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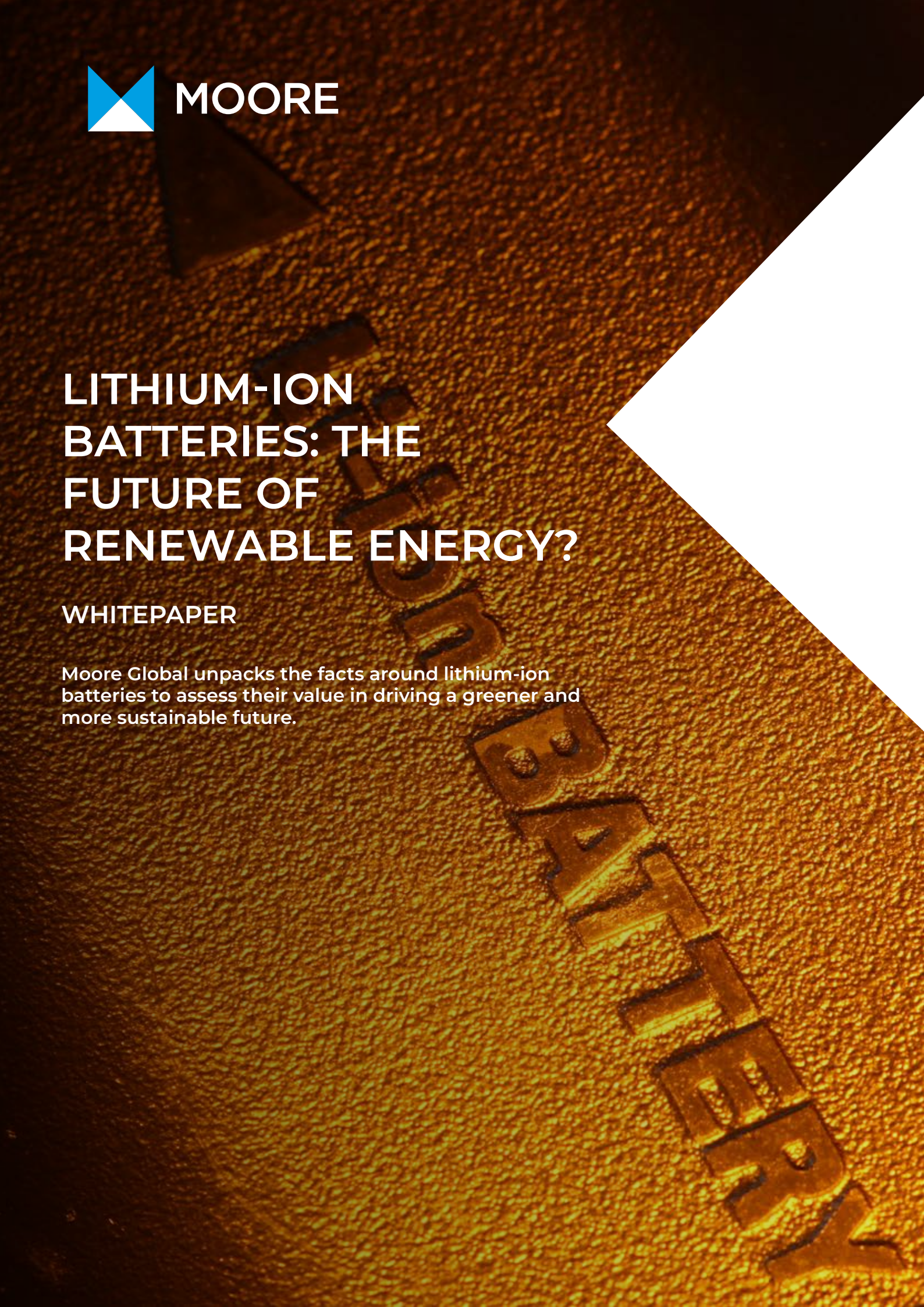
LITHIUM-ION BATTERIES: THE FUTURE OF RENEWABLE ENERGY?

WHITEPAPER

Moore Global unpacks the facts around lithium-ion batteries to assess their value in driving a greener and more sustainable future.



EXECUTIVE SUMMARY

Can the lithium-ion (Li-ion) battery play a role in creating a greener and more sustainable future for Energy, Mining and Renewables (EMR) organisations?

In a bid to significantly reduce greenhouse gas (GHG) emissions, there is a need to focus on solutions that shift the energy paradigm by providing cleaner and greener energy in more sustainable ways. According to the United Nations, in a report entitled 'Frontier Technology Issues: Lithium-ion batteries: A pillar for a fossil fuel-free economy', Li-ion batteries promise clean technology, one that can fundamentally shift the industry's reliance on fossil-fuel powered devices, and deliver measurable emission gains across multiple sectors.

