Pedal to the metal

How prepared are European carmakers for EV value chain transformation?

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Author: Yoann Gimbert
Expert group: Julia Poliscanova, Lucien Mathieu & Cecilia Mattea

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Further information

Yoann Gimbert
Emobility Analyst
Transport & Environment
yoann.gimbert@transportenvironment.org
Mobile: +32 488 27 19 97
www.transportenvironment.org | @transenv | fb: Transport & Environment

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Executive Summary

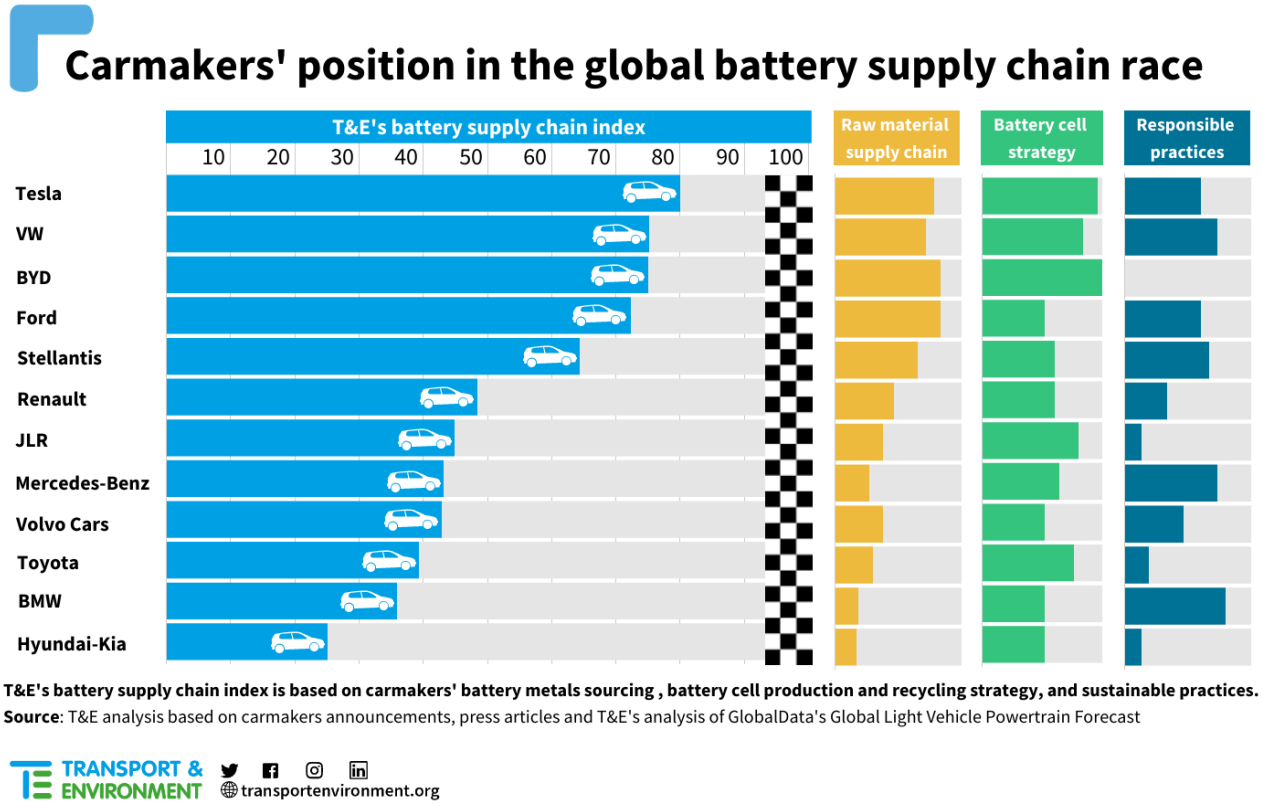
Europe is the second largest electric car market after China, with most major carmakers (OEMs) planning to fully electrify their sales in the region by 2030. Whether or not OEMs will be able to achieve those in large part depends on the ability to secure battery cells and critical minerals that go into them. But they need to act fast amidst an intensifying global race. As geopolitical tensions and sustainability concerns rise, the value of resilient and responsible supply chains is now higher than ever. To understand how well Europe's legacy carmakers are prepared T&E analysed their battery and raw material[1] strategies to 2030 and compared that to global players such as Tesla and BYD.

Key findings include:

- **While more progress has been achieved on batteries, this year's ranking shows that European carmakers are faring less well on securing the battery minerals that are needed to reach their 2030 electrification goals. Less than a fifth of the estimated demand for cobalt, lithium and nickel has been secured based on publicly disclosed contracts. Six carmakers - VW, Ford, Renault, Stellantis, BYD and Tesla - have long-term contracts for each of the metals or a substitution strategy.**
- **The level of preparedness among the carmakers (OEMs) varies widely: while Tesla leads the overall ranking (and BYD tops the minerals supply part), VW is the only legacy carmaker to score above 70 points (out of 100). Ford andStellantis are relatively well prepared, scoring above 60 points each. But the majority of OEMs have scored less than 50 points: Renault, JLR, Mercedes-Benz, Volvo Cars, Toyota and BMW, with Hyundai-Kia at the bottom of the table.**
- **The critical minerals supply today is highly concentrated in Asia, posing risks both to carmakers' resilience and Europe's strategic autonomy. As Europe aims to onshore parts of the value chain, T&E has added an additional analysis of carmakers' resilience in Europe in particular. This shows that VW, Stellantis and Mercedes-Benz are the most involved in the EU battery supply chain, while international competitors Tesla, Toyota, Ford and Hyundai-Kia are not supporting the EU industrial ecosystem. Four automakers - Mercedes, Renault, Stellantis and VW - are directly involved with Europe-based suppliers of processed materials or battery components.**

[1] Cobalt, lithium and nickel are included in this analysis; other materials will be added in the future

- **T&E also analysed the sustainability of automaker sourcing practices, which is critical for long-term resilience and consumer acceptance. European carmakers have a clear lead here with the three German brands having the highest scores, while BYD scored zero.**



Carmarkers have a long way to go to secure battery raw materials

Since T&E's previous OEM EV readiness ranking in 2021, OEMs have made progress on their strategies around BEV manufacturing, sales and charging thanks to the pull from the EU car CO_2 standards. However, the biggest gap today is in securing the minerals and metals necessary to build all those electric cars and their batteries and doing this responsibly. While progress is being made on securing battery cell supply - most carmakers have at least 12 points out of 15 - the "great raw materials disconnect"[2] is happening further midstream and upstream as carmakers are waking up to the challenge.

[2] As coined by Benchmark Minerals Intelligence

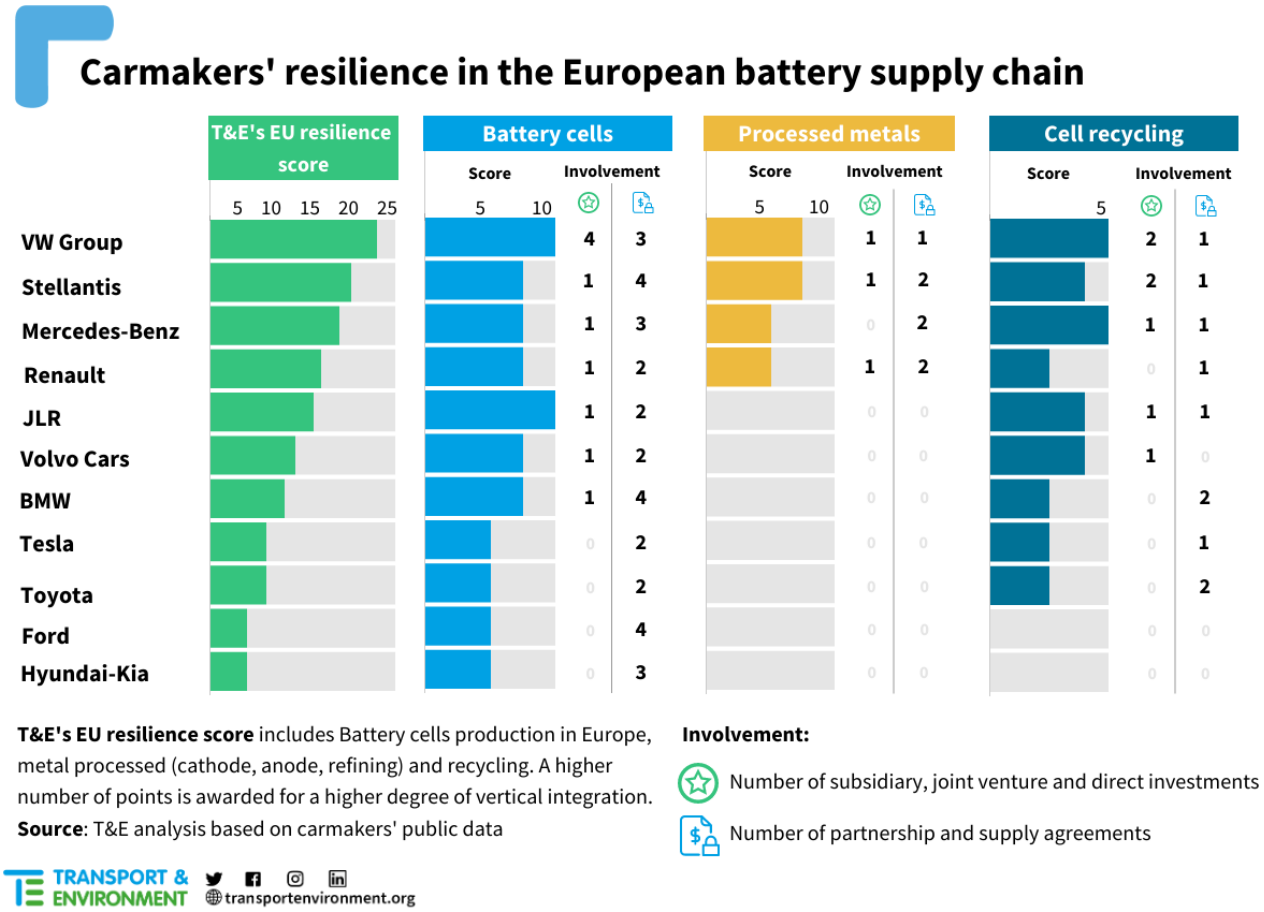
While BYD and Tesla are a lot more prepared than others in Europe, overall, only 14% of the lithium demand, 17% of the nickel demand and 10% of the cobalt demand are secured by the 12 carmakers by 2030. To quantify this, T&E relied on the publicly disclosed data, as well as allowing all carmakers to give feedback on the findings. Aggregating the three metals, 16% of the raw material demand in 2030 is secured, or less than a fifth of what is required. Given that roughly 10-20% of the metals needed are often secured on spot markets to hedge risks, this is a very low number for what would have been expected on long-term contracts.

