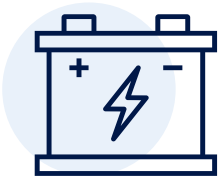
TURBULENT BATTERY CELL MARKET

Despite the drastic decline in worldwide vehicle production, there is an increase in the number of registrations of battery-electric vehicles and therefore demand for battery cells as well.



Currently, the battery cell market is going through a phase of rapid growth, but development projections point to a high variance within the next few years as well as a slowdown beyond 2030. The actual development will be characterised by the handling of a number of crises (resource and energy supply; availability of precursors, skilled labour) facing the international – and in particular the European – battery industry.

The global lithium ion battery (LIB) market keeps growing dynamically despite difficult market conditions, such as the ongoing aftermath of the COVID-19 pandemic, Russia's war in Ukraine, and the rise in raw material costs (Figure 1). According to Benchmark Mineral Intelligence, the last four years have seen investments in new LIB factories of almost 300 billion USD – more than 40% (131 billion USD) in 2022 alone.[1] This enormous expansion of the battery cell market can primarily be ascribed to the continued market diffusion of battery-electric vehicles (BEVs).

In the first half of 2022, the worldwide sales of BEVs[1] for passenger traffic grew to almost 4.3 million units, corresponding to a 63% increase year-over-year.[2] In this timeframe, batteries with a cumulative storage capacity of approximately 200 GWh were released, 79% more than in the first half of 2021.[3]

This development will presumably continue since, in the face of continued climate change, numerous governments around the world have set the date for the phase-out of light vehicles with internal combustion engines.[4] From 2035 on, only zero-emission vehicles (ZEV) will be registered in the EU – the same applying to other countries such as Great Britain or Chile.[4, 5]

Massive rise in demand with large variance in market projections

The automotive industry has long since become the largest consumer of LIBs.[6] The production of BEVs will be the largest market for LIBs for the next few years, thus the future demand for LIBs will mainly be determined by the speed of electrification of the mobility sector.

An evaluation of 17 analyses[2] of the development of the global LIB market, which were published in 2021 and 2022, show a massive demand increase as well as a large variance in market projections (Figure 1). These striking differences in projections are primarily caused by differing assumptions on which the analyses referring to the development of the conditions and the ramp-up are based, such as a progressive as well as a conservative development scenario. Examination of the scenarios that were declared as realistic by the respective authors results in a markedly narrowed funnel of scenarios, through the middle of which runs a path that represents the most likely of scenarios from today's perspective. In this scenario, the compound annual growth rate (CAGR) of the global battery cell market of the current decade is estimated to be approximately 26%.

According to the middle path of realistic scenarios in Figure 1, the battery demand will rise to 3.2 terawatt hours per year (TWh/a) in 2030 and 7.1 TWh/a in 2040. Some recent publications expect far larger battery cell production capacities.[7] However, due to bottlenecks in skilled labour and in up-stream supply chains it is questionable if these capacities can be realised (cf. Sensitivities, Figure 1). Supportive political measures or supply chain bottlenecks will continue to have a strong