To fully understand the value of this energy resource, it's important to explore the substantial potential benefits it offers, as well as to unpack the contentious environmental impact associated with Li-ion battery production, and to connect these dots to Environmental, Social and Governance (ESG) factors and the future of EMR sectors.

LITHIUM-ION: ANALYSED

In a recent report by the United Nations, Li-ion batteries, in conjunction with solar photovoltaic (PV) and wind, are reducing the cost of renewables, it is increasingly viable for organisations to invest into decentralised solutions that transform energy provision, and to complement alternative renewable grid connections. These batteries have, as the report points out, 'become an integrated part of decentralised, often mini- or micro-, off-grid renewable energy systems, replacing diesel power generators in many remote areas'.

In this white paper we look at the global energy landscape, the challenges inhibiting clean energy adoption, and the value that Li-ion batteries provide to EMR organisations, both today and in the future.

A GLOBAL OUTLOOK

It has become abundantly clear that we can no longer rely on fossil fuels to meet our ever-growing energy needs, and that we need to mitigate our reliance on these fuels and address the increasingly complex climate landscape. This is echoed in the World Meteorological Organization's State of the Global Climate 2022 report, in which it is mentioned that extreme heatwaves, drought, and devastating flooding have affected millions and cost billions in the past year, with the September-November 2022 global surface temperature 0.84˚C (1.51˚F) above the 20th-century average of 14.0˚C (57.1˚F). This ranks as the fifth-warmest September-November period in the 143-year record.

There is little doubt that there is a global energy crisis. The need to shift the foundations of energy provision towards cleaner, greener and more sustainable alternatives has become critical. For the EMR sector, it's essential that the move to more environmentally friendly, socially equitable and economically sustainable energy sources should be undertaken at speed.

However, in spite of the value of renewables across both social and ethical levels, and in the changing shape of investment into organisations that show a clear commitment to green and sustainable energy solutions, there are challenges inhibiting its uptake and that have an impact on the sector as a whole.

THE STATISTICS AT A GLANCE

Energy prices remain high with global electricity demand increasing by 389 TWh (+3%) in 2021

The global economy is slowing and the International Monetary Fund (IMF) cut this to 2.7%

Total global demand reached 13,393 TWh in the first half of 2022, up from 13,004 TWh in the same period the previous year

Global energy consumption will reach 740 million terajoules—equivalent to an additional 30 percent growth by 2040[1]

Economic, geopolitical, environmental, and social considerations are all contributing to an intensified and more robust debate regarding the future of renewable energies. The good news, however, is that there is a growing consensus that economic factors can no longer be used as the sole measurement of success or failure in years to come.

As the world faces unprecedented energy shortages, increasing energy price inflation and the adverse effects of global warming, it is necessary that governments, corporates, and individuals align with the objectives and ten simple actions of COP27.

Set against a difficult geopolitical backdrop, COP27 resulted in countries delivering a package of decisions that reaffirmed their commitment to limit global temperature rise to 1.5 ˚C above pre-industrial levels. The package also strengthened actions by countries to cut greenhouse gas emissions and adapt to the inevitable impact of climate change, as well as boosting the support of finance, technology and capacity building needed by developing countries. The core target is that emissions must be reduced by 45% by 2030 and reach net zero by 2050.

At this event on 27 November 2022, it was made clear that the fight for the climate was not a lone battle, but that it had to be a collaborative effort that engaged with industry and government to fundamentally change the narrative. It is also one that asks industry to revisit its energy provision approaches and to invest in solutions that will deliver long-term, sustainable value.

AN INCREMENTAL APPROACH

With the bar set so high on emissions targets, it is unrealistic to expect organisations to achieve these in one giant leap. Instead, EMR leaders should think of it as climbing a stepladder, each rung representing an incremental improvement contributing to cutting emissions. Targets should be perceived as aspirations with the ultimate goal of achieving sustainability that's long-lasting within realistic and robust frameworks.

"One of the most important actions we can take is to acknowledge it is not easy going green. We must challenge the daily habits of our modern society and the vast, interconnected global economy that has improved the lives of billions".

David Tomasi

EMR sector leader, Moore Global

A STEP TO THE LEFT

There is a growing global consensus that energy generation through renewable sources, such as by means of wind, hydro and solar power, is integral to reducing CO_2 emissions and creating a greener future. The simple truth is that there can, be no future for renewables without effectively solving the problem of how to store the energy once it has been produced. Batteries are, essential in ensuring energy availability and stability when the wind is not blowing and the sun is not shining.

