20 September 2020

More than just emissions

Considering ESG across the whole EV supply chain

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- ESG issues vary over different parts of the EV value chain
- In general, upstream is more environmental, social issues change, and governance issues are company specific
- As EV demand soars, ESG issues will be more closely scrutinised – it's not just about emissions

Sum of the parts: Rather than extol the merits of EVs vs internal combustion engine (ICE) vehicles, we assess the entire EV value chain through an ESG lens. We look at some of the key issues across raw materials, battery manufacturing and components as well as assembly and charging.

Targeted ESG: We examine which raw materials pose most ESG risks and what the industry is doing to minimize their use or find alternatives; the ESG issues associated with the all-important battery and what happens to batteries at the end of their life; some of the sustainability risks posed by other components that go into an EV such as plastics; whether COVID-19 will accelerate automation in EV assembly; and what is being done about the carbon intensity of electricity compared with EV penetration.

Changing drivers: The more upstream part of the supply chain tends to be affected by more environmental issues and these may overlap with social issues. For EV assembly, social issues take prevalence. We do not discuss governance issues at length because we think these are more company specific (rather than sector specific), for example, related party transactions upstream.

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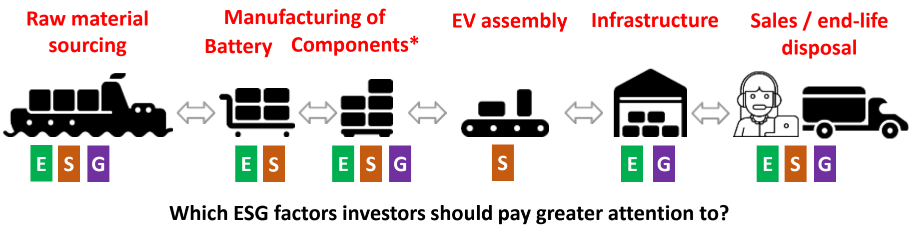
Figure 1: The Electric Vehicle (EV) supply chain faces different ESG issues



Source: HSBC; Note: *including mining of the raw material for the components

Wai-Shin Chan, CFA
Head, Climate Change Centre; Co-Head, ESG Research
The Hongkong and Shanghai Banking Corporation Limited

Will Cho*
Analyst, Korea Hardware and Internet
The Hongkong and Shanghai Banking Corporation Limited, Seoul Securities Branch

Ashim Paun
Co-Head, ESG Research; Climate Change Strategist
HSBC Bank plc

Lucy Acton*, CFA
ESG Analyst
HSBC Bank plc

Camila Sarmiento
ESG Analyst
HSBC Securities (USA) Inc.

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Mapping ESG issues to EVs

- Environmental issues tend to be more prevalent further upstream, although end of life considerations should not be neglected
- Social issues feature along the whole value chain but to varying degrees, for example health and safety vs automation
- Governance issues tend to be oriented around specific companies

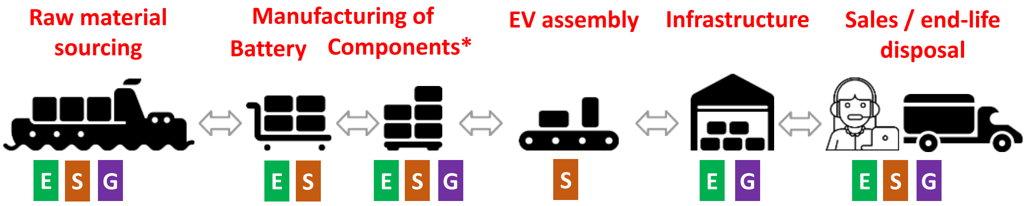
An ESG view on EV supply chain

There are more aspects to consider with respect to EVs than just potential emissions savings compared to ICEs

The general carbon emissions profile of electric vehicles (EVs) vs internal combustion engine (ICE) vehicles is broadly well known although there are nuances across manufacturers and charging. In this note, we assess the entire EV value chain through an ESG lens and look at some of the key issues by supply chain segment.

Questions that go emissions

Figure 2: Which ESG issues matter most depends on the supply chain segment



Source: HSBC; Note: *including mining of the raw material for the components

Table 1: Key ESG issues across major segments of the EV supply chain

	Environmental	Social	Governance
Raw materials	Resource management, alternative materials, environmental impact of extraction (acid etc.), use of water (availability and pollution)	Artisanal mining, worker exploitation, indigenous & human rights	Bribery and corruption, mine ownership; traceability
Batteries	Chemical spills, disposal of used/unwanted chemicals, use of water, end of life of batteries (recycle or reuse)	Health and safety, working conditions	Related party transactions
Components	Plastics use, loss of natural vegetation and habitats, soil/ water/ air pollution, carbon intensity of power and water demand	Labour exploitation, displacement, unsafe work condition, environment degradation	Illegal mining, bribery, related party transactions
EV assembly	Energy efficiency of the facility	Automation, worker contracts / furlough	Related party transactions
EV infrastructure	Carbon intensity of the power; electromagnetic pollution	Accessibility and safety	Standardisation, antitrust, related party transactions
Sales / end-life disposal	Chemical leakage, micro-plastics, air pollution from open incineration, water and soil pollution; food chain contamination	Unsafe working conditions in collection/scrapping, recycling and disposal; exposure to hazardous waste	Compliance with local regulations,