Carmakers can deploy different strategies to secure raw materials. Directly procuring supplies, either via long-term contracts or equity stakes with miners and recyclers, will ensure the materials are available to deliver on their BEV strategies on time, volume and budget. But resource efficiency and innovation are equally effective. E.g. BYD relies on a type of lithium-ion batteries that does not require cobalt or nickel, Tesla is investing in cobalt-free chemistries, while compact battery models planned by Stellantis, Renault and others will help them slush their demand for minerals.

Carmakers can help Europe onshore critical minerals supply

As fierce global competition between global automakers to secure battery metals is intensifying, another key message from T&E's analysis is that European OEMs should do more to help Europe's efforts to scale domestic supply chains. Only four carmakers (Mercedes, Renault, Stellantis & VW) currently support nascent EU start-ups in battery components and minerals processing.

Automakers - given their size, resources and large project management skills - can help the nascent minerals industry in Europe scale effectively. Supporting local refining and battery component factories - via vertical integration (e.g. in-house recycling) or investing into start-ups - is also critical to their own resilience and supply security, as well as Europe's strategic autonomy agenda. This part of T&E's analysis shows German and French carmakers to be leading, with international brands a lot less involved.



Carmakers must ensure that the materials they secure are extracted responsibly & resiliently

A key differentiating factor between carmakers will be the adoption of responsible supply chain practices and the support of low-carbon raw material streams, which will unlock both lower carbon footprint for batteries and better Environmental, Social, and Governance (ESG) rating for carmakers. Our ranking shows German carmakers - BMW, Mercedes-Benz and Volkswagen - to be leading here.

While BYD scored zero in the part of the ranking, most major carmakers are making steady progress. Bar Toyota and Hyundai-Kia, most now track their supply chains, have either joined the global Initiative for Responsible Mining Assurance (IRMA) or have responsible mining practices in their supplier codes of conduct. Where many including Tesla, Stellantis

and VW can improve on is in stronger policies to engage with local and indigenous communities.

Carmakers' supply chain strategies can make or break the EV transition in Europe

Carmakers still have a long way to go and must accelerate their transition, support the creation of the European EV ecosystem and secure the raw materials they need sustainably. Otherwise, faced with the competition from well established Chinese and American pure play EV makers, they risk losing market share in Europe, and their standing in global markets. In the next few years carmakers' industrial and supply chain strategies will make or break the EV transition in Europe, and render some obsolete.

Key recommendations

1	Policymakers should lock-in the 2035 combustion engine phase-out for EV supply chain investment certainty, and move to implement the onshoring goals recently agreed under both the net zero and critical raw materials acts.
2	Industrial and fiscal policies at both EU and national levels should encourage faster scale-up of battery and EV manufacturing in Europe. EV subsidy and support schemes should reward local manufacturing, compact models and innovative clean technologies.
3	European carmakers should accelerate their involvement into midstream and upstream battery supply chains, invest into resource light battery chemistries and efficiency. They should engage into global efforts, e.g. EU Strategic Partnerships with resource-rich countries and the Minerals Security Partnership to support minerals projects with EU offtake.
4	Product sustainability rules, such as the EU Battery regulation, must be swiftly implemented to accelerate sustainable battery cell manufacturing in Europe. Higher social and environmental standards within mineral supply chains should be ensured through an ambitious agreement on the Corporate Sustainability Due Diligence Directive (CSDDD) and a quicker adoption of best-in-class global standards (such as IRMA).

5 The EU must develop a comprehensive green industrial policy focused on robust sustainability regulations, streamlined permitting, smart trade strategies and adequate EU-level funding to expand midstream and upstream supply chain manufacturing locally. Priority should be on minerals processing, notably cathodes, anodes and precursors.

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Acronyms and definitions

ACC	Automotive Cells Company
BEV / EV	Battery electric vehicle
BMI	Benchmark Mineral Intelligence
BNEF	BloombergNEF
CAM / pCAM	Cathode active material / precursors
CSDDD	Corporate Sustainability Due Diligence Directive
ESG	Environmental, Social, and Governance
ICE	Internal combustion engine vehicle
IRMA	Initiative for Responsible Mining Assurance
JV	Joint venture
LFMP	lithium-manganese-iron-phosphate
MoU	Memorandum of understanding
NMC	Nickel-manganese-cobalt
OEM	Carmaker
R&D	Research & development
SSB	Solid-state battery
UNDRIP	UN Declaration on the Rights of Indigenous Peoples
UNGP	United Nations Guiding Principles on Business and Human Right

1. Introduction

In 2021, we released T&E's 'EV readiness index' [1] to compare the readiness of 10 major OEMs to face the emobility transition. This report raised concerns about the reliance on voluntary (and therefore uncertain) commitments from carmakers, which were too weak and not backed up by a coherent industrial strategy.

Since 2021, the landscape of the European EV industry has changed rapidly. The European Union (EU) car CO_2 standards kept driving zero-emission vehicle sales in 2021, while carmakers continued to ramp-up electric car production in Europe. In the first half of 2023, battery electric car (BEV) sales reached 12.9% in the EU27, almost 7 times higher than the 2019 level before the introduction of the car CO_2 standards. The planification of the EV ecosystem in Europe also made progress. In 2021, T&E analysis of gigafactory plans [2] showed that 730 GWh could be reached in 2030 based on announced nameplate capacities. Since then, many battery manufacturers have announced additional projects and our recent publication [3] from March 2023 showed that this figure has doubled to 1,800 GWh.

The automotive industry also faced challenges due to the Russian aggression in Ukraine, the semiconductor crisis and lasting effects of Covid-19 in China, all of which have led to supply chain disruptions and limited car production for all powertrains. Nevertheless, carmakers have shown that they can adapt to a changing environment. The five biggest European carmakers have doubled their profits since 2019 [4], despite selling 25% fewer cars overall. To secure their profits, carmakers have begun to shift from selling more mass-market cars to selling fewer but expensive premium vehicles while scrapping more affordable cars [5].

To increase their resilience, some carmakers also started to invest more in the battery supply chain. In 2022, Reuters [6] estimated that carmakers doubled their investment plans in EVs, batteries and raw materials in one year. The world's top carmakers plan to invest about €1.1 trillion by 2030. However, global investments in supply chains are not always well balanced geographically. BloombergNEF (BNEF) has shown that Europe attracted 2% of global battery manufacturing investments in 2022, compared to 41% in 2021[3].

T&E's new 'battery supply chain index' presented in this report aims to assess the progress carmakers are making in securing their battery supply chain, including how they source their raw materials. The ranking assesses 10 legacy carmakers that produced the most cars in Europe in 2022, plus Tesla and BYD to provide a comparison with international BEV leaders. The analysis is based on publicly available information as well as GlobalData's Global Light Vehicle Powertrain Forecast[4]. All major European OEMs

[3] 2021 was an exceptional year for European battery investments while investments were unusually low in China. In 2022, Chinese investments tripled compared to 2021. [7]

[4] This report includes content supplied by GlobalData; Copyright © Global Light Vehicle Powertrain Forecast, Q1 2023 [8]. All rights reserved; GlobalData is an independent provider of industry information. The permission to use GlobalData copyrighted reports, data and information does not constitute an endorsement by GlobalData of the manner, format, context, content, conclusion, opinion or viewpoint in which GlobalData reports, data and information or its derivations are used or referenced herein.

have been given the opportunity to react to the information presented here and to indicate any potential misinterpretations on T&E's part. Comments from OEMs and reviewers have been incorporated in the report as much as possible and where appropriate.