That's where the Li-ion battery comes in. Li-ion batteries, and the embedded economic, social, and environmental costs associated with their production, represent one of rungs on this ladder—and it requires robust debate.

These batteries are currently the industry standard in energy storage and attract significant research and development funding. While smaller Li-ion batteries have been tried and tested within smartphones and smaller devices, the economic viability, durability, longevity, and environmental sustainability of larger-storage-capacity Li-ion remains untested.

That said, the Li-ion battery can be viewed as an enabler, without which the efficiency and ability to implement renewable energy strategies would be substantially limited. These batteries are critical to developing low-carbon power opportunities worldwide, and will dictate how fast the global transition can happen.

However, the ESG impact of Li-ion battery production can be both controversial and polarising and requires that a balance must be found between financial performance and good social, environmental and governance practices. The benefits are there, but they must be weighed against the disadvantages to ensure that any investment in this technology delivers results that measure up to sustainability standards. This is not only key in terms of the organisations' stand on environmental issues, but aligns with stakeholder and investor demand for ESG reporting that's transparent and relevant.

Li-ion batteries can potentially be an arrow in the EMR corporate bow, offering a stable and proven green energy solution to an increasingly tricky problem. But the abilities of these batteries need to be balanced with their limitations, to ensure that they do deliver what the industry expects and needs.

A RISING TIDE

According to the World Economic Forum, the rechargeable Li-ion battery market has doubled every three years over the last decade and is forecast to attract $620bn of investment by 2040.

Historically, portable electronics have been the primary driver of growth in the battery market. However, today, the growth in demand comes from electric vehicles and renewable energy storage.

The International Energy Agency projects that by 2030, 130 million electric vehicles could be on the world's roads. While scenarios vary, significant electric vehicle and battery production investments are well underway, fuelled by national and international targets to reduce CO2 emissions. Several governments and cities have recently announced their intention to ban internal combustion engines over time.

Beyond the world of transport, the entire energy system is undergoing a transformation, and wind and solar energy are expected to account for 50% of global power generation by 2050.

THE ENVIRONMENTAL AND SOCIAL IMPACT OF THE LI-ION BATTERY SUPPLY CHAIN

Minerals such as lithium, nickel, cobalt, manganese, and graphite are all critical minerals required to manufacture Li-ion batteries, all of which require disruptive and potentially environmentally damaging mining techniques.

Lithium (Li) is a soft, lightweight metal with such a low density that it floats on water. However, it is also an alkali metal, which is highly reactive and volatile. These are the properties that lend themselves to battery production and energy storage.

Lithium has been dubbed the 'white gold' of the new millennium, and demand has increased exponentially in recent years. The production of minerals such as lithium, graphite, and cobalt is expected to increase by nearly 500% by 2050 to meet the growing demand for clean energy technologies.

Lithium salts can be found in underground deposits of clay, mineral ore, and brine, as well as in geothermal water and seawater. Open-pit and brine extraction are the two most common methods of lithium mining. Both methods have huge land footprints, are very water-intensive, require clearing of natural vegetation, can lead to water contamination, and contribute to erosion and air pollution.

Brine mining is a lengthy process involving pumping brine into evaporation ponds that are allowed to dry naturally, resulting in a mix of manganese, potassium, borax, and salts. This mix is then filtered and placed into yet another evaporation pond. It takes approximately 12 to 18 months for that mix to be sufficiently filtered for the lithium carbonate to be extracted. While it's cheap and effective, the process is water-intensive, and an estimated two million litres of water is required per ton of lithium extracted. The average electric vehicle battery contains 12kg of lithium, which equates to each battery requiring approximately 24 000 litres of water to produce.