Source: HSBC

Raw materials sourcing

The battery is the key component of the EV and the mining of the requisite raw materials is associated with a diverse range of ESG issues which may be a risk to supply as end-users such as the technology sector may face growing scrutiny from investors and customers.

Lithium is currently key to the lithium ion battery that powers electric vehicles

Lithium mining comes with environmental issues….

Environment: *Water*: The Salar de Atacama (a salt flat in Chile and Argentina), in the world's driest desert, is the home to one-third of the world's lithium deposits. To get lithium, miners drill a hole in the salt flats and pump the mineral-rich brine (water) to the surface. Thus, lithium extraction has a direct impact on the water reserves in the region. The groundwater table sinks, drying out rivers, streams and wetlands. Indigenous groups have also alleged that the mining process can contaminate drinking water. In Chile, where lithium-brine mining has been going on since the 1980s, there are some signs that portions of the salt lakes have been declining in size.

Chemicals: Hard rock mining uses less water but has ESG issues too. Lithium mined from rock uses traditional mining methods, but requires the use of chemicals (such as hydrochloric acid) in order to extract it in a useful form.

…as well as social issues

Social: While Chile is bound by an agreement with the International Labour Organization to involve indigenous people in large-scale projects that interfere with their environment, Argentina has no such agreement. In Jujuy province, home to the Olaroz-Cauchari salt flats in Argentina, there is no formal process for negotiations between indigenous communities and mining companies.

Governance: While hard rock deposits do not face the same water issues, they face the same ESG issues as miners in general: safety, corruption and bribery risks, and general human rights concerns. For example, a major middleman for raw materials is in the midst of a US Department of Justice investigation on corruption and money laundering. One must also be aware of lithium reserves in sensitive areas.

Cobalt comes with a number of different ESG risks

Cobalt is associated with more social and governance issues than environmental

Cobalt production is highly concentrated within one country, the Democratic Republic of the Congo (DRC), which accounted for roughly three-quarters of global production in 2017 and holds over 50-60% of global reserves. The DRC is one of the poorest countries in the world and was involved in a long-running civil war. According to Amnesty International, approximately 15% of cobalt in the DRC is mined by hand, often by women and children. There has been a rapid growth in demand for cobalt since early 2016 due to growth in the battery sector, cobalt's largest and fastest-growing end-product.

Although the Democratic Republic of Congo is resource rich, it also home to political risks as well as environmental and social governance (ESG) risks that could threaten the entire cobalt supply chain.

Social: *Artisanal mining* – Human rights, child labour, and environmental practices in the DRC have come under increased international scrutiny in recent years. Amnesty International drew worldwide attention to the artisanal mining by child workers in the DRC, which prodded cobalt consumers, such as Apple and Samsung, to suspend purchases sourced from Congo.

Governance: *Political instability* – In the DRC, political power has seldom passed from one administration to the next without violence in recent decades.

Armed conflicts – The DRC has experienced prolonged bouts of violence and armed conflicts in the past two decades, particularly in the eastern part of the country. Some of the largest operating mines and announced projects are in Katanga, the copper-cobalt mining province in the southeast.

Gécamines partnerships – Foreign companies operating in the Congo often have to partner with Gécamines (La Générale des Carrières et des Mines), the state-owned mining company – business relationships with foreign governments have created issues for mining companies in the past, particularly in countries with weak institutional frameworks.

> **Given the spikes in the price of cobalt over 2018-19, there is a shift away from cobalt.**

Traceability and certification

Various jurisdictions are introducing traceability regulations which will affect cobalt mining

In 2010, the Dodd-Frank Wall Street (under section 1502) reform law included a rule that requires companies to disclose if their products contained tantalum, tin, gold, or tungsten (conflict minerals) mined from the DRC or adjoining countries. This prompted companies (primarily component manufacturers or tech companies) to trace the smelters or refiners used by their suppliers. Subsequently, many companies also began attempting to trace the cobalt in their supply chains. The European Union has drafted similar conflict-free mineral legislation (to come into force in January 2021). Amnesty International and the Enough Project are among several NGOs that rank companies on their cobalt supply chains.

