveiled a *Green Balance 2030 Strategy* and decided to make organizational changes and invest in capacity building, with the objective of boosting the company's ability to implement environmental, social and governance (ESG) management.[51]

50. J. K. Ahn, "LG, SK, Hanwha Accelerate Shift to Renewable Energy with Push for RE100", *The Korea Economic Daily*, February 10, 2021, available at: www.kedglobal.com.
51. J. Min-Hee, "SK Innovation Sets Up Eco-friendly Business Unit", *Business Korea*, December 4, 2020, available at: www.businesskorea.co.kr.

The EU Batteries Regulation in support of green differentiation strategies

The EU has a long experience with product legislation and the 2013 Ecodesign Directive proved a very successful instrument to improve the energy efficiency of products placed on the EU market, by introducing mandatory labelling and minimum performance indicators. With the EU committed to becoming a climate-neutral and resource-efficient economy, the next logical step is to go beyond the use phase and address the full life-cycle environmental impact of products. To this end, the EC is actively working on widening the scope of the Ecodesign directive (Sustainable Product Initiative)[52] and targeting further sustainability improvements through product design and value chain management. This horizontal initiative is still work in progress, and will require extensive preparatory work and stakeholder engagement before reaching the legislative stage. Potentially, it could be an effective way to address the growing concerns over imported emissions, as a complement or substitute to carbon border adjustment mechanisms.

While Ecodesign criteria enjoy broad political support, they must be robust enough to ensure compatibility with the EU's international trade commitments, avoid side-effects such as stifling innovation and cost performance, and of course allow for a reliable comparison between products. Following the same approach, the Batteries Regulation faces similar methodological and practical challenges, but it is on a fast-track adoption procedure because of the political momentum around the European Battery Alliance. The EC has been working on the Regulation proposal since mid-2018 and it will enter into force in January 2022, with a gradual implementation of its requirements as of 2023.

52. European Commission, *Inception Impact Assessment – Sustainable Products Initiative*, Ares(2020)4754440, September 11, 2020, available at: https://ec.europa.eu.

Table 4: Key sustainability requirements introduced by the EC's Batteries Regulation proposal and applicable to EV battery manufacturing

Measures	Step 1	Step 2	Step 3
Carbon footprint (Article 7, Annex II)	07/2024: Mandatory declaration of carbon footprint	01/2026: Batteries subject to classification into carbon footprint performance classes	07/2027: Maximum carbon thresholds for batteries as condition for placement in the EU market
Use of recycled content (Article 8)	01/2027: Mandatory declaration about the amount of recovered cobalt, lead, lithium and nickel contained in the batteries' active materials	01/2030: Minimum shares of recovered materials as condition for placement on EU market (12% cobalt, 85% lead, 4% lithium, 4% nickel)	01/2035 Higher minimum shares of recovered materials (20% cobalt, 85% lead, 10% lithium, 12% nickel)
Performance and durability (article 10, Annex IV)	12 months after entry into force (presumably 01/2023): Information requirements on performance and durability		
Supply-chain due diligence for raw materials (Article 39, Annex X)	12 months after entry into force (presumably 01/2023): as condition for placement on the EU market, economic operators to establish transparent supply chain due diligence policies for cobalt, natural graphite, lithium and nickel, in compliance with internationally recognized principles (OECD due diligence guidance for responsible supply chains of minerals from conflict-affected and high-risk areas)		

Source: Ifri, based on 10 December EU Batteries Regulation proposal.

Methodological challenges: making the Batteries Regulation fit for purpose

Given the complexity of defining calculation methodologies, many of the requirements introduced by the Batteries Regulation will be further detailed and enacted in delegated legislation, to be adopted by the EC no later than 1 July 2023. The Commission's responsibility is crucial because the legislation could remain an empty shell if it is not supported by robust implementation rules.