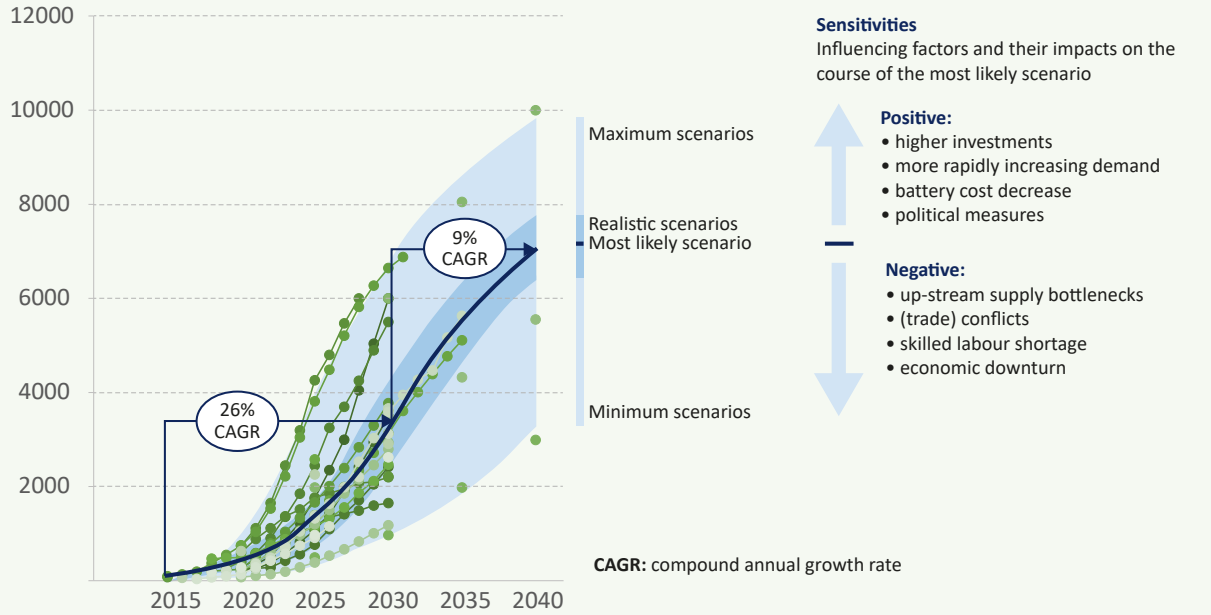
1 Battery electric vehicles (BEVs), fuel cell electric vehicles (FCEVs) and plug-in-hybrid electric vehicles (PHEVs)

2 Data sources: 21 market development scenarios from 17 market analyses by Agora Verkehrswende, Avicenne, BCG, Benchmark Minerals Intelligence, Bloomberg NEF, CEA, US DoE, Fraunhofer ISI, Goldman Sachs, W. H. Green, IEA, McKinsey, METI Japan, PWC, Roland Berger, S&P Global Market Intelligence, WEF & GBA.

influence on the development of battery demand in the coming years, as recently illustrated by the decision for strong financial support of US-based industries (Inflation Reduction Act) or pandemic-related production delays.

In the long run, market saturation and a slowdown of the battery cell market growth are to be expected. After the current phase of rapid growth until 2030, the CAGR of the following decade will fall to 9%, according to the middle path of realistic scenarios (Figure 1). This consolidation phase has corresponding consequences for market actors. The continuing market saturation will lead to increasing cost pressure and enterprises that have not secured a strong position in their respective segment will have troubles persisting in the market. The number of companies will consolidate through mergers and acquisitions and hence the market will be served by fewer but more solidly positioned suppliers.

Figure 1: Development scenarios of the global Li-ion battery market until 2040 in GWh/a.



In between the minimum and maximum scenarios (light blue area) ranges a much narrower scenario range (blue area), which was declared realistic by the respective authors and in the middle of which runs the path that represents the highest probability of occurrence from today's perspective. This is based on 17 analyses of the development of the global LIB market published in 2021 and 2022.