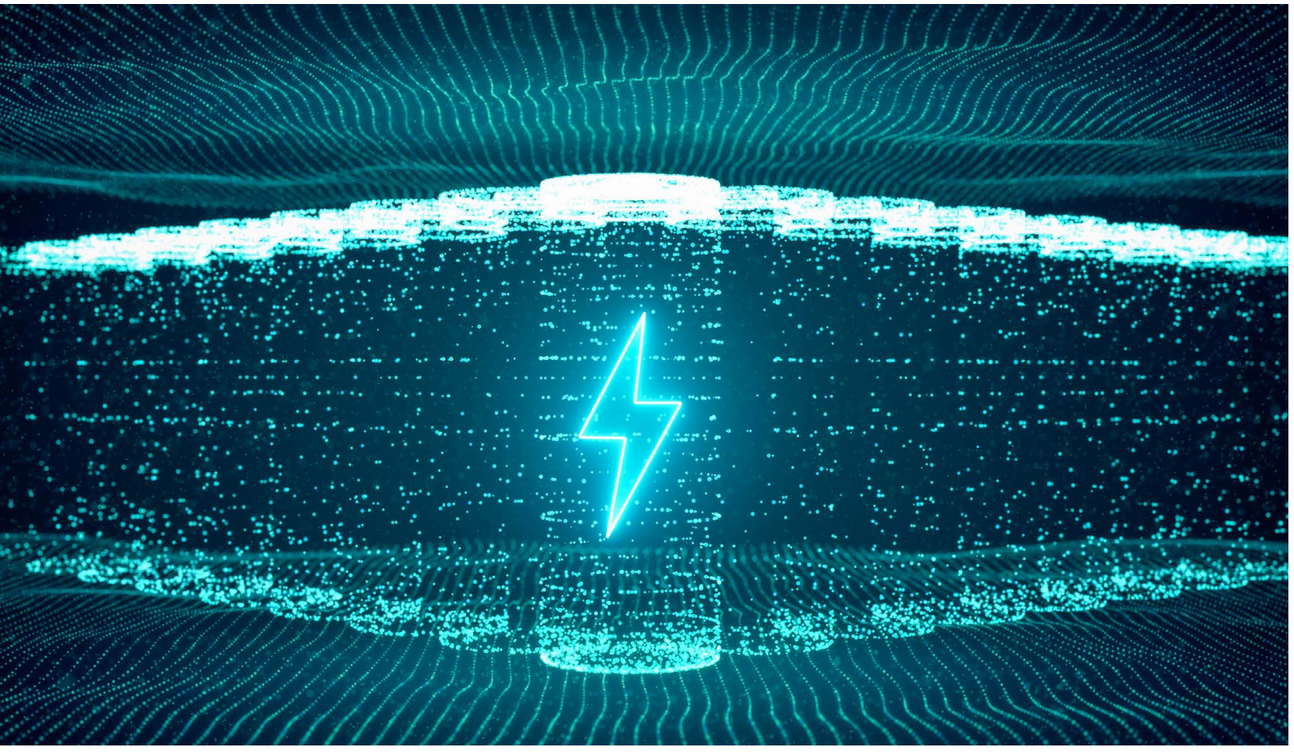
Mining activity depletes already scarce water resources on which local communities, flora, and fauna depend, and can further result in possible toxic soil and dust containing high levels of heavy metals. In many cases, communities are

Chile has the world's largest known lithium reserves of eight million tons, with its Salar de Atacama mine alone consuming 65% of the area's water, in a region where annual rainfall is less than 15 millimetres per year.

indigenous to the area and hold traditional or communal rights to land and resources. These communities are often displaced due to water shortages for themselves and their livestock.

Furthermore, toxic chemicals used in the separation process, such as hydrochloric acid, can leak from the evaporation ponds into local water supplies and affect water and air quality. Research by the Latin Lithium Congress found that a lithium processing operation in Nevada had a detrimental impact on fish 150 miles downstream.

The detrimental impact of the mining of critical mineral and lithium battery production is significant, but can be effectively mitigated. The future is firmly in the hands of governing bodies and regulators to enact and adopt effective legislature and good governance measures throughout the supply chain.



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THE CATALYST FOR CHANGE

Researchers argue that there is a need to redevelop mining technologies to reduce the carbon footprint in the manufacturing process of Li-ion batteries. There is a global shift in exploring new alternatives, improved lithium extraction methods and battery chemistries that might replace cobalt and lithium with more common and less toxic materials.

Direct Lithium Extraction (DLE) and Direct Lithium to Product (DLP) promise to increase lithium supply, reduce the industry's environmental, social, and governance footprint, and to lower costs. However, these technologies are still in their infancy and are subject to volatility.

An additional burning environmental question is the subject of electronic waste. The UN has declared that electronic waste (e-waste) has become one of the world's most pressing environmental and human health issues. Currently, most electronic waste is not efficiently disposed of or dismantled, and ends up in landfills, contaminating the soil and contributing to health and fire risks.

With an expected Li-ion battery lifespan of around 10 to 15 years for passenger vehicles, and the possibility of extending EV battery usage in the energy storage sector, battery recycling is expected to increase exponentially during the current decade. Depending on the recycling process employed, it is possible to recover up to 90 percent of the lithium contained in end-of-life batteries.

To ensure that there is no erosion of the intrinsic value of a greener future of Li-ion batteries, future regulatory and governance measures will put pressure on mining companies and battery manufacturers to not only redirect operations into finding new, more environmentally friendly mining and extraction methods, but also to expedite the need for more, as well as more efficient, second-life and recycling technologies.