Primary vs. secondary data

With regards to the carbon footprint (Article 7), the Product Environmental Footprint Category Rules (PEF CR 1) for rechargeable batteries in mobile applications[53] provide a robust starting point for elaborating a fully-fledged methodology. Published in 2018, they are the result of a four-year long drafting, consultation and reviewing process. Yet, these technical guidelines are only applicable to lithium-ion technologies, and they do not always refer to the most up-to-date secondary datasets. Above all, they are not detailed and prescriptive enough to support comparative exercises. In the current PEF-CR, primary industrial data is only applied starting from the electrode production step, while secondary datasets are applied to all the other upstream steps (up to cathode active material production). To enable differentiation strategies, the carbon footprint methodology should require using primary data for all climate hot spots of the value chain and provide the corresponding calculation rules. This is imperative to address the presumably large share of emissions attributable to mining and refining activities. Coupled with the mandatory application of detailed due diligence requirements, the possibility to factor in climate performance could lead to a major reshuffle of raw material supply strategies. Conversely, restricting the mandatory use of real operation data to the cell and module manufacturing steps would limit the differentiation potential to about 20% of the battery carbon footprint. In addition, the so-called "negligible" CO_2 impact of long-distance transport should be subject to further examination and discussion, both in the case of bringing the final product to the customer but also shipping raw materials to manufacturing facilities.

Electricity sourcing

Establishing a level playing field between battery manufacturers will also require adopting robust rules for calculating CO_2 emissions from electricity sourcing, ensuring specifically that company-led initiatives contribute to the global decarbonization goal. Recent company announcements suggest that green power supplies are progressively becoming a standard for all players targeting the European market, but their claims can be supported by a wide range of contractual arrangements. The central question around corporate sourcing of low-carbon/renewable energy is whether the additionality criterion is fulfilled, meaning that the supply of green power will directly increase in a given country or market area, as a result of a companies'

53. RECHARGE, *PEFCR – Product Environmental Footprint Category Rules for High Specific Energy Rechargeable Batteries for Mobile Applications*, February 2018, available at: https://ec.europa.eu.

voluntary commitments. For example, the 'climate' added value of corporate power purchase agreements (PPAs) is questionable when they are based on certified guarantees of origin and/or renewable energy purchase from already-built renewable production units which have benefitted (and/or are benefitting) from financial public support.[54] In those cases, the specific power contract does not guarantee additional renewable supplies compared to legacy investments and government-led expansions. Hence, they should not be taken as a reference for the carbon footprint calculation methodology and country average grid mixes should always prevail, unless it can be rigorously demonstrated that the specific power contract contributes to additional renewable supplies in the host country. This is the only way to prevent a situation whereby countries would simply "dedicate" their existing renewable production to the factories supplying the European market, in the interest of lowering the carbon footprint of exported goods, without further decarbonizing their electricity mix.

Articulating climate performance with abiotic resource efficiency

Another major challenge will be to ensure that batteries have the lowest possible carbon footprint while also guaranteeing the most efficient use of mineral raw materials, both to mitigate supply risks and limit the social and environmental impacts from resource extraction activities. The EC's Product Environmental Footprint methodology does include abiotic resource use (minerals and metals) in the list of default environmental impact categories to be considered in life-cycle assessments. However, there is no scientific consensus on the right approach to assess resource efficiency. While the current PEF methodology recommends measuring the abiotic depletion potential, LCA researchers are investigating the possibility of complementing this indicator, notably with considerations on resource dissipation after their use in the technosphere.[55]

Contrary to the carbon footprint, the resource use indicator is not mature enough to be translated into a legally binding performance indicator. Hence, the Batteries Regulation intends to promote resource efficiency by introducing minimum requirements on selected means: the use of recycled materials (Article 8) and the durability of the product (Article 10). Mirroring the gradual approach adopted for the carbon footprint, the EC proposes to introduce labelling and

54. CRE, *Le fonctionnement des marchés de détail français de l'électricité et du gaz naturel – Rapport 2018-2019*, November 23, 2020, available at: www.cre.fr.
55. A. Beylot *et al.*, *Abiotic and Biotic Resources Impact Categories in LCA: Development of New Approaches*, *JRC Technical Report*, 2020, available at: https://ec.europa.eu.

information requirements as a first step before enacting minimum shares of recycled content for all batteries sold into the EU market. While the EC's laudable intention is to promote high-quality recycling, a very large majority of industrial stakeholders warns that shifting the focus from the objective to the means could lead to unintended consequences. On the one hand, experience with recent EV battery models shows that their lifespan could be longer than initially thought (at least 10 to 15 years), and this would be even more the case if repurposing and second-life applications are developed. For this reason, the future availability of secondary materials is highly uncertain. On the other hand, the battery market is growing exponentially, and manufacturers are constantly adjusting battery chemistries to meet customers' needs. Therefore, binding shares of recycled content could turn out to be a limiting factor for the nascent battery industry, potentially requiring imports of recycled materials from other continents.