The Enough Project, which campaigned for the conflict mineral rule in the US, releases a regular report that ranks companies on their efforts to monitor their supply chains in the DRC. In the 2017 Conflict Minerals Company Ranking, Apple was ranked number one. Apple requires all cobalt refiners to agree to outside supply chain audits and conduct risk assessments. The company completed mapping of its supply chain for cobalt in 2016. The company reports that as of 2017, 100 percent of its cobalt smelters participated in a third-party assessment program.

Responsibility is shifting towards companies

Companies are also piloting new technology to trace their supply chains. In 2019, Ford announced plans to use a blockchain-based platform to trace supplies of cobalt from Huayou Cobalt. Huayou, a Chinese company with mines in the DRC, is one of the biggest producers of cobalt for batteries. In 2016, Amnesty International accused it of buying cobalt mined using child labour. Ford reports that it will work with LG Chem and Huayou to improve transparency.

Table 2: Amnesty International ranking on companies that consumer cobalt

Rating	Companies
All possible actions taken	None.
Adequate action taken	Apple, Samsung SDI
Moderate action taken	Dell, HP, BMW, Tesla, LG Chem
Minimal action taken	Sony, Samsung Electronics, General Motors, Volkswagen, Fiat Chrysler, Daimler, Hunan Shanshan, Amperex Technology, Tianjin Lishen
No action taken	Microsoft, Lenovo, Renault, Vodafone, Huawei, Tianjin B&M, BYD, Cosligh, Shenzhen BAK, ZTE

Source: Amnesty International, Time to recharge 2017

Responsible Cobalt Initiative

The Responsible Cobalt Initiative, an industry group focused on the cobalt supply chain, includes members from all along the EV value chain including battery maker Contemporary Amperex Technology Co. Ltd., cobalt producer Zhejiang Huayou Cobalt, auto company Daimler, and Samsung SDI. The initiative also experiments with blockchain technology. In our view, it will be difficult for blockchain to work in the DRC given the prevalence of conflict and an opaque legal system. Therein lies the difficult truth beyond the certification and the traceability. Despite the focus from governments and companies, cobalt from illegal or artisanal mines is still making its way onto the global market.

Table 3: Alternate battery technologies may reduce (known) ESG risks

Battery Technology	Raw materials used					ESG Advantages over Li ion battery
	Lithium	Nickel	Cobalt	Manganese	Aluminium	
Lithium-ion battery	✓		✓	✓	✓	The regular Li ion battery – excessive longevity and energy density, making it ideal for battery use. Some instances have seen thermal runaway, where models (Tesla) have caught fire. Use of certain rare earth raw materials having ESG issues makes it a necessity to dig into alternatives.
Cobalt-free Lithium battery	✓	✓	✗	✓	✓	Reduces the dependency on cobalt, a rare and expensive component hence overcoming the ESG risks associated with cobalt mining
Hydrogen fuel cells	✗	✗	✗	-	-	Reduces the dependence on less available lithium, zinc and cobalt. However, it uses platinum instead of cobalt which makes it very expensive.
Sea water battery	✗	✓	✗		✓	Reduces dependence on both rare elements – lithium and cobalt.
Gold nanowire battery	✗		✗	✓		Uses gold nanowires in manganese dioxide, hence reducing dependence on lithium and cobalt. No power loss in the battery causes increased shelf life hence less battery recycling.

Source: HSBC

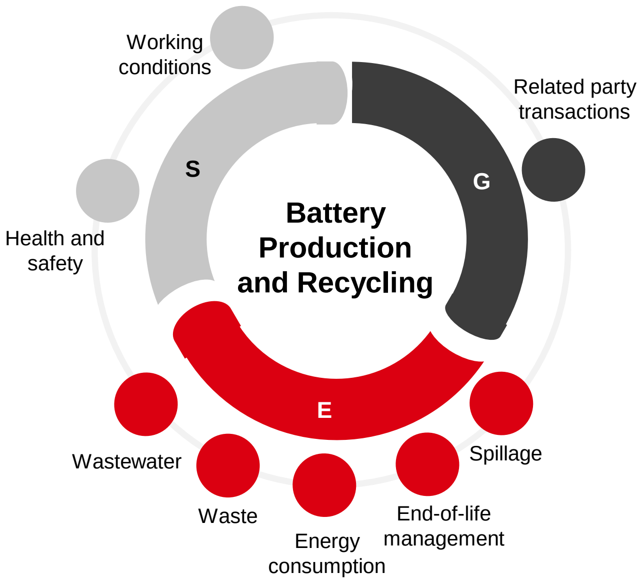
Battery manufacturing

The battery is the most important part of an EV and the stricter requirements for battery quality set by customers and regulators highlight the importance of cutting-edge R&D. At the same time, we think ESG angles will come into play given the challenges of battery technology upgrades, chemistry transition and new material development.

