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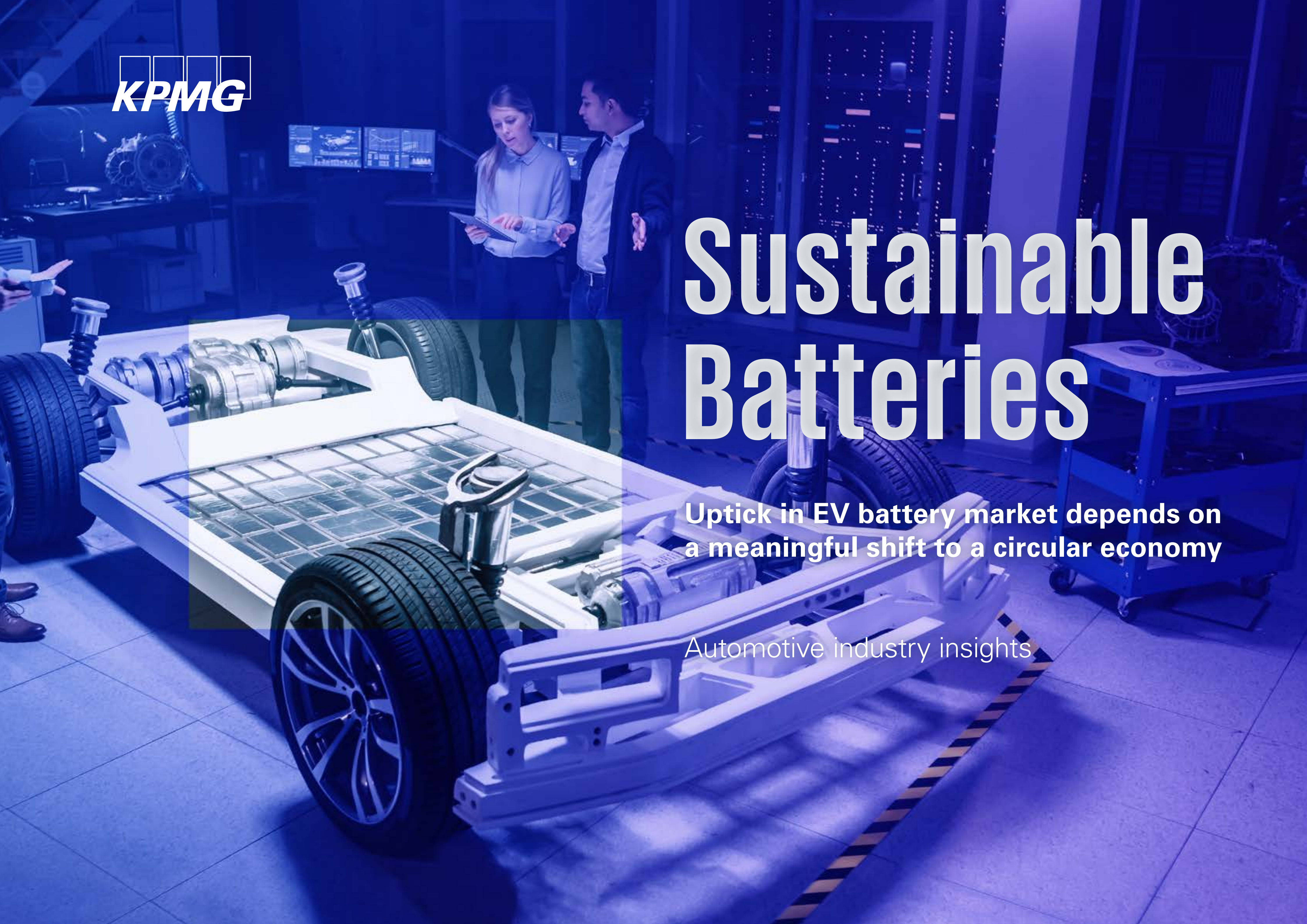
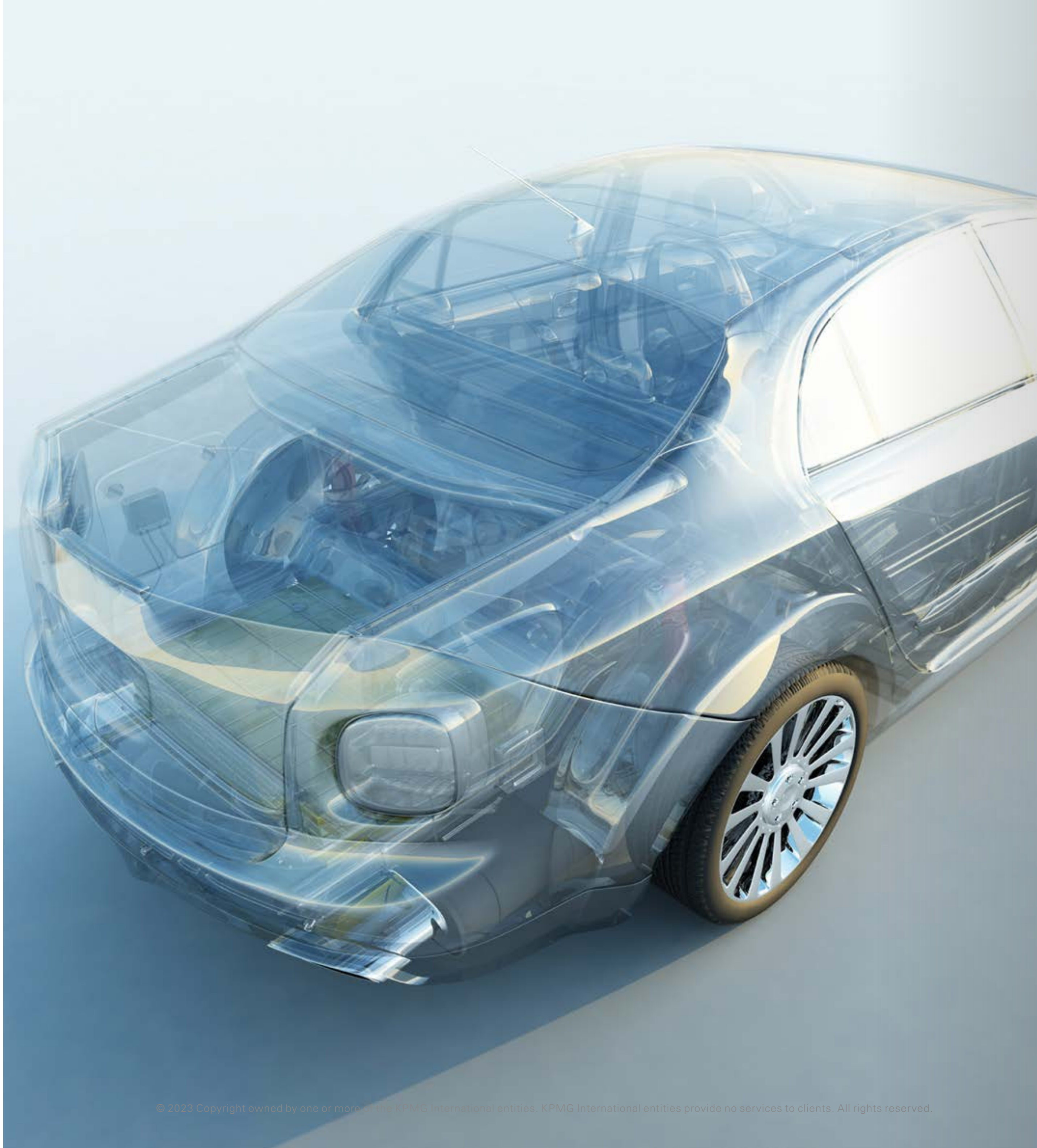