To avoid such counterproductive effects, a compromise solution could be to introduce the recycled content information and labelling obligation earlier than 2027, as the proposal currently suggests, but to refrain from setting mandatory thresholds. With regards to the performance and durability of EV batteries, the EC's proposal does not go further than an information and labelling requirement, applicable as of 2023. This non-prescriptive approach should ease the industry's concerns about the risk of constraining their ability to meet user-specific needs. In the longer term, the concept of efficient abiotic resource use should be further investigated and refined, so that it may ultimately be appropriately translated into future EU product legislation.

Implementation challenges: grasping the full potential of the Batteries Regulation

Industry engagement

To prepare the implementation/delegated acts, the EC will be assisted by Joint Research Centre with a €6.2 million budget set aside for technical studies. However, establishing robust methodologies will not be possible without strong industry engagement in the different workstreams. Given the shortfalls in the available CO_2 LCA literature, industry engagement will be paramount to improving the understanding of which production steps should be considered climate hotspots, define appropriate rules to produce primary data and identify the most accurate secondary datasets for all remaining steps involved in battery production. In this regard, it should be stressed that most responses to the latest public consultation on the EC's draft regulation came from EU-based producers of raw materials and manufacturers of battery components, cells and modules. Global market leaders were largely underrepresented in the responses, with the notable exception of the Japan Battery Association, warned about the risk of creating undue barriers to entry.

Reaching out to the dominant non-EU stakeholders should become a priority to benefit from the widest possible industry expertise, but also to minimize the risk of triggering new trade disputes. Likewise, the EU should strive for synergies with international standardization efforts, such as the UNECE performance and durability standards set to be adopted by 2021/2022, and also build on the work of the Global Battery Alliance (GBA), launched in the context of the World Economic Forum and involving more than 80 public and private organizations from diverse geographical locations. Focusing on traceability issues, the GBA is expected to roll-out a fully operational "battery passport" in 2022, providing a digital twin to the physical battery and enabling access to data on key environmental performance indicators. The EU regulatory push and this voluntary initiative can be mutually reinforcing and facilitate swift and large-scale adoption by the industry.

Implementation timeline

The implementation timeline will also be subject to intense lobbying during the interinstitutional negotiation process. On the one hand, the industry is rightly calling for "realistic" timeframes to develop calculation methodologies, but also to collect the necessary data from a global and fragmented supply chain, and thus comply with the declaration requirements. On the other hand, fast-track implementation is the only chance to lock-in sustainable manufacturing strategies before EVs become a mass-market product. Once the OEMs have settled the supply chain arrangements for one specific EV model, they will not make any significant adjustment until the lunch of a new industry cycle. In other words, the window of opportunity to influence supplier selection processes materializes only every 4-5 years, and green battery supplies cannot be structured overnight due to the capital intensiveness and long project lead times in the battery and raw material industries. Likewise, an ambitious timeline could help convince the battery industry of the urgency to engage in the consultation processes and dedicate enough resources to support the EC's drafting process. As customers detailing their technical specifications to battery suppliers, the OEMs' support for the EU's regulatory initiative should play an instrumental role in mobilizing the whole value chain. Yet, the majority is expressing broad support but refusing to take a proactive stance in the sustainable battery manufacturing discussion. Only BMW submitted an individual (and supportive) response to the EC's 2021 public consultation, whereas the position paper issued in July 2020 by the European car industry association (ACEA) stipulated that LCAs should remain "a voluntary tool" based on international standards (ISO 14040/44).[56]

Enforcement procedures

Enforcement is another make-or-break issue for the EU Batteries Regulation. Verifying whether products sold in the EU follow energy and emission performance requirements during their use phase is already challenging and the Dieselgate scandal shed light on the structural flaws of the EU's testing and approval procedures. While the shift from lab to real-world testing has eased concerned, it remains irrelevant for ensuring compliance with sustainability requirements in the manufacturing phase. Taking the example of the CO_2 footprint declaration, checking the accuracy of the manufacturers' declarations would require on-site investigations and measurements for all production steps. To prevent cheating, third-party certification should act as safeguard, but only on the condition that auditing bodies can prove that they are qualified and fully independent from the suppliers. In the end, national market surveillance authorities will bear the responsibility of checking the validity of the information provided by the manufacturer in order to demonstrate compliance. The question is whether Member States will provide them with sufficient means to fulfill this unprecedently ambitious task. To ensure a level playing field between EU-made and imported battery products, the regulation should include detailed enforcement procedures and exploit the full potential of digital traceability technologies to minimize the burden on national market surveillance authorities.