Section 2 then describes the key factors required to secure the EV supply chain transition. Section 3 assesses and ranks carmakers according to the quality of their involvement in the battery supply chain. All results, sources and other methodological details are available in the Excel Annex file.

2. What's needed to win the industrial EV race

This section presents the factors that T&E believes are critical for legacy OEMs operating in Europe to succeed in the global EV transition. These are then used to rank carmakers' battery supply chain strategy globally.

The emobility transition is now well underway and OEMs have made progress thanks to the EU car CO_2 standards. Carmakers have launched many EV models to cater to consumer demand, got involved in battery cell manufacturing (by vertically integrating or via partnership) and even partially become energy companies as they enter charging and power markets. However, the biggest gap today is in securing the minerals and metals necessary to build all those electric cars and their batteries. While progress is being made on securing battery cell supply, the "great raw materials disconnect"[5] is happening further midstream and upstream. Moving beyond their transitional tier 1 suppliers, carmakers now need to become more involved deeper in the supply chain to succeed. The Covid-19 pandemic, the semiconductor crisis and the Ukraine war have all shown that carmakers' production is sensitive to disruption in supply chains and volatility in commodity markets. By being more involved in the upstream battery supply chain and by securing early the components (e.g. battery cathodes), materials and critical minerals they need, carmakers can gain resilience and meet their BEV commitments without disruption.

A global race for critical minerals represents at least three challenges to the European OEMs: secure the minerals necessary for battery and electric cars at volume and speed required, avoid over-reliance on singular partners or countries (i.e. concentration) and do so with full respect of social, community and environmental safeguards. This won't be easy as European carmakers are competing globally with Asian and American players that in some cases are further ahead. To assess how well prepared the European players are to the challenge of the emobility supply chain transition, T&E is focusing on battery and minerals supply chains in its latest 'battery supply chain transition index'.

T&E's index focuses on traditional ICE carmakers and their transition from ICE to BEV. The index evaluates and compares 10 major carmakers with production volumes of more than 300,000 cars[6] in Europe in 2022, namely: BMW Group, Mercedes-Benz, Ford, Hyundai-Kia, Jaguar-Land Rover (JLR), Renault Group, Stellantis, Toyota, Volvo Cars and Volkswagen Group (VW). As Volvo Cars and JLR have low production volume (less than 500,000 units) compared with their competitors, they benefit from a small carmaker

[5] The term was coined by the CEO of Benchmark Mineral Intelligence, Simon Moores [9].
[6] Commercial vehicles, vans and minibus excluded.

status with rules adapted to maintain a fair ranking. On top of these legacy carmakers, T&E has also included Tesla as the American OEM is a top BEV seller, plans to extend its production capacity in Europe and could become the 3rd largest BEV manufacturer in Europe by 2030[7]. The analysis of Tesla's supply chain and industrial criteria focused on Europe would provide valuable insights as to how European automakers compare to one of the global leaders. Similarly, BYD was also included in the ranking to provide a comparison of legacy OEMs with an established Chinese BEV maker.

In terms of supply chains, T&E looks into batteries and the three key battery raw materials - lithium, nickel and cobalt - in this index. However, as the index is updated and expanded in the future, other key materials of the supply chain, notably steel and aluminium, will be added.

The breakdown of points by category is described in Table 1 below. The BEV cell supply strategy (25 points) is based on how OEMs secure their battery cells, if they adopt circular economy principles and how they manage innovation. Then, looking at the raw material supply itself (60 points), we analyse both upstream (mining & refining) and midstream (processing, notably cathodes and anodes) parts of the supply chain. These are both equally critical to carmaker strategies, and much attention is particularly missing in the case of midstream materials processing.

The security of their supply is assessed based on the quantity of material already secured for their 2030 needs, as well as the long-term contracts and partnerships that carmakers entered into for the three battery raw materials. Within this category, 15 points are awarded if carmakers manufacture precursors, cathode or anode materials via vertical integration (subsidiary, joint venture or direct investment)[8]. Raw material contracts are given 30 points, the highest score in the index. For each metal (lithium, nickel and cobalt), a maximum of 10 points are awarded if carmakers extract or refine the metal in-house, via a joint venture or have direct investments.
Finally, T&E has also assessed the supply chain practices and sourcing strategies as to their responsible human rights conduct and environmental stewardship (15 points).

Table 1: Breakdown of the battery supply chain index

Battery cell supply strategy	Battery cell manufacturing	15
	Battery cell recycling	5
	Battery chemistry	5
	Sub-total	25
Battery raw material supply chain	Battery raw material secured	15
	Battery raw material contracts	30
	Midstream supply chain	15

[7] T&E analysis of GlobalData's BEV production forecast in Europe.
[8] Fewer points are awarded for supply contracts and memorandums of understanding, see section 2.4 for more information.

	Sub-total	60
Responsible supply chain practices		15
T&E's battery supply chain index *(sum of yellow cells)*		**100**

The rationale behind each criteria is presented in the following sections, while details on the methodology are provided in the attached Excel Annex file.

2.1. Vertical integration of the battery supply chain

Having a foot in battery cell making is also paramount to OEMs' industrial success. Carmakers that have strong links with battery makers become more resilient as they can secure their production volumes in advance. For instance, they can pre-book a part or the whole battery production output of a partner in the event of disruptions in the supply chain. By producing cells in-house or with a joint venture partner, carmakers would not face higher margins from external suppliers and therefore better control costs. Establishing a close partnership with a supplier also makes it easier to manage the battery chemistry and cell design to optimise battery cells for their vehicle structure and pack design. Carmakers' involvement in the battery supply chain therefore reflects long-lasting commitments and is a sign of timely and ambitious strategic shift towards BEVs.

T&E's 'battery cell manufacturing' score (15 points) is designed to reward carmakers with more vertical integration of the battery cell supply chain globally. Points are awarded in the following order:

- The highest score is awarded to in-house cell production (15 points),
- Next, for the set-up of a joint venture or direct investment (equity) to support a battery cell supplier (10 points),
- Then long-term partnerships with a cell supplier are given 5 points.

2.2. Circular economy and batteries

As first-generation electric cars reach the end of their life, carmakers are beginning to pay more attention to the management of their batteries at the end of the vehicle life. Recycling battery cells does not only have an environmental benefit, it is also a key industrial strategy for carmakers as they can 1) secure raw materials supply and 2) secure a bigger economic value from batteries.

T&E's 'battery cell recycling' score rewards carmakers' recycling projects (5 points). The maximum score is given to carmakers that are already running recycling projects or have at least started the construction of a vertically integrated recycling plant. 4 points are awarded to carmakers that have in-house R&D and have at least started the construction of a recycling plant as part of a joint venture or direct investment. Then, 2 points are awarded for carmakers having either in-house research & development (R&D) projects or partnerships with recycling companies.

2.3. Innovation in battery technology

Innovation in battery cell chemistry or battery manufacturing could be a game-changer for the EV industry. By using new cathode and anode technologies, cell manufacturers can increase the energy density of their battery and decrease the amount of raw material needed. For instance, new lithium-manganese-iron-phosphate (LFMP) batteries [10] could reach higher energy density (up to 190 Wh/kg at pack level), surpassing the density of some nickel-manganese-cobalt cells (e.g. 167 Wh/kg[9] for the battery pack of the VW ID.4 using nickel-manganese-cobalt NMC712 cells) without the need of nickel and cobalt. Early movers to LFP are expected to reduce their reliance on nickel and cobalt more quickly and would gain more experience in managing this type of chemistry. New battery technologies such as solid-state batteries (SSB) have the potential to reach higher energy density and faster charging rate with a lower carbon footprint [12]. Sodium-ion batteries will also be a new alternative to reduce dependence on lithium.

Based on these innovations, carmakers could choose to reduce their battery size and weight as the higher density technologies would provide the same driving range. This would enable them to access the mass market segment faster, accelerating the transition. Consequently, carmakers could increase their resource efficiency and secure more batteries and BEVs for a given amount of raw material available. Within the tight critical metals market, doing more with less is a sound economic policy.

To reward carmakers' best battery chemistry strategies, T&E's 'battery chemistry' score (5 points) is based on the use of LFP chemistry in 2022[10] (2 points), on investment or partnerships in innovative technologies (2 points) and on the early production of sodium-ion batteries (1 point). Regarding innovation, the maximum score (2 points) is awarded when the company has developed its own innovative technology while 1 point is given to carmakers relying on partnerships.

2.4. Securing battery raw material supply

Automaker BEV commitments cannot materialise without securing on time and in volumes the lithium, nickel and cobalt all those batteries need. According to BNEF [14], the pressure on the battery raw materials market has been easing recently, with lithium, nickel and cobalt expected to be in surplus in the next few years[11]. However, uncertainties remain towards the end of the decade and beyond 2030.