Sustainable Batteries

Uptick in EV battery market depends on a meaningful shift to a circular economy

Automotive industry insights

Content



Current situation

The trends of energy transition and decarbonization – with their economic, environmental and geopolitical impact – are having a deep effect on the Electric Vehicle (EV) battery market. These two trends are very much linked to the concept of circular economy – a fact made more consequential in view of the EU's new Battery Regulation, which will ensure the repurposing, recycling and reusing of EV batteries at the end of their use phase or operational life.[1] The directive will specifically: (1) expand the scope of those batteries that are to be repurposed, recycled and reused; (2) introduce carbon footprint labeling for EV batteries and a 'Battery Passport'[2]; (3) mandate a minimum percentage of recycled materials – like cobalt, lead, lithium and nickel – in new batteries; (4) introduce a due diligence obligation on battery manufacturers; (5) mandate more stringent collection targets for portable batteries.

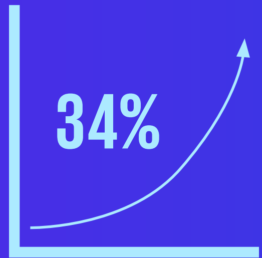
This new directive legislation – still in progress – is part of the European Green Deal approved in 2020 and is closely linked to the EU's new Circular Economy Action Plan (CEAP), as well as the new industrial strategy in Europe. And, given that automakers are inking joint-venture agreements with battery manufacturers to expand EV battery manufacturing capacity, the onus of repurposing, recycling, and reusing these waste EV batteries will fall on these automotive OEMs themselves.

More importantly, the main objectives of the EU directive are not only there to compensate for weaknesses in the internal EV batteries market (like dependency on critical raw materials from outside of Europe and a lack of domestic battery production capacity) but to also reduce its overall environmental impact – recycled materials can lower the carbon footprint of EV batteries by 40 percent.[3] In the end, the Life Cycle Assessment (LCA) of EVs shows a shift from the use phase (emissions) to the production phase (resource-related impact).