Strong growth of production capacities – worldwide as well as in Europe

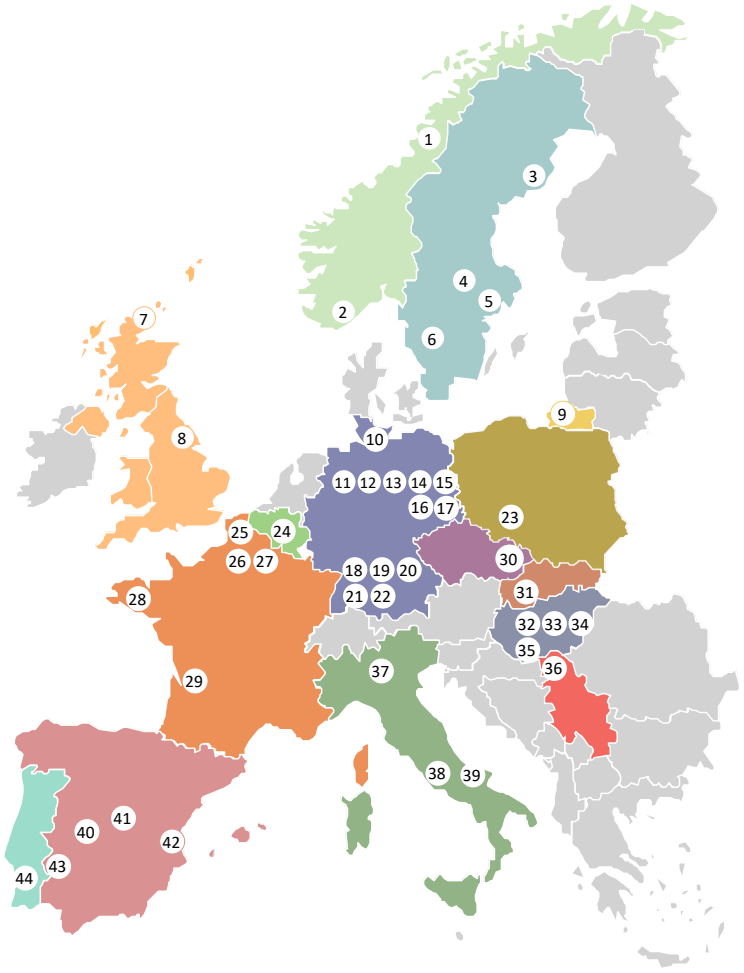
The dynamics in the global battery cell market is as high as ever on vendor side as well. In the face of the rapid growth of the predicted demand for LIBs, the number of planned and announced gigafactories the world over has risen considerably in the last few years. The better part of the new production sites were recently announced by established manufacturers such as CATL, LG Energy Solution, SK On, and Samsung SDI. Particularly in Europe and North America, where the installation of regional capacities is expedited massively at this time, numerous new market actors as well as classic automobile companies have disclosed the development of new production sites for LIBs, or expansions of planned production volumes.

In Europe there are currently approximately 50 sites[3] at the planning stage, under construction, or already partly in operation, whose cumulative annual production capacity will presumably yield between 920 and 1600 GWh/a by 2030 (Figure 2). Considering that factories can produce battery cells neither permanently at full capacity nor without defects, the real production capacity in 2030 will probably range between 850 and 1300 GWh/a. This number corresponds roughly to a 21% increase compared to the Market Analysis Update Q2 2022.[8] In case of maximum realisation of announced production capacities,

3 Pilot plants and projects that have not gone beyond property options (e. g. Freyer in Finland or Coventry in Great Britain) were not considered.

Figure 2: Battery cell production sites in Europe that are in planning, under construction or partly already in operation (i. o.).

		Start of production	Max. Capacity in GWh/a	Investments in Mio. EUR	Jobs
Norway					
1	FREYR	2024	43	4500	1500
2	MORROW	2024	43	470	2000
Sweden					
3	northvolt	i. o.	60	4000	2500
4	northvolt	2025	50	n/a	1000
5	northvolt	i. o.	0.35	750	1000
6	northvolt	2025	50	2900	n/a
Great Britain					
7	amte	i. o.	0.5	n/a	n/a
8	Envision AESC	i. o.	38	1185	1650
	Nanotech Energy	n/a	n/a	1140	n/a
Russia					
9	Rosatom	2026	12	n/a	2000
Germany					
10	northvolt	2025	60	n/a	3000
11	国轩高科	2023	18	n/a	n/a
12	PowerCo	2025	40	1300	2500
13	QuantumScape	2024	21	n/a	n/a
14	Tesla	n/a	100	5000	2000
15	Blackstone Resources	i. o.	10	40	n/a
16	CATL	i. o.	100	1800	2000
17	SVOLT	2025	16	n/a	n/a
18	SVOLT	2027	24	1700	2000
19	ACC	2025	40	2168	2000
20	Leclanché Energy Storage Solutions	i. o.	2.5	48	n/a
21	CELLFORCE	2024	1	n/a	n/a
22	VARTA	2026	2	1000	500
Poland					
23	LG Energy Solution	i. o.	65	2800	1800
Belgium					
24	ABEE	n/a	3	n/a	n/a



For companies without an assigned number, the exact location within the country or within Europe has not yet been disclosed.