Given the global race to secure the limited supplies, the average numbers do not mean that every global carmaker will easily secure what they need at competitive prices. Securing critical minerals early, beefing up procurement policies and an active involvement deeper into the value chain are all needed to secure the volumes on time, in a resilient manner and with strong environmental stewardship at its core.

[9] The 82kWh pack weighs 489 kg. [11]

[10] The maximum score is awarded to carmakers who reached 39% LFP battery use in 2022. 39% is the average LFP share in the passenger car market based on BloombergNEF's Lithium-Ion Batteries State of the Industry 2023 database [13].

[11] BNEF projects the lithium resource market will remain tight in 2023 and 2024, before easing after 2025 as more projects are commissioned.

Just like Henry Ford invested in rubber plantations last century, carmakers today have every interest in tying closer links with the upstream industry (miners or recyclers) to secure their raw materials supply early on. With the right strategy and level of involvement, carmakers can both protect themselves against volatile market prices and support the growth of a sustainable supply chain. For instance, early contracts to meet carmakers' long term material demand would enable the mining sector to have improved market visibility and better plan investments. OEM involvement in the upstream supply chain can also support the financing of new raw materials projects, European start-ups, as well as advanced cleaner technologies [12].

T&E's 'battery raw material supply' score (60 points) is designed to assess carmakers' progress in securing the battery material needed for their BEV plans, both in the upstream and midstream part of the supply chain. The first quantitative criterion assessed is how much of the lithium, nickel and cobalt required has already been secured. For this, T&E assessed the quantity of material required for OEMs' global production in 2030[13], comparing this demand with the amount of material already secured in the contracts that are publicly disclosed. The share of the three raw materials secured so far is marked out of 15 points, with each metal given highest score when at least half of the demand is secured[14].

T&E assumes that it might not be realistic for all carmakers to already secure 100% of their supply given that some projects that will operate in 2030 might not already offer contracts to customers. There also remains uncertainty over both the volumes and battery chemistries. In many cases, the details of contracts are confidential, so T&E chose to allocate 15 points out of 60 points on quantitative factors, while 45 points are awarded for other more qualitative factors (see below).

The more qualitative criterion assessed is the long-term contracts and partnerships signed, and is marked 10 points max for each metal. Carmakers having their own subsidiary, a joint venture or direct investments in a mining or refining company get the maximum score as they directly support the development of new projects, and therefore are guaranteed to access the material. The maximum score is also given for companies when their contracts secure more than 50% of their 2030 demand. Carmakers only having long-term supply contracts are awarded half points (5 points) as these still provide planning certainty and visibility to the mining sector. OEMs' use of more uncertain memorandums of understanding (MoU) and non-binding contracts gives a minimum score of 2.5 points. While contracts with large and experienced mining companies may provide more security, we have not differentiated contracts by company size as OEM investments can provide the certainty the junior miner needs to be successful; in addition, new companies and start-ups may have more sustainable and ethical business practices.

[12] For instance, lithium extraction from geothermal brines or re-mining of waste tailings.
[13] Based on the global light duty vehicle BEV production targets mentioned in Annex 7.1. More information on the methodology is provided in the Annex 7.2.
[14] Each metal is marked out of 5 points and the maximum point is given for securing 50% of the metal demand.

In this category, we reward small carmakers that make efforts to secure battery materials, but on top award them 22.5 bonus points as their business size would not enable them to directly invest in the battery material supply chain compared to competitors.

Reducing demand is another strategy, similarly effective, that carmakers have to boost their resilience. In this ranking, T&E therefore supports carmakers that optimise battery chemistry to reduce dependence on specific minerals in 2030, for example nickel and cobalt by opting for LFP batteries, or cobalt only by opting for high nickel or high manganese chemistries. Therefore, carmakers that plan to use only nickel-free or cobalt-free chemistries will receive the maximum mineral score (for each metal, 5 points for the secured demand score and 10 points for the contract score).

2.5. Securing battery midstream material supply

In addition to raw materials, carmakers would also need a resilient midstream supply chain, i.e. processing of raw materials into battery-grade compounds and materials such as precursors for battery cathodes. On this aspect, automakers can form partnerships with companies specialising in cathode and anode material production to enhance their supply chain resilience and security. Investing or partnering in this value chain can also help control costs, therefore increasing the accessibility of BEVs to the mass market.

The sourcing of midstream processed metals is marked out of 15 points with 10 points for both cathode active materials (CAM) and cathode precursors (pCAM), and 5 points for anode materials. In each sub-category, the maximum score is given to carmakers having a joint venture or direct investment in processing projects and half points is given if carmakers only have supply agreements.

2.6. Responsible supply chain practices

As carmakers go electric and become more involved in the raw material supply chains, they must also ensure that the materials they secure are extracted responsibly. This is paramount not only for the sustainable transition more broadly, but also for consumer (and investor) acceptance, and therefore long-term competitiveness of companies themselves.

With regulations such as the EU Battery Regulation, the German Due Diligence Law and the draft EU Corporate Sustainability Due Diligence Directive in place or being finalised, companies are being asked to engage further in and improve their own operations as well as their supply chains. This means that carmakers that use their influence to ensure that the metals and components used in batteries are extracted and processed sustainably without fossil-based energy, while respecting the environment, human rights and community livelihoods, are best placed longer term.

T&E's 'responsible supply chain practices' score (15 points) is broken down into the following criteria:

- **Low-carbon processes** (4.5 points): carmakers can use their raw material contracts or investments to promote the development of extraction or processing technologies to reduce the carbon footprint of battery minerals. For instance, in Europe, Mercedes is cooperating with the

Canadian company Rock Tech Lithium that plans lithium refining in Germany [15] with a roadmap to achieving CO_2 neutral production of lithium hydroxide by the end of 2030. Points are given to carmakers that engage in such operations.

- **Responsible battery minerals sourcing** (3 points): In this category, the point is awarded to carmakers who have comprehensive standalone material policies that explicitly mention responsible battery minerals sourcing for lithium, nickel & cobalt in their materials policy (no point if the three metals are not mentioned). Further, an additional point is awarded if the company policy with regards to raw materials sourcing is based on the OECD guidelines for Multinational Enterprises and the OECD guidelines for conflicted affected and high-risk areas (that are relevant to cobalt in particular).
- **Human rights** (2 point): The points are awarded if carmakers have a standalone human rights policy (i.e. explicitly mentioned in their own in-house policies and not covered by other initiatives) that refers to the United Nations Guiding Principles on Business and Human Rights (UNGPs). The UNGPs are the best practice set of guidelines for States and companies to prevent, address and remedy human rights abuses committed in business operations.
- **Indigenous rights** (1 point): The majority of current and upcoming extraction projects in transition minerals globally are on or near the land of Indigenous People, so policies to engage those and ensure their consent is important. For instance, they can commit to the UN Declaration on the Rights of Indigenous Peoples (UNDRIP) and commit to respect the right to free prior and informed consent (FPIC). The point is awarded when carmakers mention both UNDRIP and FPIC.
- **Responsible initiatives & networks** (1 point): There are many initiatives and networks working towards responsible sourcing of materials such as the Responsible Minerals Initiative. Given that most minerals are sourced outside of the jurisdiction of EU safeguards, such global initiatives are important to raise standards globally. For this category, the maximum score is awarded to carmakers who are members of at least 4 outstanding global initiatives (excluding IRMA that has a specific score below).
- **IRMA** (2 point): The initiative for responsible mining assurance (IRMA) is the leading multistakeholder certification initiative promoting more socially and environmentally responsible mining, accepted by the European Commission as best practice globally. On top of the responsible initiatives score, an additional point is therefore awarded to carmakers who plan to source their battery materials from suppliers that are IRMA certified in the coming years.
- **Digital tracing of raw materials** (1.5 point): Innovations such as blockchain technologies can ensure the traceability of raw materials, which in turn is necessary for effective due diligence. Carmakers that invest in companies, or join partners and networks who are developing this tracking technology to improve traceability are rewarded.