R&D into battery technology will include ESG angles

The lithium-ion battery (LIB) is currently the battery type of choice because of its energy density, performance, efficiency and discharge qualities. The other batteries that can be used include Nickel-Metal Hydride Batteries, Lead-Acid Batteries and Ultra-capacitors. There is a lot of investment into battery R&D, for example solid-state battery, which uses a solid electrolyte (instead of a liquid electrolyte) which eliminates the need for a separator..

Figure 3: ESG factors in battery manufacturing

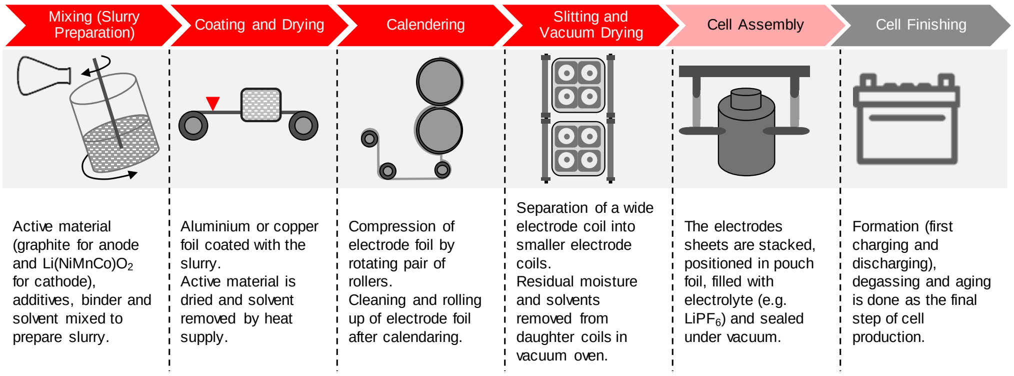


Source: HSBC

The growing demand for lithium-ion batteries

The demand for lithium-ion batteries (LIB) has risen significantly in recent years. It is estimated (by Mossali[1]) that LIB sales for electric vehicle application will reach 180m by 2045, compared to 5m in 2015. The production of lithium-ion batteries includes the preparation of the electrode materials, cell manufacturing and assembly into a battery pack. While the exact chemistry may vary, a lithium-ion battery typically has a lithium metal oxide as cathode, binders, a carbon anode, and electrolyte which comprises lithium salts, such as $LiPF_6$ in organic solvents.

Figure 4: Lithium-ion Battery Manufacturing



Source: Lithium-Ion Battery Cell Production Process, Heiner Heimes, February 2019

Battery manufacturing is energy intensive…

Some 10-75% of emissions from EVs come from the battery manufacture stage

Energy and emissions: The manufacture of the EV battery is the most energy and emissions intensive part of the EV – accounting for between 10-75% of energy use and emissions of the whole EV production process, depending on the energy source, battery chemistry and production approach. According to some studies, the Green House Gas (GHG) emissions of manufacturing a battery electric vehicle during the raw material and production phase can be up to 1.3x-2x higher than that of ICE vehicles[2].

Water is required to prepare electrolytes and other reactive materials, to remove impurities, to wash production equipment and manufacturing areas during the battery manufacturing process. Wastewater is generated from various processes and this can contain pollutants such as lithium, nickel, cobalt and copper.

…and comes with safety issues

Workplace safety: As with any factory, the exposure to hazardous chemicals, heavy machinery, electrical hazards, and pressurized equipment can pose health and safety risks. These include exposure to carbon dust and organic chemicals such as ethylene and propylene, as well as manganese compounds and other volatile organic liquids[3]. Beyond exposure to hazardous chemicals, acute facility incidents related to manufacturing of lithium-ion batteries might also include fires although these are relatively uncommon.

1 Lithium-ion batteries towards circular economy: A literature review of opportunities and issues of recycling treatments, Mossali, E, 2020
2 Environmental Effects of Battery Electric and Internal Combustion Engine Vehicles, Lattanzio, R,.K., 2020
3 Current status of Environmental, Health and Safety issues of Lithium Ion Electric Vehicle Batteries, Vimmerstedt, L. et al., 1995

Disposal and recycling of lithium-ion batteries

Here today, what use tomorrow?

Proper disposal: Lithium-ion batteries have a relatively short life span of 3-8 years (at least for use in EVs[4]). Circular Energy Storage estimates that the world could generate 1.2mn tonnes of battery waste by 2030[5]. If not properly disposed of, lithium-ion batteries can cause soil and groundwater contamination due to the leaching of electrolyte and metals. The chemicals within the batteries are *highly reactive* and can release toxic gases such as hydrogen fluoride, and the electrolytes can be flammable.

Recycling: Most components of lithium-ion batteries such as the cobalt, copper, steel, nickel and aluminium can be recycled – but they must first be recovered and this can be expensive and technically challenging. As a result of these challenges, only 5% of used lithium-ion batteries are recycled globally with variance across regions. For example, lithium-ion battery recycling rates are below 5% in the EU and US, around 2-3% in Australia but close to 70% in China[6]. Despite the technical challenges, if lithium (and cobalt) demand continues to rise, the economic value of these materials could become a driver for battery recycling.