		Start of production	Max. Capacity in GWh/a	Investments in Mio. EUR	Jobs
France					
25	Verkor	2025	50	1600	1200
26	ACC	2023	40	2600	1700
27	Envision AESC	2027	31.5	800	1200
28	BOLLORÉ LOGISTICS	i. o.	0.25	n/a	n/a
29	SAFT	2021	0.2	200	n/a
Czech Republic					
30	MES	i. o.	1.2	38	250
Slovakia					
31	InoBat	2026	10	100	150
Hungary					
32	SK Innovation	i. o.	17.5	1500	1410
33	SAMSUNG SDI	i. o.	40	n/a	n/a
34	CATL	n/a	100	7340	n/a
35	SK Innovation	2028	30	1980	2500
Serbia					
36	ElevenEs	2026	16	n/a	n/a
	InoBat	2025	32	n/a	n/a
Italy					
37	ITALVOLT	2024	70	4000	4000
38	FAAM	i. o.	8.3	505	n/a
39	ACC	2024	40	2000	n/a
Spain					
40	Envision AESC	2025	50	n/a	3000
41	Phi4tech	n/a	2	80	150
42	PowerCo	n/a	40	3500	3500
43	Phi4tech	2027	20	400	200
Portugal					
44	CALB	2025	45	n/a	n/a
Europe					
	Eurocell	2023	6	740	n/a
	PowerCo	n/a	120	n/a	n/a

sufficient traction batteries for approximately 20 million BEVs could be produced in Europe by 2030.

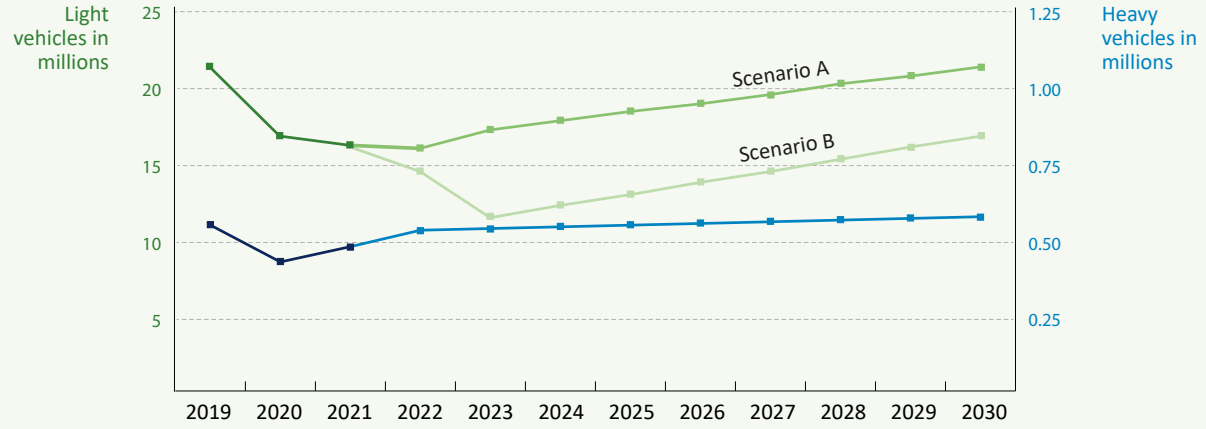
Vehicle production is in decline but the basis for the high demand for LIBs

The largest cell demand results from the production of BEVs. Despite challenges such as pandemic-related production and supply chain issues or increased raw material prices (cf. Challenges section) the worldwide trend towards zero-emission road traffic continued its acceleration in 2022. Sales of electric vehicles for passenger transport in 2022 are expected to amount to more than 10 million units, significantly exceeding the 6.6 million vehicles sold in 2021.[9]