3. Automaker ranking results

3.1. Ranking

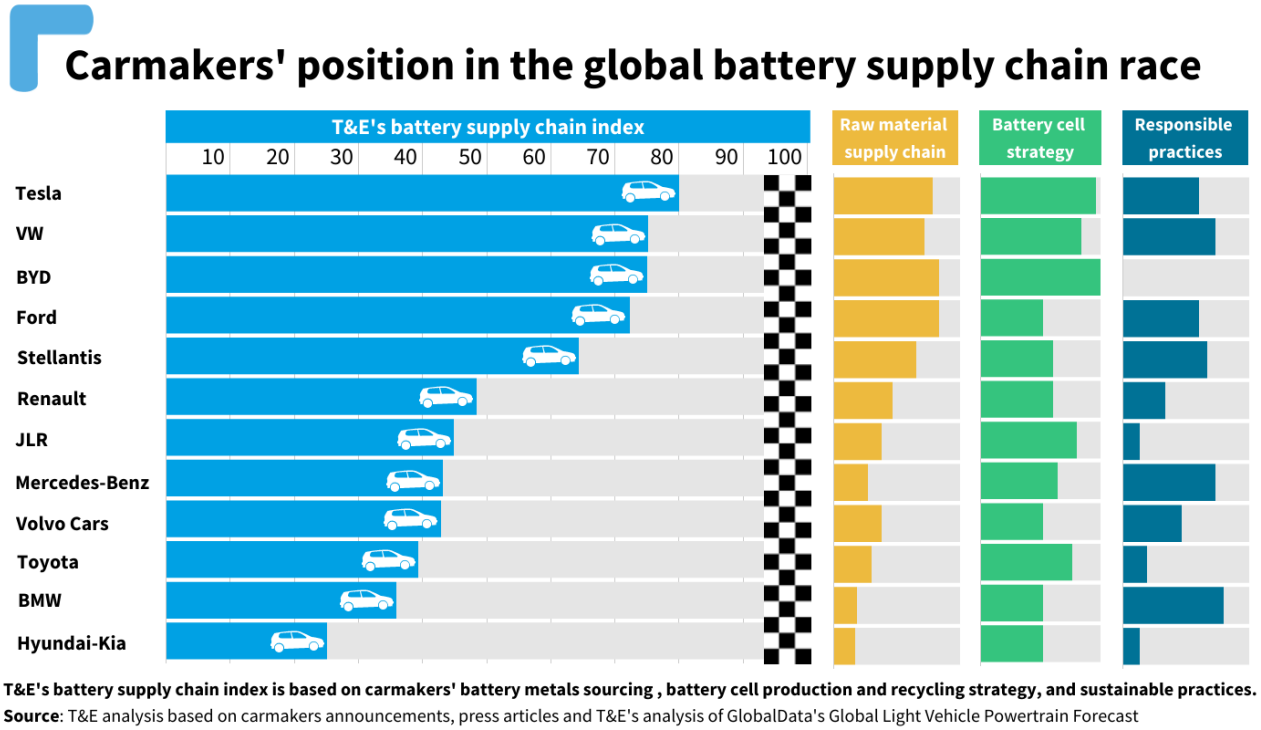


Figure 1: OEMs' position in T&E battery supply chain ranking

The level of preparedness among the carmakers (OEMs) varies widely: while Tesla leads the overall ranking (and BYD tops the minerals supply part), VW is the only legacy carmaker to score above 70 points (out of 100). Ford and Stellantis are relatively well prepared, scoring above 60 points each. But the majority of OEMs have scored less than 50 points: Renault, JLR, Mercedes-Benz, Volvo Cars, Toyota and BMW, with Hyundai-Kia at the bottom of the table.

While some carmakers reach high scores for their battery cell strategy (all carmakers get at least 10 points out of 15), the midstream and upstream parts of the supply chain are lagging behind. On battery materials - in terms of both secured supply and long-term contracts - a score of 30 out of 60 points has been reached. Only six companies – Tesla, BYD, VW, Ford, Renault and Stellantis – have long-term contracts for each of the three key metals or plan to change battery chemistries to end their dependence on one of the metals. Overall, this shows that the 12 OEMs ranked here still have a long way to go in terms of securing their raw material supply chain to make a success out of the EV transition.

This corroborates T&E's overall concern that while progress has been made on battery gigafactories in Europe, securing the supply of critical minerals further upstream (and in a sustainable way) is a glaring gap in many corporate strategies. Europe's new Critical Raw Materials Act plans to require companies to stress test their supply chains. Many OEMs are only waking up to the need to secure metals now amid a fierce global competition.

Carmakers are slowly becoming more involved in the upstream and midstream parts of the supply chain with many public announcements being made. But the lack of information and data on contractual agreements makes it hard to judge how robust these are.

Looking at lithium, nickel and cobalt, contracts with material quantity publicly available show that only 16% of the global material demand in 2030 is secured by carmakers. Carmakers started ramping up BEV production in 2019 ahead of the introduction of 2020/21 EU car CO_2 standards, but they seem to be just starting the race to secure their raw material supply chain and have a long way to go. In this race, raw material availability will not limit the overall BEV market growth as new supply (mining and recycling) projects are coming online, while chemistry innovations allow optimisation of resource efficiency. However, whether or not all carmakers individually will be able to secure the battery metals they need, and do so at cost-competitive prices (without high volatility) is a big question. Those that started early are better placed to succeed; our ranking shows VW, Ford and Stellantis to be ahead of legacy carmakers assessed in this ranking. As a comparison, one of the Chinese leading automakers, BYD is leading in the raw material supply category as the Chinese OEM is shifting away from nickel and cobalt use in its batteries and invests directly in lithium mining.

In the midstream part of the ranking (15 points out of the 60 points in the battery material supply chain category), Tesla leads with 12.5 points given its own cathode material production projects and supply contracts for precursors and anode materials. BYD, VW, Ford and Mercedes-Benz receive 10 points as they are all involved in some part of the midstream supply chain through subsidiaries, joint ventures or direct investments. Stellantis and Toyota are less involved and only have supply agreements for cathode active material. Renault, BMW and Hyundai lag in this part of the ranking with no public announcements for this part of the supply chain.

Another key differentiating factor will be the adoption of responsible supply chain practices and the support of low-carbon raw material streams, which will unlock both lower carbon footprint [12] for batteries and better ESG rating for carmakers. Our ranking shows German carmakers - BMW, Mercedes, and VW - to be leading here. Overall, more vertical integration in the whole battery supply chain will also enable carmakers to improve resilience and protect themselves against financial market volatility.

Table 2: Details of the T&E's battery supply chain index results

OEM	Battery raw material supply chain (/60)	Battery cell strategy (/25)	Responsible supply chain practices (/15)	Total (/100)
Tesla	24	47	9	80.0
VW	21	43	11	75.1
BYD	25	50	0	75.0
Ford	13	50	9	72.3
Stellantis	15	39	10	64.3
Renault	15	28	5	48.3
JLR	20*	23	2	44.8
Mercedes-Benz	16	16	11	43.1
Volvo Cars	13*	23	7	42.8
Toyota	19	18	3	39.2
BMW	13	11	12	35.9
Hyundai-Kia	13	10	2	25.0

* Due to their small business size, Volvo Cars and JLR benefit from 22.5 bonus points in the battery material supply chain category.

Tesla tops the battery supply chain strategy ranking with 80 points. Regarding battery cells, the American OEM produces its own 4680 cells at its gigafactory in Texas. Tesla scores well on raw materials, as T&E's analysis of GlobalData's forecast shows that the OEM is likely to move fully to cobalt-free chemistries (high nickel, high manganese and LFP) by 2030, while it has numerous contracts for lithium and nickel sourcing. In terms of sustainability, the BEV OEM is a member of IRMA, has a human rights policy and considers lithium, nickel and cobalt as priority metals. However, Tesla does not use its supply contracts to promote low-carbon extraction of battery raw materials and could improve its indigenous people's rights policy. Tesla is already planning lithium refining and CAM manufacturing in Texas.

VW comes second with 75.1 points. The German carmaker has opted for an ambitious cell manufacturing strategy, setting up its own subsidiary, Powerco, with 2 gigafactories already planned in Germany and Spain. In addition, joint ventures for nickel and cobalt (JV with Huayou Cobalt and Tsingshan in Indonesia) and for cathode materials (JV with Umicore and Huayou) make VW one of European carmakers most involved in the upstream and midstream supply chain. The carmaker has also adopted a

comprehensive set of policies on responsible sourcing of battery materials, due diligence and human right policies as well as a contract to buy CO_2 free lithium from Vulcan Energy. VW is a member of IRMA and plans to progressively apply the standard within their battery supply chain to source mined materials from IRMA certified mines. Regarding the end-of-life of batteries, VW is also the first carmaker to start operating its own pilot plant for recycling in Europe.

BYD comes third with 75.0 points. As the Chinese company started its battery cell activities long before it started producing cars, it gets the maximum score for battery cells. The Chinese carmaker has adopted a different strategy from the legacy OEMs, as it has chosen to switch to nickel- and cobalt-free chemistry to avoid dependence on nickel and cobalt supplies, so it only needs to secure its lithium supply chain in T&E's ranking, where it performs well thanks to vertical integration. The Chinese carmaker is also among the first to get involved in the production of sodium-ion batteries [16]. The OEM is planning its own mining project, has direct investments in lithium miners and other supply contracts. However, BYD came last on the "responsible sourcing" part of the index, having secured zero points there.

Ford comes fourth with 72 points. Ford's cell strategy is mainly based on two joint ventures: one with SK On in the US and one with LG Chem and Koç Holding in Turkey. Ford stands out as the carmaker with the best disclosure of its material contract details, and has the largest percentage of raw material secured globally. We have estimated that at least 60% of its lithium demand and 74% of its nickel demand in 2030 are secured, and Ford has a direct investment in a nickel project that will also produce cobalt. Ford has two contracts to buy lithium from geothermal sources[15], a set of policies including OECD due diligence guidelines and human rights, and is part of IRMA, but Ford would need to align its indigenous rights policies with UNDRIP.