Li-ion batteries are difficult to recycle because there are multiple types…

However, the various battery formulations make lithium-ion battery recycling difficult – especially because they are designed with performance in mind, and not recycling or disposal. In addition, unregulated recycling could result in further environmental problems such as contamination and leaching, or social risks such as the use of child labour in battery disassembly.

Reuse and repurpose: Lithium-ion batteries can retain around 60%-70% of the charge-storing capacity after their life in EVs; as such, they can be used for other purposes such as energy storage for renewable energy. This repurposing reduces the raw materials required for new batteries as well as the relative emissions of manufacturing new batteries (for other purposes).

Car batteries in the regulatory cross-hairs

…but regulation may change this in the future

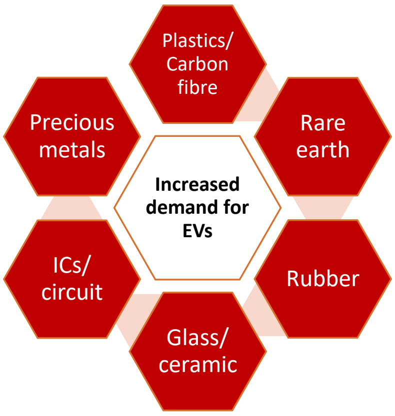
The EU and China have regulations which hold the OEM maker responsible for having schemes in place to recycle batteries. As part of the new EU Circular Economy Action Plan, the bloc will build a new regulatory framework for battery recycling. In China, the Ministry of Industry and Information Technology announced[7] in 2019 a new regulation for the recycling of used new energy vehicle (NEV) power batteries. The regulation requires achievement of 98% nickel, cobalt and manganese and 85% of lithium recovery. The state of California in the US has also formed an advisory group to develop policies related to the recycling of lithium-ion batteries.

4 Lithium-ion batteries towards circular economy: A literature review of opportunities and issues of recycling treatments, Mossali, E, 2020
5 *PV magazine*, Lithium batteries – 1.2m tons ready for recycling by 2030, 04 November, 2019
6 *Energyworld*, Charging up Lithium-ion battery landscape in India, 29 July 2020
7 New energy vehicle waste power battery: Comprehensive utilization of industry standard conditions, 2019

Components and other materials

Besides the battery however, there are many other components that go into the make-up of the full EV, for example, various plastics, other metals and electronic equipment.

Figure 5: Rising EV demand will drive up the demand for other commodities



Source: HSBC

At present, the recycling of many components is not economical

Most materials are associated with some ESG issues – although many of these can be somewhat mitigated through appropriate sourcing, tracing, and better design. The issues are not necessarily higher than other manufactured produces which use these materials. However, at the end of life, it is not clear how much of these components are separated out or extracted from the vehicle and whether they are recycled or reused. It may be uneconomical to do so but circular economy regulations are being considered in a number of jurisdictions.

Table 4: Each component part may be associated with varying ESG issues

Material	Drivers for higher demand	ESG issues
Plastics / carbon fibre	Light-weighting (batteries are heavy); better thermal stability & electrical properties (cooling systems, electrical cable sheathing, etc.)	Polypropylene (bulk use) is uneconomical to recycle; non-biodegradable; microplastics, micro-fibres, food chain impacts; soil / water pollution
Rare earth	Neodymium, dysprosium & praseodymium are used in permanent magnets	Illegal mining, labour abuses, unsafe working conditions, vegetation loss, soil erosion, soil / water pollution, acidification, and waste-water with radioactive residues
Rubber	Higher weight implies greater torque for breaking; more wear and tear of tyres; 30% more replacement	Natural rubber plantation, loss of vegetation and wildlife habitats; 85% small landholders implies less capacity for sustainability measures
Glass / ceramic	New solid-state Li-ion battery uses glass and ceramic instead of liquid electrolyte; glass use in sensors and cameras; ceramic for temp. control components	Sand shortages; unsustainable mining; exploitation of natural resources; impact on (river) ecosystem & habitats
ICs / electronics	Power electronics- inverters, actuators, power management, etc.; micro-processors	High water and energy demand in semiconductor industry; waste-water management; suppliers geographically concentrated (risk of disruptions)
Precious metals	Silver used in electrical components	Mining leads to loss of vegetation and habitat, soil / water degradation, air pollution from particulate matter

Source: HSBC

Plastics: lightweight, but end of life poses problems

Plastics: EV batteries account for about one-fifth of the electric vehicle weight and overall EVs are 10-15%[8] heavier than ICE vehicles. More weight can impact vehicle performance (acceleration and breaking) and required torque and breaking requirements. Light-weighting of various components without compromising safety, durability and strength is an important feature of EV manufacture. Plastics in the form of polypropylene, polyethylene and polycarbonate are commonly used in EVs. Other polymer composites and various alloys are also being used depending on the application. Plastics are highly durable and often difficult to break down and so pose various environmental risks.