Considering all propulsion technologies, the production numbers of the worldwide automotive industry have been in strong decline since 2019. In 2021, approximately 13.5 million vehicles less were produced than in 2019 – a decline of almost 15%.[10] While some challenges for the automotive industry lessened, such as pandemic-related production losses and disrupted supply chains, others, such as the semiconductor shortage, are still keeping production lines from working at capacity.[11] Despite these production hindrances the number of BEVs produced worldwide is increasing. Though, supply issues are still causing temporary underproduction and, currently, especially long delivery times.[12]

Compared to 2019, vehicle production figures in Europe fell by an above-average 25% (approximately 5.5 million vehicles) in 2021. Following the Russian invasion of Ukraine and the resulting uncertainty regarding energy supply, additional challenges for the automotive industry have arisen in 2022 that will impact vehicle production volumes and costs in Europe.[13] Due to supply constraints with semiconductors and missing parts from suppliers within the warzone, many vehicle manufacturers recently had to lower production rates.

Figure 3: Number of light vehicles produced in Europe (dark green) and forecasts of production numbers without (medium green) and with (light green) impact of potential limitations in energy supply (Scenarios A and B, respectively) as well as production volumes of commercial vehicles (dark blue) and their forecast (light blue).



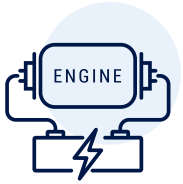
High variance in cell demand in Europe in the near future

Additionally, some European original equipment manufacturers (OEMs) and suppliers with energy-intensive production processes could come under considerable pressure due to the uncertainty pertaining to the energy supply and the volatility of energy costs. According to forecasts from S&P Global Mobility and S&P Commodity Insights, the resulting potential production losses of Europe-based assembly plants could amount to more than one million vehicles per quarter, starting with the last quarter of 2022 through 2023.[14] It cannot be ruled out that the assembly of electric vehicles could be affected by a potential lowering of production.

Calculations based on the two scenarios published by S&P have shown demands for LIBs in the coming years differing by more than 30% (Figure 3). The demands were

calculated for an identical degree of electrification of light vehicles (incremental increase to 81% of passenger vehicle registrations in 2030, progressive scenario[4]). In the scenario without notable influence of an uncertain energy supply (Scenario A), the quarterly production of Europe-based automobile producers between the last quarter of 2022 and the end of 2023 is estimated to be four to 4.5 million units per quarter, corresponding to a moderate growth. Moreover, moderate growth is assumed to continue through 2030, thus the production would reach 2019 (i.e. pre-pandemic) levels at the end of the decade. However, in the face of potential constraints regarding energy supply the production could fall to 2.75 to three million units, which is considered in a scenario containing energy uncertainty (Scenario B). In this case, the declining trend could continue until the end of 2023, and an increase in production numbers will only occur in the following years. Thus, it is assumed that the production numbers in 2030 will only reach the level of 2020.

The production of commercial vehicles decreased between 2019 and 2020 as well. However, as soon as 2021, more commercial vehicles were already produced year-over-year, leading to an assumed minor growth until 2030 (Figure 3, blue line).[10]



Industry supply with cells made in Europe in the coming years is possible but not yet secured

Despite the remarkable increase in battery cell demand, the production capacities announced in Europe will most likely be able to meet future demand (Figure 4). From 2024, the calculated battery demand of the automotive industry ranges within the production capacities announced by battery producers.

However, if only those production sites are built that are regarded as certain and production commences according to the announced schedules (lower edge of orange area, Figure 4), a European self-sufficiency with cells would only be possible to approximately 68% in the scenario of rapid recovery of vehicle production by the end of the decade (Scenario A).