[1] European Parliament, "New EU rules for more sustainable and ethical batteries", March 2022
[2] EV batteries will carry a QR code, linked to an online database where EV owners, businesses and regulators can access information on the battery's composition.
[3] WEF, "3 challenges en route to electric vehicle batteries driving the circular economy", December 2022

Figure 1:

Key insights related to EV batteries and circular economy



Expected annual average growth rate of the global demand for EV batteries from 2022 (340 GWh) to 2030 (3,500 GWh) – a tenfold increase in just 8 years

US$2 billion

Expected savings, if 61% of batteries are reused, plus an estimated 1Mt of CO_2 and 20GWh of storage system costs will be avoided in 2030

Battery weight that must be recycled in Europe by 2030, including specific mandated recycling requirements for lithium, cobalt, copper, nickel and lead content

Source(s): IEA, ARUP and Stena Recycling

Impact of Russia-Ukraine conflict on EV battery market

The ongoing war between Russia and Ukraine has jeopardized the automotive market, which was already reeling under the semiconductor shortage following the COVID-19 resurgence. Apart from causing inflationary spikes that threaten the demand for new EVs, the war has also caused volatility in the prices of nickel and other EV battery metals. As Russia and Ukraine hold significant reserves of these metals, and with no clear end to the conflict in sight, there is no knowing as to when this price volatility will end and commodity markets will stabilize.

There are many current efforts underway to build gigafactories to power new EV models. However, without adequate supply of these crucial metals, production of EV batteries will be impacted and scale economics might not come into play. For this reason, battery manufacturers and automakers are trying to reconfigure their EV battery materials supply chains and shift them away from nickel/cobalt-heavy configurations. A case in point are lithium-iron-phosphate (LFP) batteries – already prevalent in China – that have lower costs, a better safety profile and charge faster. On the flip side, they have a lower driving range than nickel-cobalt configured batteries.

Challenges to overcome

Critical supply and production of battery materials

The supply of the critical metals needed to produce efficient and high-performing electric vehicles has limits based on volume. Production of some of these metals, such as nickel, neodymium, cobalt and lithium would have to scale threefold to meet projected global electric vehicle demand in the coming ten years.

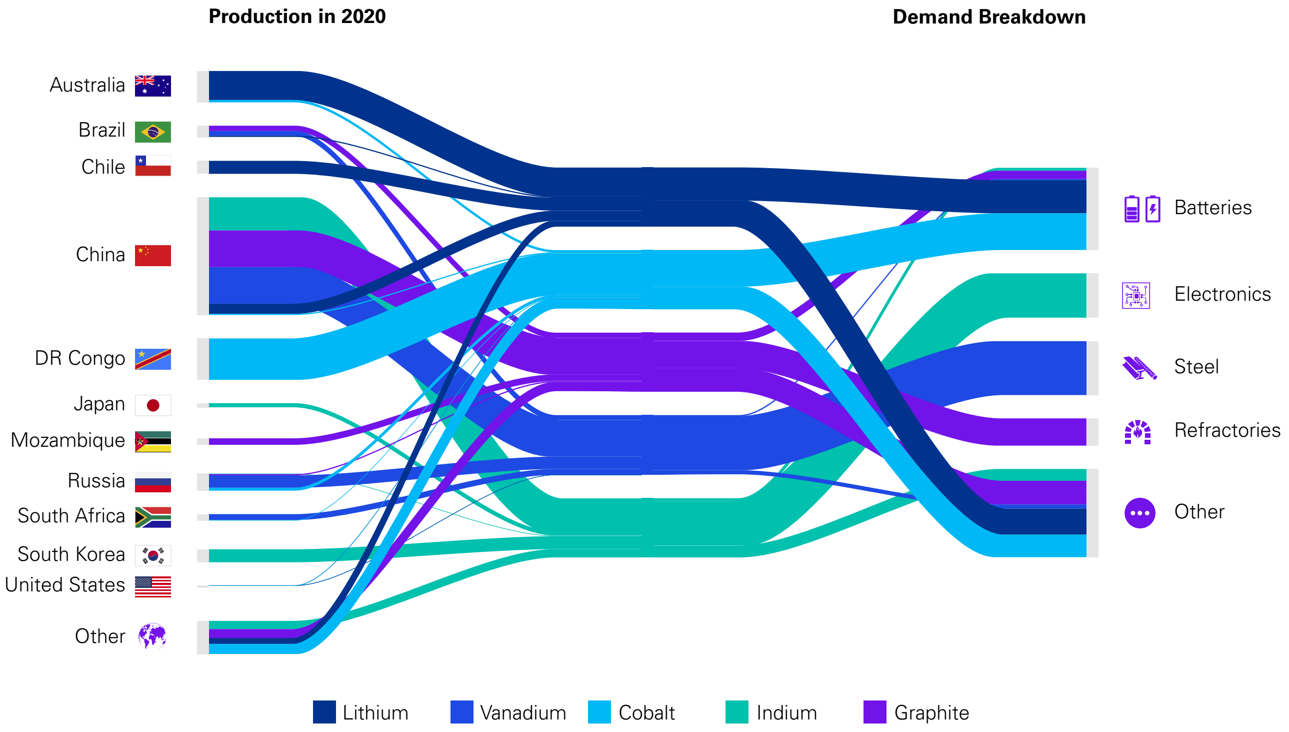
Furthermore, value chains for critical metals are long and complex. Scaling up production requires significant investment, and it needs to commence immediately in order to have new mines operational ten years hence. Moreover, critical metals are also used as leverage to exert geopolitical influence. In addition, mining activities now fall under the remit of not only the "E" (environmental) but also the "S" (social) of ESG governance, according to evolving national and regional regulations.[4]

The fostering of a circular economy for EV batteries can partly solve the critical battery materials supply issue in the short-term. However, it should be kept in mind that if primary sources of these critical materials dry up, then the secondary market (i.e., the one enabled by the circular economy) might very well also be in jeopardy.