Carbon fibre: strong and durable but not readily recyclable

Carbon fibre possesses traits of high strength, low weight and durability without corrosion or much degradation[9]. However, the production of carbon fibre can be up to 14x as energy intensive as the production of steel. Carbon fibre is manufactured by refining oil to get acrylonitrile, then baked under high temperatures, a process that emits up to 20 tCO_2 per ton of carbon fibre[10]. However, the process is inefficient – up to a fifth of carbon fibre produced can be wasted. Recycling of carbon fibre is not readily available but new technologies are emerging[11] [12] although the process is still fairly energy intensive. In the EU, automotive sector-specific regulations require recycling of at least 85% of end-of-life materials.

Rare-earths: environmental problems associated with mining

Rare-earth permanent magnets: Electric traction motors used in EVs employ rare-earth based permanent magnets that enable them to be compact, torque-dense and reliable. Neodymium-iron-boron (NdFeB) is the magnetic material most popular for EV applications[13]. Other rare-earth elements such as dysprosium and praseodymium are also used in these magnets to improve their properties.

Neodymium extraction can be environmentally degrading and potentially cause freshwater and terrestrial toxicity, acidification, freshwater eutrophication and also contamination from radioactive residue[14] [15]. There have also been reports of unregulated mining which has resulted in more environmental damage, unsafe working condition and labour abuses. EV manufacturers are working on reducing their dependence on rare-earth materials. For example, in some of its EV models, Tesla Motor has used induction motors which do not require permanent magnets. Similarly, other manufacturers, such as Nissan and BMW, have used hybrid motor technology[16] which also requires fewer permanent magnets.

Rubber: braking causes dust particles and air pollution

Rubber: EV tyres usually experience more wear and tear due to the rapid torque as well as the higher weight of the vehicle. A study by Goodyear tyre company reveals that EVs need 30% more frequent tyre replacement than conventional vehicles due higher weight and greater torque[17]. This wear and tear can lead to more dust particles which contribute to air pollution. More generally, rubber plantations have been linked to loss natural vegetation and habitats for the wildlife[18].

Glass: sand shortage and ecosystem damage

Glass / ceramics: Newer solid-state lithium-ion batteries may use glass and ceramic instead of liquid electrolytes. Glass is also required in sensors and cameras; ceramics are also used in temperature control components. Demand for both glass and ceramics may potentially lead to unsustainable mining of resources, shortages of raw materials (e.g. sand) and damage to ecosystems through riverbed and wildlife loss.

8 Influence of batteries weight on electric automobile performance, Berjoza et. al. 2017
9 *The Guardian*, Carbon fibre: the wonder material with a dirty secret, 22 March 2017
10 Carbon Fiber and Global Environment, Toraya
11 *Composite world*, The state of recycled carbon fiber, 9 April 2019
12 An Environmental Comparison of Carbon Fibre Composite Waste End-of-Life Options
13 Electric vehicle traction motors without rare earth magnets, Widmer et. al., 2015
14 Environmental Impacts of Rare Earth Mining and Separation Based on Eudialyte: A New European Way, Schreiber et. al., 2016
15 Recycling Decisions in 2020, 2030, and 2040—When Can Substantial NdFeB Extraction be Expected in the EU?, Reimer et. al. 2018
16 Electric vehicle traction motors without rare earth magnets, Widmer et. al. 2015
17*Green car congress*, Goodyear develops new tire technology to optimize EV performance; also introduces Oxygene concept with moss, 7 March 2018
18 *Rainforest Alliance*, Global Platform for Sustainable Natural Rubber (GPSNR), 24 April 2019

Electronics: various ESG issues plus disposal questions

Integrated chips / electronics: Modern vehicles, and especially EVs, have increased demand for control equipment and processors such as integrated microchips as well as power electronics such as inverters, actuators and other power management systems. The semiconductor manufacturing industry has its own environmental and social issues. For example, high demand for electric power and water resources and the generation of large amounts of waste and wastewater during the production process – although these are common across all sectors which use electronic chips. Appropriate disposal of these chips at the end of life for the vehicle is difficult and can lead to contamination of the local environment.

Precious metals: Silver and gold have wide applications as contact metal in EVs. Sometimes, the mining of these metals is associated with environmental issues.

EV assembly

The assembly part of the EV value chain is more concerned with social issues, with these coming to light during the COVID-19 pandemic where factory operations have been suspended.

The move to automation….