Stellantis comes fifth with 64 points. The group has a comprehensive battery cell strategy, based mainly on its Automotive Cells Company (ACC) joint venture with Mercedes-Benz and TotalEnergies's Saft. Stellantis has chosen to invest directly in mining companies with stakes in at least 4 companies for lithium, nickel and cobalt[16]. Stellantis also stands out for its partnerships in low-carbon materials with 2 contracts for lithium extracted from geothermal brines and one for nickel processed with an energy-efficient bioleaching process[17]. Stellantis is involved in the European production of cathode materials through ACC's supply agreement with Umicore. Stellantis has responsible sourcing standards for battery materials and human right policies but it would need to align its indigenous rights policies with UNDRIP and the group is not part of IRMA.

Renault comes sixth with 48 points. For its cell strategy, Renault has opted for a direct investment in the French battery manufacturer Verkor. The carmaker disclosed the quantity of raw material it secured in its contracts and has a direct investment in Lithium de France. Renault has contracts for low-carbon lithium

[15] Lake Resources in Argentina and EnergySource Minerals in California.
[16] Stellantis is the second largest shareholder of Vulcan Energy for lithium. It invested in ACG Electric Metals for nickel, Alliance Nickel and Kuniko for both nickel and cobalt.
[17] For lithium, Vulcan Energy in Germany and Controlled Thermal Resources (CTR) in California. For nickel, Terrafame in Finland.

and nickel sourcing[18] but lacks a set of standalone policies on human rights and indigenous rights, as well as a membership in IRMA.

JLR comes seventh with 45 points. JLR's battery cell strategy is based on a partnership with Agratas, the battery subsidiary of its parent company Tata, which will build a gigafactory in the UK. JLR benefits from bonus points allocated to small carmakers (22.5 bonus points as small businesses might not have the capacity to be involved significantly in the upstream and midstream supply chain). JLR would need to refine its policies regarding responsible supply chain practices, human rights and due diligence for battery materials.

With 43.1 points, **Mercedes** comes eighth. Mercedes became an equal shareholder in ACC with Stellantis and Saft in 2022. On battery recycling, Mercedes has started to build its own recycling plant in Germany, with the first stage planned to start at the end of 2023. However, the German carmaker appears to have a low involvement in the upstream supply chain, with only one contract publicly disclosed for lithium sourcing[19]. Regarding the midstream supply chain, Mercedes benefits from ACC's supply agreement with Umicore for cathode materials. Mercedes is second on the responsible supply practices category with a comprehensive set of policies and its future suppliers will be required to source exclusively from mines that have been audited in accordance with the Standard for Responsible Mining of IRMA. Mercedes also has a partnership with Rock Tech Lithium to define a roadmap to achieving CO_2 neutral production of lithium hydroxide by the end of 2030.

Volvo Cars comes ninth with 42.8 points. Volvo Cars also benefits from bonus points for small carmakers. Volvo developed a consistent battery cell supply strategy as it has chosen to set up a joint venture with Northvolt. Volvo lacks a membership in IRMA and has no contracts for low-carbon materials.

Toyota comes tenth with 39 points. The Japanese carmaker invested in cell manufacturing in Japan and the United States. Despite having a subsidiary (Toyota Tsusho) that owns a lithium mine in Argentina, the carmaker does not seem to have involvement in the sourcing of other materials. Toyota would need to better specify its responsible supply chain practices.

BMW is ranked eleventh with 36 points. The German group has notably invested in Northvolt to secure its battery cell strategy in Europe and it has a JV with Brilliance Automotive that will produce cells in China. The carmaker is part of a joint technology consortium for recycling with Northvolt and Umicore in Europe but it has yet to set-up its own battery recycling plant. BMW has the most ambitious responsible sourcing policy: BMW has human rights and indigenous rights policies and has joined IRMA in 2020 with the aim to influence the supply chain to obtain IRMA certification for mines. BMW invested in Lilac Solutions's new environmentally-friendly lithium mining process and in Mangrove Lithium's green lithium-refining solution. However, BMW loses the most points in the battery minerals section of the ranking because the German company has not disclosed sufficient information about how it intends to secure nickel, cobalt, or cathode materials.

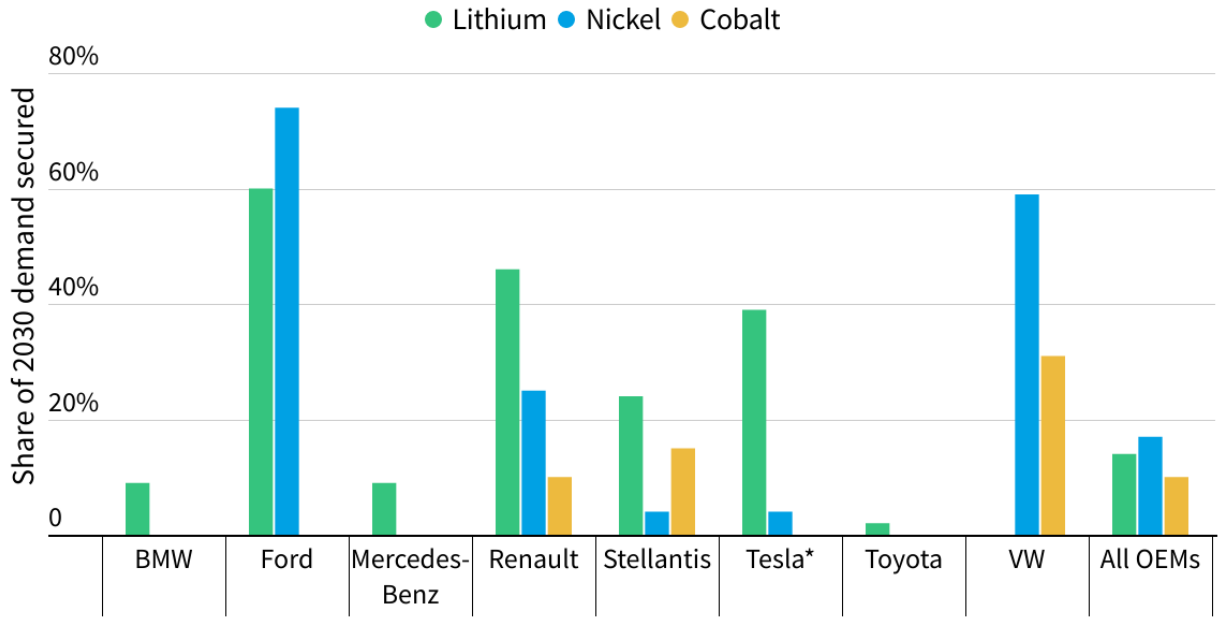
[18] For lithium, Vulcan Energy in Germany and Lithium de France (Arverne Group). For nickel, Terrafame in Finland.
[19] Supply agreement with Canadian-German-start-up Rock Tech Lithium from 2026.

Hyundai-Kia comes last with 25 points. The Korean carmaker has two JVs with LG Chem and SK On in the US. The Korean group has one direct investment in the nickel supply chain with Korea Zinc but has not disclosed any other contracts in the upstream and midstream supply chains. The carmaker also lacks clear responsible supply chain practices.

3.2. Raw material secured for global demand by 2030

Based on the data gathered on the battery raw materials secured, Figure 2 compares the share of lithium, nickel and cobalt 2030 demand secured by carmakers. Carmakers appear to have very different strategies, with some having no contracts publicly disclosed at all, while others, such as Ford, well advanced with many contracts disclosed (including the quantity of material secured).

Overall, for each metal, less than a fifth of the demand is secured: 14% of the lithium demand, 17% of the nickel demand and 10% of the cobalt demand are secured by the 10 carmakers by 2030. Aggregating the three metals, a sixth (16%) of the raw material demand in 2030 is secured. Given that roughly 10-20% of the metals needed are often secured on spot markets to hedge risks, this is a very low number of what would have been expected on long-term contracts.



Carmakers that do not provide public information on the quantity secured are not displayed

* Tesla is assumed to go to cobalt-free chemistries and does not need to secure cobalt

Scope: Global demand of raw material used in BEV and PHEV batteries of light duty vehicles (cars and vans)

Source: T&E analysis based on carmakers' raw material contracts publicly disclosed

Figure 2: OEMs' share of 2030 global battery material demand secured

European carmakers seem to be only at the beginning of their efforts to secure the raw material for their battery plans, so they should accelerate their involvement in this part of the supply chain to deliver on

their BEV strategies. Given the global competition on BEVs is only intensifying, the critical minerals are also paramount in order to accelerate plans, enter the Global South markets and work with miners and processors alike to ensure investments and high social and environmental criteria are embedded in future projects.