[4] KPMG in the Netherlands, "Resourcing the Energy Transition", March 2021

Figure 2:

Geographic production and demand flows of critical materials



Source: KPMG in the Netherlands, Resourcing the Energy Transition, March 2021

Increasing battery collection rates for OEMs

In 2019, 51 percent of portable End-of-Life (EoL) batteries that were sold in the EU were collected for recycling.[5] However, the collection rate of Li-ion batteries, which dominate EV battery types, is particularly low and only a fraction are either stored in the homes of consumers, exported outside the EU as part of used products or get recycled as e-waste. Mostly, these portable waste batteries actually end up in municipal landfills.

Given the EU's new battery directive, the percentage of EoL EV batteries in the EU that are returned to automotive OEMs will increase over the next few years to around 20%. This is a direct consequence of the mandated collection target of 80% of all portable batteries in the EU by 2030, which will affect the entire EV battery value chain.[6] This could potentially slow down the uptake of EVs, as automotive OEMs might pass on the costs of increased battery collection to consumers who would then find EVs less affordable.[7]

If automakers are to comply with this increase in EV battery collection rates, they must develop processes that would repurpose, recycle and reuse these waste EV batteries. In the absence of such processes, these waste EV batteries will likely sit as "liabilities" on automakers' balance sheets and prove to be a long-term cost burden. In fact, given evolving regulations, one million EV batteries in Europe will likely need to be collected, treated, reused and recycled by 2030.[8]

Cost-prohibitive recycling processes

Most OEMs, mainly through partnerships and collaborations, are already looking for recycling solutions, so as to consolidate access to resources, minimize compliance costs and add a new 'secondary supply source'. Recently, Hydrovolt – a joint venture between Norsk Hydro (aluminum producer) and Northvolt (EV battery maker) – has commenced recycling operations for 25,000 EV batteries in Norway, with plans to expand to continental Europe in the near future.[9] The black mass (containing nickel, manganese, cobalt and lithium, and other materials such as plastics and copper) generated at this recycling plant will be used to produce EV batteries at the new 50 GWh battery manufacturing plant in Gothenburg, Sweden, which itself has been set up as a joint venture between Northvolt and Volvo Cars. In a further development, Northvolt and Interzero partnered up to start collecting and recycling used Li-ion batteries in Germany by 2023.[10]

In spite of these developments, recycling is a conservative and cost intensive solution that doesn't actually leverage the remaining value of EoL EV batteries. Collection and transportation also remain a challenge to battery recycling – transportation costs alone are 41 percent of the cost of recycling EoL EV batteries.[11] Apart from dealing with the new EU Battery Regulation on hazardous material transportation of waste EV batteries, the battery producer is also mandated to set up take-back systems, without being allowed to pass the additional costs on to the owner, either directly or indirectly. Thus, from a regulatory point of view, transportation costs for waste EV batteries could rise further still.[12]

5, 6 European Parliament, "New EU rules for more sustainable and ethical batteries", March 2022
7 ACEA, "Position paper – EU Batteries Regulation: main automotive priorities", October 2021
8 WEF, "3 challenges en route to electric vehicle batteries driving the circular economy", December 2022
9 Financial Times, "Northvolt and Norsk Hydro to expand battery recycling JV in Europe", May 2022
10 Euwid, "Interzero and Northvolt found Li-ion battery recycling joint venture", September 2022
11, 12 Science Direct, "Transportation of electric vehicle lithium-ion batteries at end-of-life: A literature review", November 2021

Even though scaling up recycling processes can help reduce battery transportation costs, recycling fees will likely increase in the next few years due to a potential lack of requisite recycling capacities and reduced recyclable metal content in the batteries.

The recycling of lithium, the most important metal in EV batteries (given the current technology) remains, unfortunately, the most challenging and technologically complex task. In fact, a negligible amount of lithium is recovered from waste batteries in the EU, since it's cost prohibitive and companies are better off recovering other metals (cobalt, nickel, copper), whose recycling processes are economically viable. Apart from causing a loss in their value (a concept that should not be part of a pure circular economy strategy), current Li-ion battery methods of disposal like stockpiling, burning and landfilling are also detrimental to the environment. In other words, we need more closed loops in the current EV battery linear value chain.