56. ACEA, *Position Paper on the Revision of the EU Batteries Directive*, July 2020, available at: www.acea.be.

Conclusion

Although restricted to one specific product, the Batteries Regulation and its sustainable manufacturing requirements offer one of the most promising approaches to tackling the climate and environmental impact of imported goods, the biggest blind spot of Europe's green agenda. Provided the initial ambitions of the EC's proposal are not watered down and the methodological and implementation challenges can be handled, the battery industry will be compelled to not only compete on performance and price but also increasingly on greenness. Some may argue that unmatched environmental standards will apply to EVs only and create a double standard, but it is rather an opportunity to strengthen consumer trust and comfort the EV's long-term role in Europe's climate-neutrality journey.

So far, the lack of reliable and comparable data has prevented car manufacturers from mapping the sustainability of their products and in turn making informed decisions on how to structure their battery supply chain. This practical hurdle will soon be removed, and OEMs will be increasingly and legitimately pressured to factor greenness into their battery supply chain arrangements. While mandatory thresholds may help ruling out the least sustainable battery products from the European market, a more disruptive aspect of the Regulation lies in its potential to increase awareness of the environmental impacts of each production step. Forced to address this potentially inconvenient reality, OEMs could trigger a race to the top, not only among battery manufacturers but among all stakeholders of the value chain, including the extraction and refining segments.

The Batteries Regulation does not cross the red line of green protectionism in the sense that locating the battery value chain in Europe is not *per se* the unique and ideal solution to improve the climate and environmental performance of EV battery products. The localization trend will rather be fueled by the desire to reduce shipment costs and, more importantly, to ensure timely EV deliveries to the booming European market. Yet, the focus on sustainability requires taking a holistic approach to value chain management, to ensure that all environmental hotspots are consistently and effectively addressed. Such considerations may strengthen the case for establishing closer business ties between the different segments of the EV battery value chain, and incentivizing OEMs to take a more active role in the upstream segment where green differentiation has a large untapped potential. Compared to Asian incumbents, European companies may be one step ahead in scrutinizing the environmental footprint of their operations and their resolve could finally turn into a competitive advantage, especially if coupled with EU financial public support to enter these highly capital-intensive industries.

Ultimately, the Batteries Regulation could be a game changer for market competition. Customers are shifting from ICEs to EVs on environmental grounds and they are likely to favor products with the best environmental profiles, for the sake of being consistent with their personal values. By enabling comparative exercises, the Batteries Regulation will empower consumers to make a difference if the information is brought to them in a user-friendly manner. Likewise, Article 70 of the regulation will oblige national authorities to include the sustainability requirements in the technical specification and award criteria for the purchase of products containing batteries. With public authorities representing around 3% of the market for passenger cars and light-duty vehicles, and 75% for the bus market[57], public procurement strategies have a strong potential to influence industrial dynamics.

In the end, the success of the EU's green regulatory push will hinge on industry engagement as the EC cannot adopt robust calculation methodologies without up-to-date technological knowledge and understanding of industrial processes. The scale of the methodological and implementation challenges should not refrain EU policy-makers from setting up ambitious implementation timelines. On the contrary, civil society and political representatives should make the Batteries Regulation a central pillar of the European Green Deal, as a way to convince both the global EV value chain and public authorities to dedicate enough resources for an early implementation of the transparency requirements. If the political signal is clear, stakeholders will follow and the Batteries Regulation will be a resounding success for Europe's green industrial policy.

57. European Commission, *Impact Assessment Report Part III – Proposal for a Regulation concerning batteries and waste batteries*, December 10, 2020, available at: https://eur-lex.europa.eu.

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