4. EU resilience

4.1. Battery gigafactory plans can meet the cell demand in Europe

The ramp-up of the EV industry in Europe depends on the EU's ability to secure batteries and battery materials. In 2018, 27% of batteries fitted on European light-duty vehicles (cars and vans) were produced in Europe[20].

Since then, the production from first gigafactories (mainly LG Chem in Poland and Samsung SDI in Hungary) have ramped-up to reach 71 GWh in 2022. This means that 68% of the battery capacity needed to produce electric cars and vans in 2022 has already been covered by European battery production. This includes the following companies:

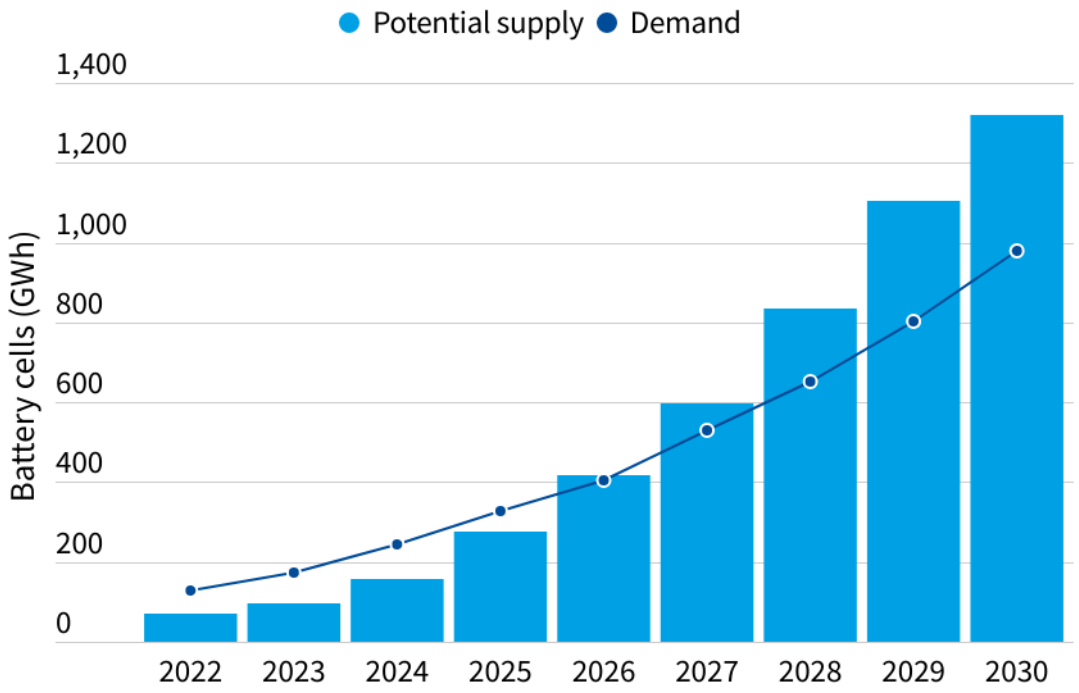
- LG Chem in Poland with an output of at least 48 GWh
- Samsung SDI in Hungary with an output of at least 16 GWh
- SK On in Hungary with an output of at least 5.7 GWh
- Envision AESC in the UK with an output of at least 1.5 GWh
- CATL in Germany with an output of at least 0.5 GWh

In the medium term, T&E shows that Europe can be self-sufficient in terms of battery production capacity from 2027 onwards, confirming previous analysis [17]. Unless major gigafactory projects are significantly delayed, the actual European battery cell production would reach 1,320 GWh in 2030 (equivalent to 71% of the total announced capacity of 1,860 GWh[21] based on more than 50 announced gigafactory projects). This level of supply would outstrip demand by 35% (total demand around 1,000 GWh in 2030).

Europe was previously expected to be second after China [19] in 2030 but the latest data by Benchmark Mineral Intelligence (BMI), following the investments due to the US Inflation Reduction Act (IRA), now puts Europe in third place after the US. While T&E calculations look at the capacity of all public announcements, BMI has a different methodology to identify projects' likeliness and maturity. BMI now puts Europe in third place with 750 GWh of production output, as China will have 3,670 GWh and the US will have 810 GWh in 2020.

[20] T&E analysis of GlobalData dataset with the whole European light duty vehicles production (including light commercial vehicles).

[21] T&E's modelling includes a progressive ramp-up of the battery production up to a maximum utilisation rate of 85% as considered by the IEA [18]. The modelling also includes production scrap depending on the plant age.



Battery plants assumed to progressively ramp-up up to 85% of their nameplate capacity.
25% to 5% production scrap included depending on plant age.
Demand from cars, vans, trucks, energy storage system. Demand for cars & vans based on GlobalData's forecast for Europe.
Source: T&E analysis, company reports, GlobalData's Global Light Vehicle Engine Forecast (Q1 2023)

Figure 3: Battery cell production output and demand scenarios in Europe

4.2. OEM resilience in the European battery supply chain

While carmakers are making progress to secure their battery cells in Europe, they also need to support the overall battery material supply chain with investments in processed battery metals and in recycling processes in Europe. Carmakers would need a resilient midstream supply chain, i.e. processing of raw materials into battery-grade compounds and materials, such as precursors for battery cathodes. This remains the most concentrated part of the value chain today, with most processing done in China, posing significant geopolitical risks to the global EV industry.

Producing in-house or sourcing battery materials locally can both reduce supply chain risks and reduce emissions associated with longer logistics and transportation. As experienced and large Tier 1 OEMs, carmakers are also best placed to help Europe's nascent onshoring activities scale up effectively. To do this, automakers can either vertically integrate themselves or form partnerships with companies engaged in refining processes, as well as those specialising in anode and cathode material production in Europe to enhance their supply chain resilience and security. Investing or partnering in this value chain can also help control costs, therefore increasing the accessibility of BEVs to the mass market.

To evaluate the resilience of carmakers in Europe, T&E defined the following methodology:

- **The battery cell resilience score** (10 points) is designed to reward carmakers with more vertical integration in the battery cell supply chain in Europe. The highest score is awarded to in-house cell production in Europe (10 points), next for the set-up of a joint venture and direct investment (equity) to support a battery cell supplier (7.5 points), then long term partnerships with a cell supplier are given 5 points.

- **The processed battery metal resilience score** (10 points) is designed to reward carmakers with more vertical integration in the midstream battery supply chain in Europe. It is divided in 2 categories: cathode/precursors and other materials (anode, refined metals) with 5 points each. In each sub-category, the maximum point (5 points) is awarded to carmakers having a joint venture or direct investment with a company in Europe. 2.5 points are awarded for other contract types (long term supply/offtake agreement or MoU).

- **The cell recycling resilience score** (5 points) is designed to reward carmakers with more vertical integration in the battery cell recycling in Europe. The maximum score (5 points) is awarded to carmakers that are already running a recycling plant in Europe or have at least started the plant construction. 4 points are awarded to carmakers that have in-house projects in Europe or have at least started the construction of a recycling plant as part of a joint venture. Then, 2.5 points are awarded to carmakers having partnerships with recycling companies in Europe.

Based on this methodology, VW, Stellantis and Mercedes are the most involved in the EU battery supply chain while international competitors Tesla, Toyota, Ford and Hyundai-Kia are not supporting the EU battery ecosystem. The analysis also shows that four carmakers (VW, Mercedes-Benz, Renault and Stellantis) are already involved in European midstream projects. Details of the OEMs' score and the methodology are provided in the attached Excel Annex file.

Table 3: Details of the T&E's battery supply chain index results

OEM	Battery cell resilience (/10)	Processed battery metals resilience (/10)	Battery recycling resilience (/5)	EU resilience (/25)
VW	10	8	5	23
Stellantis	8	8	4	19
Mercedes-Benz	8	5	5	18
Renault	8	5	3	15
JLR	10	0	4	14
Volvo Cars	8	0	4	12
BMW	8	0	3	10
Tesla	5	0	3	8
Toyota	5	0	3	8
Ford	5	0	0	5
Hyundai-Kia	5	0	0	5

5. Conclusions

Since T&E's previous OEM EV readiness ranking in 2021, OEMs have made progress on their strategies around BEV manufacturing, sales and charging thanks to the pull from the EU car CO_2 standards. The deep dive into the upstream and midstream battery supply chain has enabled new conclusions to be drawn about carmakers' strategies. Despite many recent public statements on the importance of raw materials, actual data to beef up those words is hard to come by. Only a sixth of raw material demand in 2030 is secured by carmakers based on data disclosed publicly. Only six companies – Tesla, BYD, VW, Ford, Renault and Stellantis – have long-term contracts for each of the three key metals or plan to change battery chemistries to end their dependence on one of the metals. Carmakers seem to be only at the beginning of their efforts to secure the material for their battery plans, and they still have a long way to go. As fierce global competition between American, Asian and other global automakers to secure their battery metals is intensifying, the key message from T&E's ranking is that European OEMs are still far from their goals. They should accelerate vertical integration, investments and all manner of involvement in this part of the supply chain to deliver on their BEV strategies on time, volume and budget.