Barriers and limitations for new markets

A more holistic circular economy strategy is needed to keep up with both the demand and business context around EV batteries. Even though some repurposing related solutions can be synergistic with existing OEM businesses (i.e., home energy storage, EV chargers, etc.), entering new markets associated with the circular economy will likely require developing new capabilities, sales channels and markets. It is possible that some profitable end-solutions can be non-core to the automotive value chain. These, though, will require extra efforts to penetrate, on top of the need to acquire the necessary procedural and technical expertise. Such profitable end-solutions exist in the form of utility-scale storage, back-up power in the telecom sector and real estate (residential, commercial and industrial). However, EoL EV batteries will require extensive refurbishment and repair to be made ready for these second-life applications.[13]

It's not just about EoL EV batteries themselves though. As OEMs and battery manufacturers currently scale up their EV battery production, there is also a lot of waste being generated during the manufacturing process itself. Therefore, the challenge is also to resolve this scenario and find new markets to where this waste can be directed. In 7 to 10 years' time when End-of-Life EVs increase substantially in number, bigger battery volumes can be expected from scrapyards.

Battery designs not optimized for circular economy

The profitability of circular business models is directly linked to battery design and operational efficiencies. The array of battery pack sizes, chemical make-ups and designs make it difficult for EV batteries to be recycled, refurbished or reused, and are not conducive to ready repair, modularity, adaptability and disassembly. Product-related challenges – like EV battery design variety, as well as process-related challenges, like non-detachable joints, plus manual disassembly – are very real barriers to making the circular economy for EV batteries more efficient.[14]

It's not just inadequate battery design and lack of material standardization that make the repurpose, recycle and reuse of EV batteries economically unviable and unsustainable, as lack of process efficiencies and under-utilization of renewables in the battery manufacturing process also contribute greatly.

Given the exploding demand for EV batteries in this decade, the rapid ramp-up of battery manufacturing capacity could be a hindrance to the intended benefits expected from economies-of-scale and operational efficiencies. If there is no concerted effort to standardize the different battery sizes, chemical make-ups and designs then process automation and efficiency could be impeded. In addition, the existing geographical footprint could make it difficult to further optimize labor and logistics costs.

It's not just lack of standardization of materials and battery pack design that restricts battery recycle and reuse, battery manufacturing processes should also incorporate renewable energy and process efficiencies.

Goran Mazar
EMA Automotive and ESG Head at KPMG

[13] ARUP, "Circular business models for the lithium-ion battery industry", 2020
[14] MDPI, "Optimization of Disassembly Strategies for Electric Vehicle Batteries", November 2021

Figure 3:

Challenges related to the circular economy and EV batteries

	Challenge	
1	Critical supply and production of battery materials	Production of critical metals would have to scale threefold in the coming ten years.
2	Increased battery collection rates for OEMs	Collection rates of all portable waste batteries in the EU will likely increase to 80% by 2030.
3	Cost-prohibitive recycling processes	In the EU a negligible amount of lithium is recovered from waste batteries as it is cost prohibitive.
4	Barriers and limitations to new markets	Waste EV batteries will require extensive refurbishment and repair to be made ready for second-life applications in adjacent industries.
5	Battery designs not optimized for circular economy	Currently battery pack sizes, chemistries and designs make it difficult for waste EV batteries to be recycled, refurbished or reused.

Source: KPMG Germany, 2023

The way forward

A circular economy is a 'regenerative' model that looks to retain the value of resources 'circulating' in it – products, parts and materials. It does so by attempting to design out waste and pollution, keep products and materials in use, increase productivity and regenerate natural systems (see Figure 4). Existing materials will have to be utilized in new, circular ways if we are to reduce the need to extract from terrestrial and oceanic sites, while continuing to use other available materials in the market.

In recent years, as the urgency to act against climate change has intensified, the circular economy as a concept has gained increasing momentum among business, policymakers and consumers. Redesign, recycling, reusing and repurposing across the resource lifecycle will play a key role in addressing geopolitical and geo-graphic constraints – mitigating potential price volatility and supply shortages, particularly for resources that cannot be substituted, and also reducing the need for resource extraction and emissions. Existing circular economy strategies have consolidated surety of supply but existing recycling efforts will not be enough. Ironically, the more far-reaching our climate ambitions, the greater the potential reliance on 'non-renewable' mined materials becomes; possibly negating the positive environmental impact of manufacturing these green technologies in the first place.

[15] KPMG Netherlands, "Circularity Transition Indicators v2.0", February 2021

[16] WBCSD and KPMG, "Circular Transition Indicators v3.0 – Metrics for business, by business", May 2022

Integrate circularity into your value chain – where to start?

Circular business profitability is highly dependent on operational efficiencies, which can be more easily achieved through optimized battery design and technological considerations. Integrating these concepts from the very beginning of the EV battery value chain (i.e., cell and battery pack design) is critical, and will require close collaboration with battery manufacturers, start-ups and automakers. Key concepts that must be considered include: increasing modularity, enhancing component life spans, reducing embodied emissions, increasing layout standardization, designing for disassembly, reducing use of undesirable materials, unifying chemical make-up, enhancing information availability at EoL and incorporating recovered materials. For example, when it comes to modularity, one control system can be adapted to control several batteries or cells (as opposed to multiple control systems). Similarly, the current lifespan of control systems (around 15 years) can be increased to match that of EV batteries (around 20 years), which will avoid premature End-of-Life.