Employment opportunities across the EV supply chain
According to the UN Industrial Development Organisation, in 2017, around 14m people were directly employed in the auto sector. Traditional auto-related jobs such as fuel supply, engine making, casting and forging may give way to the manufacture of batteries, electric motors etc. At the same time, the sector is embracing more automated assembly. The net result could be an increase in overall employment given that the size of the automotive sector itself is expected to increase. For example, the European Climate Foundation estimates the increase in employment at 5,00,000 to 8,50,000 by 2030 for the European Union.[19].

…could be accelerated by COVID-19….

COVID-19 impacts: During the pandemic, several EV manufacturers shut operations and/or furloughed employees. For example, Tesla furloughed around 11,000 employees and closed its operations in Fremont, California in mid-April[20]. However, in May it asked its employees to return to work. Tesla also had to shut its Shanghai gigafactory for over a week in early February 2020 due to the spread of COVID-19[21]. Chinese EV start-up Byton suspended its US operations and furloughed employees for 6 months from 1 July 2020[22]. Rivian, another US start-up, postponed the launch of its first electric truck to 2021 due to the pandemic-related shutdown of operations[23] although the company said that it will continue to pay workers during the shutdown[24]. The EV sector was also impacted by the disruption of the global supply chain for batteries, electronics and sensors[25].

20	**2000**
# of moving parts in an EV powertrain	# of moving parts in an ICE powertrain

…but this was going to happen eventually…

The automation risk: EVs have fewer moving parts due to the relatively simpler nature of the drivetrain and how this is powered. For instance, a typical EV powertrain has around 100x *fewer* (20) electromechanical parts than an ICE powertrain (>2000)[26]. As such, the assembly of an EV is technically more simple (around *30%*[27] less work) than an ICE vehicle. There have been

19 Zero emissions vehicles (ZEVs): Towards a policy Framework', Niti Ayog (India), 2018'
20 *Fox Business*, Tesla furloughed 11,000 California workers in coronavirus before contentious restart, 14 May 2020
21 *The Verge*, Tesla says China has ordered its Shanghai factory shut down over coronavirus fears, 29 January 2020
22 *Bloomberg*, Chinese Electric-Car Startup Planning U.S. Entry Halts Operations for 6 Months, 30 June 2020
23 *Forbes*, Second Wave Of Coronavirus Could Delay Rivian's R1T Electric Pickup, 14 July 2020
24 *Week*, Rivian's workers in Normal to be paid during plant shutdown 20 March, 2020
25 *Week*, Rivian's workers in Normal to be paid during plant shutdown 20 March, 2020
26 *Inside EV*, Here's Seven Reasons Why Electric Vehicles Will Kill The Gas Car, 22 September, 2018
27 *Assembly*, Electric Vehicle Makers Rethink Assembly Processes, 6 November, 2019

concerns about job losses or less hours among workers in the auto sector[28]. Full automation of the assembly line is difficult however as some human support is usually required. Tesla has tried to fully automate its Model 3 assembly line but it missed its expected production capacity because of "excessive automation"[29], according to the CEO. As robotics develops to become more precise, we would expect more automation in the future.

….and communities will have to realign accordingly

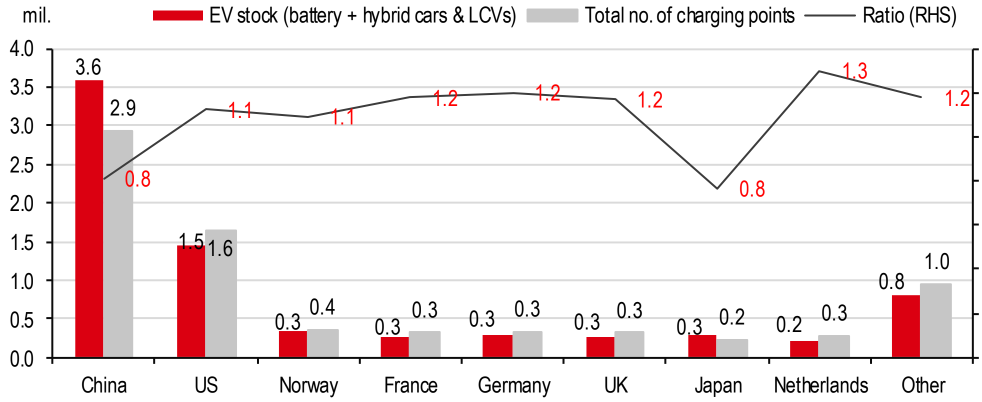
Local community re-skilling: Vehicle assembly facilities tend to be major employers within the local community. Labour skills and engineering knowledge may have to be realigned for EVs over ICEs. However, the supply chains tend not to sit within the local community; for example smaller factories that produce parts for engines, transmissions, exhaust and fuel systems could try to re-tool to produce components for batteries and electric motors[30]. However, it is likely that the manufacture of components will become commoditised and as such these components are likely to be produced where it is cheapest to do so – and not necessarily close to assembly facilities. Local workers unable to reskill (or facilities that are unable to retool) will fall out of the supply chain.