But speed should not trump quality, so automakers should also keep an eye on the sustainability of their sourcing practices and implement responsible best practices through their supply contracts. In terms of responsible practices, the analysis shows that German carmakers are leading this part of the ranking, while such a large Chinese carmaker as BYD has not scored any points. Carmakers also need to strive to improve their resource efficiency by focusing on well-designed, efficient and right-sized BEVs, with innovative battery technologies chosen to minimise the resources required.

When looking at the midstream part of the supply chain - either material refining or cathode and anode material processing - carmakers should support the growth of this value chain in Europe to improve their own resilience as well as help Europe's efforts to onshore and diversify the supply chains. Four carmakers (VW, Mercedes-Benz, Renault and Stellantis) are already involved in European midstream projects.

Carmakers still have a long way to go and they must continue to accelerate their transition, support the creation of the European EV ecosystem and secure the raw materials they need. Otherwise, they risk losing market share in Europe to global competition, as well as their current standing in global markets. Now that car CO_2 standards are no longer the driving force behind the EV market, carmakers have a responsibility and a competitive impetus to secure the EV transition and to protect their European market share. Their industrial, technological and financial choices can still make or break the EV transition in Europe.

6. Recommendations

In order to support the sustainable and competitive growth of the European BEV industrial ecosystem, T&E recommends the following:

- Policymakers should lock-in the 2035 combustion engine phase-out for EV supply chain investment certainty, and move to implement the onshoring goals recently agreed under both the net zero and critical raw materials acts.

- Industrial and fiscal policies at both EU and national levels should encourage faster scale-up of battery and EV manufacturing in Europe. EV subsidy and support schemes should reward local manufacturing, compact models and innovative clean technologies.

- European carmakers should accelerate their involvement into midstream and upstream battery supply chains, invest into resource light battery chemistries and efficiency. They should engage into global efforts, e.g. EU Strategic Partnerships with resource-rich countries and the Minerals Security Partnership to support minerals projects with EU offtake.

- Product sustainability rules, such as the EU Battery regulation, must be swiftly implemented to accelerate sustainable battery cell manufacturing in Europe. Higher social and environmental standards within mineral supply chains should be ensured through an ambitious agreement on

the Corporate Sustainability Due Diligence Directive (CSDDD) and a quicker adoption of best-in-class global standards (such as IRMA).

- The EU must develop a comprehensive green industrial policy focused on robust sustainability regulations, streamlined permitting, smart trade strategies and adequate EU-level funding to expand midstream and upstream supply chain manufacturing locally. Priority should be on minerals processing, notably cathodes, anodes and precursors.

7. Annexes

7.1. Carmakers' EV commitments

Table 4: Carmakers' EV commitments in Europe and globally by 2030

	Global 2030 targets
BMW	50% ZEV [20]
Ford	50% BEV [21]
Hyundai-Kia	3.64 million BEVs [22]
JLR	82% by 2029 [23]
Mercedes-Benz	100% BEV for cars assumed in the US and EU [24] 50% BEV for vans [25]
Renault	Renault brand: 100% BEV in Europe [26] (passenger cars)
Stellantis	100% of sales in Europe (passenger cars only) and 50% BEV in the US [27]
Toyota	3.5 million BEVs [28]
Volvo Cars	100% [29]
VW	50% BEV [30]

7.2. Carmakers' raw material secured

The share of raw material secured for each carmaker is calculated with the following methodology:

1) The quantity of lithium, nickel and cobalt secured is based on public information (carmakers website and press releases). The mass of material in various contract is announced with various units, therefore the following conversion are applied to express the total amount of metals secured in terms of metal content:

Table 5: Metal content per raw material compound

Compound	**Metal content**
Li hydroxide monohydrate	16.5%

Li carbonate	18.8%
Lithium spodumene concentrate	2.8%
Nickel sulphate	22.3%
Cobalt sulphate	20.5%

2) For each material (lithium, nickel and cobalt), the metal demand is based on T&E analysis:
   - For each carmaker, the 2030 battery demand is derived from GlobalData's global production forecast including vans and light commercial vehicles.
   - Then, a correction factor is applied to account for the difference between GlobalData's forecast and carmakers' global BEV targets. This correction ensures that the battery demand is aligned with OEM BEV commitment (section 7.1).
   - The metal content per chemistry is based on BNEF's Lithium-Ion Batteries State of the Industry 2022 database and T&E assumptions while the average chemistry per carmaker is derived from GlobalData's global production forecast.
   - Based on the battery demand needed to meet global targets, on the share of each battery chemistry, on the metal content per chemistry and on a cell production loss factor[22] from BNEF, T&E estimated the quantity of each metal required to meet carmakers 2030 EV targets.

3) The percentage of material secured is calculated based on the quantity secured calculated in point (1) divided by the quantity needed to meet the 2030 global EV target calculated in point (2).

[22] 5% inactive material, 15% material loss during the formation cycle and 5% overall waste material. [31]

7.3. Carmakers' detailed ranking

				Score	BMW	BYD	Mercedes-Benz	Ford	Hyundai-Kia	JLR	Renault	Stellantis	Tesla	Toyota	Volvo Cars	VW
Battery supply chain strategy	Battery material supply chain	Battery raw material secured	Share of 2030 lithium demand secured	5.0	0.9	0.0	0.9	5.0	0.0	0.0	4.6	2.4	3.9	0.2	0.0	0.0
			Share of 2030 nickel demand secured	5.0	0.0	5.0	0.0	5.0	0.0	0.0	2.5	0.4	0.4	0.0	0.0	5.0
			Share of 2030 cobalt demand secured	5.0	0.0	5.0	0.0	0.0	0.0	0.0	1.0	1.5	5.0	0.0	0.0	3.1
			Sub-total	**15**	0.9	10.0	0.9	10.0	0.0	0.0	8.0	4.3	9.3	0.2	0.0	8.1
		Battery raw material contracts	Lithium contracts	10	10.0	10.0	5.0	10.0	0.0	5.0	10.0	10.0	10.0	10.0	5.0	5.0
			Nickel contracts	10	0.0	10.0	0.0	10.0	10.0	5.0	5.0	10.0	5.0	2.5	5.0	10.0
			Cobalt contracts	10	0.0	10.0	0.0	10.0	0.0	5.0	5.0	10.0	10.0	0.0	5.0	10.0
			Sub-total	**30**	10.0	30.0	5.0	30.0	10.0	15.0	20.0	30.0	25.0	12.5	15.0	25.0
		Midstream supply chain	Cathode and precursors	**10**	0.0	10.0	5.0	10.0	0.0	5.0	0.0	5.0	10.0	5.0	5.0	10.0
			Anode	**5**	0.0	0.0	5.0	0.0	0.0	2.5	0.0	0.0	2.5	0.0	2.5	0.0
			Sub-total	**15**	0.0	10.0	10.0	10.0	0.0	7.5	0.0	5.0	12.5	5.0	7.5	10.0
		Sub-total		**60**	10.9	50.0	15.9	50.0	10.0	22.5	28.0	39.3	46.8	17.7	22.5	43.1
	Battery cell strategy	**Battery cell manufacturing**		**15**	10.0	15.0	10.0	10.0	10.0	15.0	10.0	10.0	15.0	15.0	10.0	15.0
		Battery reycling		**5**	2.0	5.0	5.0	2.0	2.0	4.0	4.0	4.0	5.0	2.0	2.0	5.0
		Battery chemistry	LFP share in 2022	2	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0
			Innovation	2	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	1.0	1.0
			Sodium-ion	1	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			Sub-total	**5**	1.0	5.0	1.0	1.0	1.0	1.0	1.0	1.0	4.0	2.0	1.0	1.0
		Sub-total		**25**	13.0	25.0	16.0	13.0	13.0	20.0	15.0	15.0	24.0	19.0	13.0	21.0
	Responsible supply chain practices	Low-carbon processes		4.5	1.5	0.0	1.5	1.5	0.0	0.0	3.0	4.5	0.0	0.0	0.0	1.5
		Responsible battery minerals sourcing		3	3.0	0.0	3.0	1.5	0.0	0.0	1.5	1.5	3.0	0.0	3.0	3.0
		Responsible initiatives & networks		1	1.0	0.0	0.8	0.8	0.0	0.3	0.3	0.5	0.8	0.5	0.8	1.0
		IRMA		2	2.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	2.0
		Digital tracing of raw materials		1.5	1.5	0.0	1.5	1.5	0.0	1.5	0.0	1.5	1.5	0.0	1.5	1.5
		Human rights		2	2.0	0.0	2.0	2.0	2.0	0.0	0.0	2.0	2.0	2.0	2.0	2.0
		Indigenous rights		1	1.0	0.0	0.5	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0
		Sub-total		**15**	12.0	0.0	11.3	9.3	2.0	2.3	5.3	10.0	9.3	2.5	7.3	11.0
	Total			**100**	**35.9**	**75.0**	**43.1**	**72.3**	**25.0**	**44.8**	**48.3**	**64.3**	**80.0**	**39.2**	**42.8**	**75.1**

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