However, prior to even working on these concepts, the Circular Transition Indicators (CTI) framework can help to assess not only the feasibility of these concepts but also the timing of their implementation (see Figure 5). Specifically, the CTI framework lets a company: "…determine its circular performance, have the ability to close the loop, generate insights into resource use optimization and measure the impact on business performance."[15] It can help automakers form a clear understanding of the expected commercial landscape, in terms of returning EoL battery demand, collection rates, existing types, carbon footprint, etc.

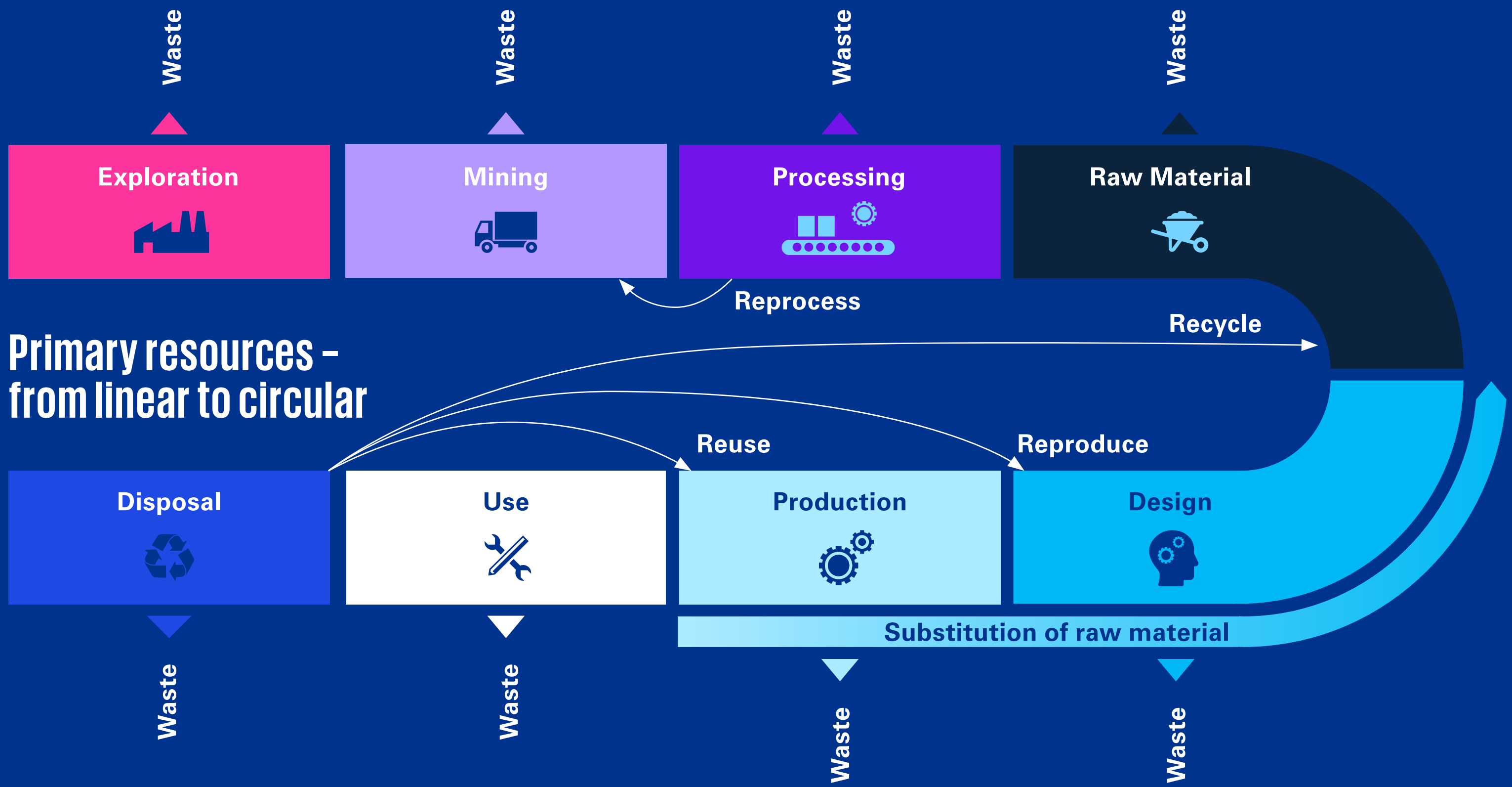
Specifically, the CTI framework can help automakers and battery manufacturers in tracking some circularity metrics (like circular inflow %, critical materials %, circular material productivity, etc.), thereby assessing a company's ability to close the loop, while also optimizing high-value material recovery, as well as connecting material flow indicators to conventional financial metrics.[16]

Explore new business models and improve collaboration

Automakers need to understand the levels of adjacency of potential business models and evaluate barriers for entry and limitations. In order to penetrate new markets and obtain the required knowledge and expertise, they need to consider potential partnerships or collaborations. The new circular economy business models (CBMs) are: (1) Product and process design; (2) Circular supplies; (3) Sharing platforms; (4) Product-as-a-service (PaaS); (5) Lifetime extension; (6) Refurbish and maintain; (7) Recycling. Integration of the above CBMs has the potential to be economically sustainable – at least theoretically – given that all these CBMs do not exist in silos but rather co-exist and interact to create a complete circular ecosystem.