EV charging infrastructure

Charging infrastructure is waking up to carbon intensity

In terms of numbers, China and the US have the most EVs, however in terms of proportion of vehicle sales, Norway saw the highest share in 2018 (49%), followed by Iceland (19%) and Sweden (8%). The uptake of EVs is a function of affordability, regulation, perception and incentives but also the access to charging infrastructure. China currently has the largest number of charging points in the world with plans to add more[31].

Figure 6: The ratio of potential charge points to cars in certain countries



Source: Global EV Outlook 2020, IEA; LCVs= light commercial vehicles.
Notes: Total no. of charging points includes private. Ratio is charge points to EV stock.

Electricity grids are naturally decarbonising over time

At a national level, China used 28% renewables to generate electricity in Q1 2020 whereas in the US, renewables contributed 17% of electricity generation in 2019. At a sub-national level however, the picture can be different. For example, in California, renewables contribute 32% of electricity generation and EV car sales comprised about half the entire US EV market (close to 160,000 new vehicles) in 2019. The state has a goal to reach 5m ZEVs (Zero Emission Vehicles) on the road by 2030 and 250,000 charging stations by 2025[32]. According to Germany's 2030 Climate action programme, the country plans to register 7-10m EVs and make 1m charging stations available by 2030.

28 Strategies for a Fair EV future, UAW research department
29 *Bloomberg*, Musk Says Excessive Automation Was 'My Mistake', 14 April 2018
30 Strategies for a Fair EV future, UAW research department
31 *Greenbiz*, A look inside China's timely charging infrastructure plan, 21 July 2020
32 *California Public Utilities Commission*

Variable charging incentives

Demand-side management is being deployed…

Besides reducing the overall carbon intensity of the grid, there are other initiatives that can improve the efficiency of charging EVs in a similar manner to "demand side management" of normal electricity (e.g. turning on the washing machine overnight). For example, Charge Forward, a pilot scheme in the US, asked customers to delay the times during which they charge their EVs in order to align with when more of the grid is served by renewable energy. Various schemes offer lower rates as incentives to EV customers.

…as well as the active purchasing of renewables for use in EV charging

Ensuring EV charging aligns with renewables[33]: This essentially means carving out the renewable portion of generation and earmarking them for charging EVs. It is usually the operator of the charging points that will source the renewable energy through power purchase agreements (PPAs). Some examples include:

- US – EVgo aims to power its EV charging network with 100% wind or solar energy;
- US - Austin Energy's Plug-in EVerywhere Network allows customers to source 100% of their charging electricity from wind;
- UK – a collaboration of automakers (Daimler, Volkswagen Group, Ford, BMW and Hyundai) are trying to ensure that their network of 40 High Power Charging sites uses 100% renewable energy.[34]

Some charge points are directly connected to renewable energy

Some operators are directly linking their charging stations to renewable energy.

- Tesla is connecting solar panels to its chargers;
- Some of Google's charging stations are directly connected to solar energy systems;
- San Diego Gas & Electric installed solar canopies to their charging stations with energy storage.

What about end of life?

As EV numbers increase and as the current fleet ages, more consideration will have to be given to what happens to the EV at the end of its life. We touched on many of these issues in the above sections. In some cases, a new battery can be put into an old EV, but other questions remain as to what happens to old EV batteries and ultimately, the vehicle. For example, how much of an EV can be recycled – economically and technologically? As the circular economy becomes more embedded into our thinking, we think "whole car" recycling may begin to appear on the horizon for governments. Perhaps EVs will go where ICE cars have not gone before.

Conclusion

The climate and emissions benefits of EVs vs ICE vehicles are generally known – although there are still many areas to consider such as the efficiency of production and the carbon intensity of the electricity used for charging.

Breaking down the EV supply chain, however, shows there are very many different ESG issues that affect the various segments in different ways. In general, the more upstream part of the supply chain tends to be affected by more environmental issues and these may overlap with social issues. For EV assembly, social issues take prevalence.

We have not discussed governance issues at length in this report – there are the usual issues surrounding material sourcing, for example, potential bribery and corruption. However, the governance issues may be more company specific rather than sector specific. For example, we think that related party transactions can creep in as an issue given the various parts of the EV supply chain and how fragmented the industry becomes further upstream.

33 *World Resources Institute*, 4 Emerging Ways to Pair Electric Vehicles and Renewable Energy, 19 November 2019
34 *Electric Cars report*, First IONITY high power EV charging station launched in UK, 24 May 2019

Disclosure appendix

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Issuer of report
The Hongkong and Shanghai Banking Corporation Limited
Level 19, 1 Queen's Road Central
Hong Kong SAR
Telephone: +852 2843 9111
Fax: +852 2801 4138
Website: www.research.hsbc.com

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