Another challenge that remains is the supply situation with raw materials, active materials, and components for battery cell production. Furthermore, delays in the development of announced capacities loom as some companies are currently debating prioritisation of projects in the USA. This could lead to a shortage of batteries from European production. A temporary delay in the realisation of the announced production sites by only a single year would prevent full coverage of demand by the end of this decade by European cell manufacturers in the scenario of fast recovery (Scenario A).

Challenges are increasing pressure on European market

International funding policies: In the main markets for BEVs and battery cell production, a ramp-up and the development of a corresponding industry ecosystem are supported by political funding measures, creating unequal market conditions in some cases. By imposing requirements on the qualifications for subsidies and generally restricting the market for foreign companies, the funding policy in China is primarily aimed at strengthening Chinese companies. In the USA, large parts of the recent legislation aimed at increasing climate protection and the transformation of certain industries are tied to conditions regarding locally produced content, which might be in violation of rules set by the World Trade Organization (WTO).[15] In contrast, the EU aims for fair competition, according to which non-European actors are not per se excluded from the internal market, either in regard to financial support or by regulations in preparation.

Raw materials risks: Until 2030, the worldwide demand for raw materials for LIBs such as nickel, graphite, and lithium will increase by a factor of 8, 7, and 5, respectively, compared to 2020, and thereby, in parts, considerably surpass the global supply at the beginning of the decade.[16] Though, a substantial part of the raw materials and intermediate products for battery cell production is neither mined nor produced in Europe in significant amounts. Despite the announced raw material projects in Europe, this import dependency will not

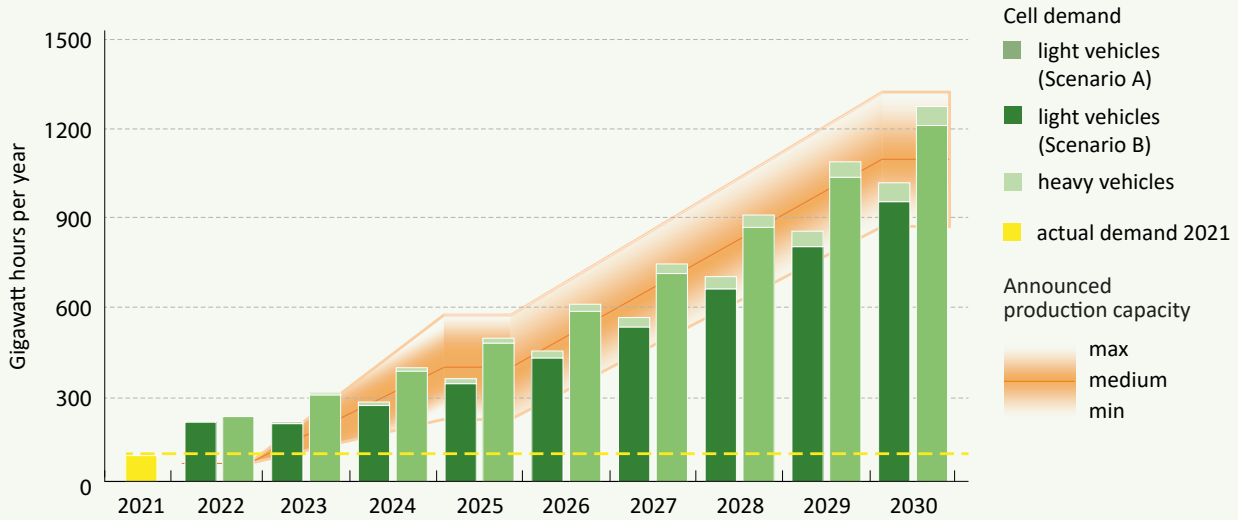
4 Assumed increase in the percentage of BEV in relation to total vehicle production up to 81% (passenger cars), 55% (light commercial vehicles) and 40% (heavy-duty commercial vehicles) until 2030. The market share of passenger cars is based on a modelling of car emission reductions by T&E on the basis of plans outlined by automobile manufacturers, which is higher than currently discussed within the context of "Fit for 55". The market share of electrically propelled light commercial vehicles would suffice to satisfy the emission reduction goal proposed by the EU. The market share of battery-electric heavy-duty commercial vehicles is in line as well with the EU's goal of establishing zero-emission road traffic by 2050.