Figure 4:

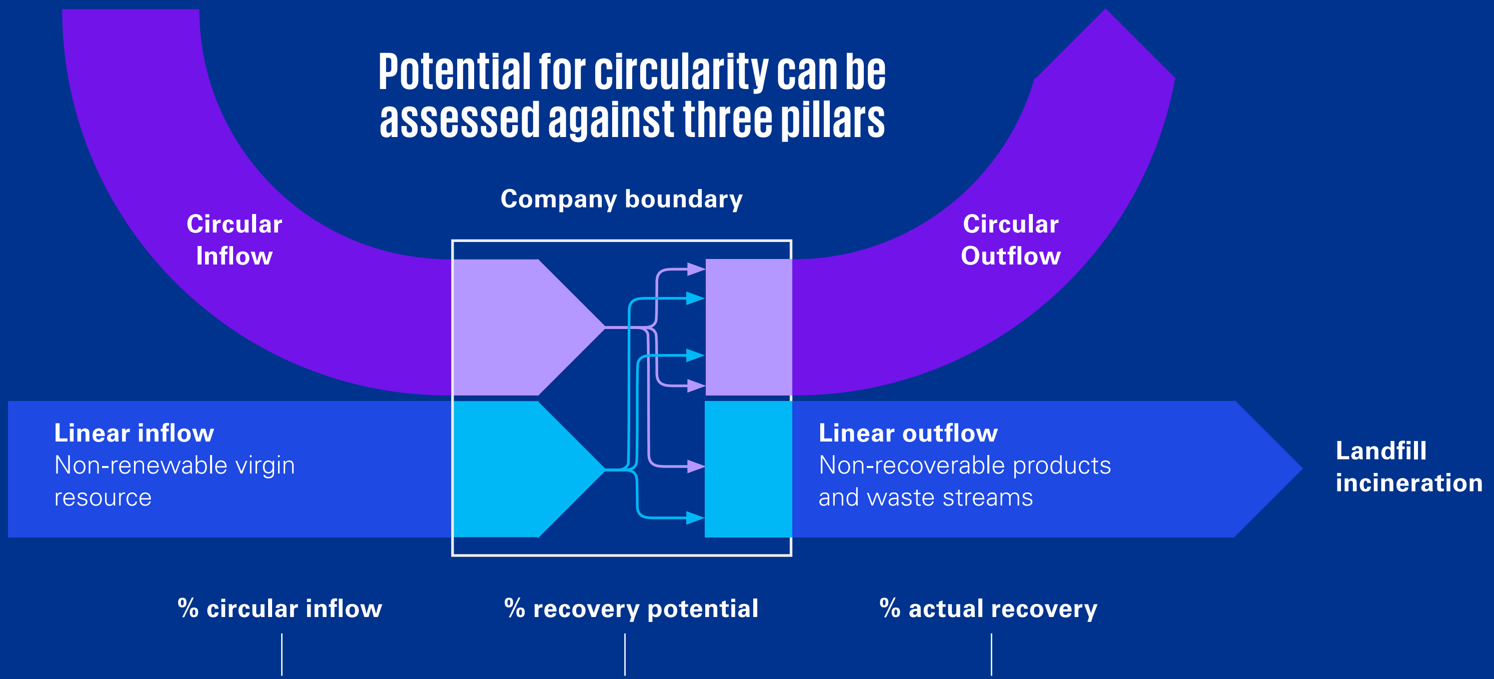
The circular economy



Source: KPMG in the Netherlands, Resourcing the Energy Transition, March 2021

Figure 5:

The Circular Transition Indicators (CTI) framework



Inflow: Movement towards secondary resources and substitution of 'critical' resources with non-critical alternatives; this could be constrained by the non-availability of secondary feedstock and suitable substitutes for virgin critical resources.

Recovery potential: Improved design to focus on modularity, disassembly and recyclability (such as the use of mono-materials), which will rely on new forms of technological innovation.

Actual recovery: Addressing current collection constraints through new business models (incentivizing recovery through product-as-a-service and buy-back schemes), more mature return logistics (to enhance collection), and innovation in new recycling technologies (to improve recycling yield, which may be constrained due to limited amounts of harvestable resources).

Source(s): WBCSD and KPMG Germany, 2023

It must be noted that OEMs across the globe are already exploring opportunities to increase the uptake of electric vehicles through innovative business models – battery-as-a-service being one of them. Some OEMs in Europe have also adopted a battery renting or leasing business model. However, the required rate of commercialization has not been reached. Fortunately, opportunities are there across the entire EV ecosystem, as batteries being rented or leased can set a good example that governments and stakeholders, such as energy companies or mobility-as-a-service providers in diverse locations, can follow.

In addition, automakers are already working on tracking and tracing critical raw materials through blockchain technology. In a recent development, Volvo Cars reached an agreement with two global battery manufacturers and blockchain tech firms like Circulor to implement cobalt traceability for its EV batteries – an encouraging move given the digital 'Battery Passport' requirement in the EU's new Battery Regulation. The agreement could even end up serving as a key enabler of the circular economy for EV batteries.[17]

Consider starting small-scale pilots

Some OEMs are leveraging low initial volumes to pilot small-scale waste battery recycling and repurposing projects. This solution is also a great way to start building brand image around the circular economy. For example, Volkswagen has already started a pilot recycling plant in Germany that will create a closed-loop process to recycle EoL batteries that can no longer be repurposed or refurbished for second-life applications. The company intends, through this recycling plant, to recover valuable raw materials such as lithium, nickel, manganese and cobalt, along with aluminum, copper and plastics, and aims to achieve a recycling rate of more than 90 percent.[18] It's not just automakers jumping into the fray, companies from adjacent industries like BASF and Aurubis (a multinational chemical company and a multi-metal recycling provider respectively) have also begun piloting such small-scale recycling projects.[19]

Define your optimal geographical footprint

A decentralized geographical footprint can help to optimize transport and labor costs but will make it difficult to achieve local economies-of-scale in new markets. Defining an optimal geographical footprint will, therefore, be critical to achieving profitability in any chosen circular business model. This will include: (1) location assessment of the closed-loop plant – whether that plant should have more proximity to the supply center or the demand center; (2) volumes of EoL batteries available for repurpose, recycle or reuse at a particular location; (3) a close link (in terms of logistics and transportation) between EoL battery demand and supply centers.

Sorting out a collection strategy for these EoL batteries, therefore, becomes paramount to defining an optimal geographical location – prior even to attaining the required technical know-how.

Amalgamating a closed-loop production of EV batteries with different End-of-Life strategies (and, therefore, an all-encompassing CBM) could potentially increase circularity for EV battery materials from 5% today to 23% by 2030.[20] In addition, there will be financial benefits – having a fully circular EV (including circular batteries) could unlock lifetime revenues that are 15–20 times more than its sales price.[21]

"

Automotive OEMs should acquire or collaborate with companies providing circular economy solutions and battery manufacturers. Standardization in terms of battery type, circularity by design and EoL/ End-of-Use information will be key here to the smooth implementation of new CBMs that accommodate the uptake of EVs.

Arnoud Walrecht
Partner and Global Circular Economy Lead,
KPMG in the Netherlands

[17] Volvo Cars, "Volvo Cars to implement blockchain traceability of cobalt used in electric car batteries", November 2019
[18] Automotive Manufacturing Solutions, "Volkswagen Components begins battery recycling pilot", February 2021
[19] CHEManager, "BASF to Build Battery Recycling Pilot at Schwarzheide", July 2021; Renewable Now, "Aurubis launches pilot plant for battery recycling in Hamburg", March 2022
[20] Journal of Cleaner Production, "What is the contribution of different business processes to material circularity at company-level? A case study for electric vehicle batteries", January 2023
[21] WEF, "Driving Ambitions: The Business Case for Circular Economy in the Car Industry", May 2022

Current experiences

Developing a circular economy strategy for leading global automotive OEM

The client's strategy over the last few years had been focused on the development of hybrid vehicles, but market trends made it necessary to switch towards higher battery capacities for the development of PHEVs & BEVs.

KPMG supported the client when they evaluated the different business models relating to End-of-Life EV batteries over the period 2021-2035. We also provided a clear picture of the associated market in Europe, including potential business models and how other OEMs were positioning themselves along the EV battery circular value chain. The different business models were financially modeled; defining current and expected cost structures and calculating profitability based on the client's forecasted European sales over the next 15 years. Associated risks were identified, including a deep dive into various logistics scenarios, and mitigation plans were developed. Finally, a strategic recommendation was developed to increase overall revenues and maximize profitability, including a detailed implementation roadmap to realize the defined 3R (recycle, repurpose, remanufacture) strategy.

Defining a circular economy strategy for a leading European telco company

A leading European telecommunications company has committed to using nearly 100% of reusable or recyclable resources and parts by 2025.

KPMG performed industry benchmarking to identify circular market trends in the telecommunications and other sectors and pinpoint the critical internal and external stakeholders that were pivotal in helping the client achieve its circular ambitions (e.g., business unit heads, key suppliers). We also developed a stakeholder engagement plan for its circular economy team for working with these engaged stakeholders. In addition, we conducted a material flow analysis to identify the circular opportunities in the business (e.g., refurbishing set-top boxes, digitizing network equipment, improving purchasing policies) and then modeled the financial implications of these actions.

Implementing circular measurement and steering for global software and hardware manufacturer

A leading global software and hardware manufacturer wanted to understand the circularity of five of its devices in the hardware division, as well as better understand how to increase the circularity percentage and kick-start opportunities for improvement.
The client was specifically interested in the Circular Transition Indicators (CTI) methodology.

KPMG implemented the seven steps of the CTI framework in three phases:

- Phase 1 (Scope & Selection): Determine the scope for the assessment and select the relevant indicators from the CTI framework

- Phase 2 (Collect & Calculate): Identify relevant data and assess its quality to ensure that accurate input leads to relevant insights

- Phase 3 (Analyze, Prioritize & Apply): Interpret and contextualize results and translate them into relevant insights for business decision-making

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