decrease significantly until 2030. Regarding supply with battery materials, Europe is and will remain dependent on international collaboration, which needs to be further diversified, particularly in the context of increasing international geo- and trade-political tensions.[17] The establishment of resilient supply chains for suppliers and precursor materials is of equal importance to battery cell production and automotive industry. In the first quarter of 2023, the Accompanying Research on Battery Cell Production will publish a study on the resilience of supply chains of five essential battery raw materials. Therein the interdependencies alluded to here are analysed in depth.

Missing precursors: European cell manufacturers currently lack direct access to capacities in the up-stream value chain (battery components, electrode active materials as well as their precursors). For example, the import dependency of European cell manufacturers for anode materials is approximately 90% in the case of synthetic graphite, and 100% for natural graphite.

Uncertain energy supply: The European battery industry is increasingly confronted with high and volatile energy prices, diminishing its competitiveness in particular with competitors from Asia and the USA. Since the first quarter of 2020, the energy prices in Europe have jumped significantly and have since been fluctuating, but remain on a high level. For example, in June 2022 a megawatt hour (MWh) of electrical energy for industrial customers cost 456 USD in Germany and 409 USD in Great Britain. At the same time, it cost 136 USD in the USA and 94 USD in China.[18]

Figure 4: Announced LIB production capacities in Europe for the current decade (orange area) and projected demand for LIBs in European automotive industry for Scenario A (green) and B (dark green). The actual demand in 2021 is shown by the yellow column/line.



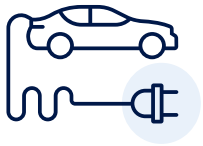
Projection of the **demand** for battery cells in automotive production in Europe for an incremental increase in the share of registrations of light and heavy electric vehicles to 81% and 40% respectively by 2030. For light vehicles, the demand was extrapolated for one scenario without and one with a significant influence of the energy supply on vehicle production (Scenario A and B, respectively).

With numerous, mostly very ambitious announcements, there are uncertainties regarding their implementation, especially after 2025. For this reason, the **production capacities** are presented in a minimum and a maximum view. Furthermore, it was assumed that all announcements by the manufacturers are maximum figures and that in practice the cell factories will achieve a yield of 90% at a capacity utilisation of 85%.

Engineering industry: Although the European engineering industry is represented in all scale stages of battery production, most suppliers cannot deliver the numbers required by cell manufacturers and often only feature one process step of the entire battery production process. Consequently, Asian engineering companies are currently establishing themselves as equipment manufacturers in Europe. In order to stay competitive, European companies will have to be able to offer equipment for many process steps, up to turn-key solutions, in the near future.

With this goal in mind, multiple collaborations between manufacturers and new alliances have recently been established.

Skilled labour shortage: Both the scale-up of the battery cell production and the transformation of the automotive industry will be impaired if the demand for skilled labour cannot be met soon. According to recent estimates, until 2035 up to seven million people could leave the German labour market for demographic reasons.[19] In contrast, according to recent estimates, a demand for up to 464,000 workers with skills required in the European battery ecosystem will arise within the same timeframe, as shown by analyses of the Accompanying Research on Battery Cell Production, which will be published in the first quarter of 2023.[20]



The market outlook is currently characterised by a strong growth of battery production. The aforementioned challenges could have a significant impact on battery demand as well as supply. Nonetheless, all of these challenges are known to all stakeholders and can be overcome by common efforts of industry, special interest groups, and policy makers. This is a worthy goal since the establishment of a sustainable and innovative European battery ecosystem does not only assure employment but also the transition to a circular economy in the mobility sector. Moreover, batteries are a base technology for the next phase of the energy transition in which increased importance falls to electrical energy storage technologies.

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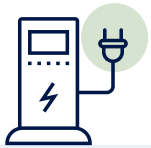

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