CALCULATING THE CLIMATE IMPACT OF LI-ION BATTERIES

Over the last ten years, the Li-ion battery has gone from an enabling technology for mobile electronics to being a gateway to the world's decarbonisation and reduction of greenhouse gases.

This reliance on Li-ion batteries demands that organisations accurately calculate CO2 emissions and the resultant climate impact during the production of these batteries.

The Li-ion battery value chain is complex and requires as many as 20 raw materials to be mined and sourced worldwide. These materials pass through several energy-intensive refining stages before entering an advanced manufacturing process. Each has a very different climate impact and a variable dependency on the energy source used.

Calculating the true impact of Li-ion batteries on climate change is further complicated by the lack of primary data. Of all Li-ion battery life cycle research, only a few studies use primary data. Even in these cases, the primary data is rarely derived from real plants or production sites, but is usually an estimate or a result from modelling.

UNDERSTANDING THE IMPACT

Although the research available today shows large differences in how to measure and evaluate the embedded climate impact of Li-ion batteries, there is, a view on the main variables that should be used.

01

Cumulative Energy Demand (CED)

With this metric, we understand how much energy has been used to produce the battery, regardless of the energy source. It may include all energy used to produce the battery, from raw material extraction to the final assembly, or any part of the process in between. When measured per unit, this is the metric a company in the value chain can alternate by changing its process or operation, regardless of its energy source.

02

Amount of GHG or CO2 emissions (CO_2e)

This is what really matters when analysing the climate effect of Li-ion batteries. The metric is, however, only of marginal interest when not combined with CED data. A company that achieved nearly zero CO2 emissions by buying green energy from the grid will only have moved fossil fuel consumption to somebody else on the grid. Energy must be used efficiently, even when the energy source is clean.

03

To extract useful data and ensure comparability, the above variables need to be considered and combined with so-called functional units, the most common being:

- (MJ/kWh) Mega Joules per Kilowatt-Hour
- (Kg CO_2e/kWh) Amount of CO2 or other GHG emissions turned into CO2 equivalents required to produce the battery's capacity
- (Kg CO_2e/kg) Kilogram CO2 equivalents per kilogram of battery
- (g CO_2e/km) the amount of CO2 emission from the battery per driven kilometre

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The biggest challenge in measuring the CO2 footprint of a battery is that it can't be physically measured in the usage phase. While the emissions from the combustion of fuels can be measured by analysing the emissions, and the emissions from an electric motor can be measured by how much energy it consumes, the only method to track the embedded emissions from a battery is to measure the direct and indirect energy consumption for the different steps in the production chain.

The complexities of accurately calculating and comparing various analyses on the effects of Li-ion batteries on the global climate are further brought into perspective by significantly debatable and currently unclear system boundaries, and the extent to which the extensive variables are utilised in any calculation or analysis. Is it assessed using the cradle-to-the-grave approach, which would incorporate CO2 emissions from the mining of raw materials through the production of the batteries, as well as second-life and recycling considerations, or is it necessary to adopt a narrower, far more focused approach?

The above conundrum would, be far easier to solve if legislation were to be put in place, dictating parameters and governance measures within which companies are required to make these measurements.

IMPROVING EFFICIENCIES

Over time and with the evolution of technology, experts agree there will be vast improvements to the entire value chain, and that batteries will become more efficient and also have lower usage requirements. The benefits of this will far outweigh those of current solutions, such as fossil fuels.

With the production of Li-ion batteries gaining momentum and the extensive interwoven web of the production value chain reaching far and wide, it is clear that concise regulations and governance requirements need to be put in place to help ensure batteries have a sustainable future . These requirements need to be equitable and fair across the entire value chain, as well as define and regulate methodologies and emissions levels within the EMR sector.

"There are today over 100 research articles that cover the environmental impacts from lithium-ion batteries dating back to as early as 1999. The focus of the research varies, as do the methods. For this reason, the results are also widely different, with a climate impact ranging from 39 kg CO_2e/kWh to 196 kg CO_2e/kWh. If an electric vehicle uses a 40-kWh battery, its embedded emissions from manufacturing would be equivalent to the CO_2 emissions caused by driving a diesel car with a fuel consumption of 5 litres per 100 km between 11,800 km and 89,400 km. Before the electric car has even driven one meter. While the lower range might not be significant, the latter would mean an electric car would have a positive climate impact only after seven years for the average European driver".

Hans Eric Melin

Circular Energy Storage
Analysis of the climate impact of lithium-ion batteries and how to measure it.

FINANCIAL BENEFITS OF ESG REPORTING

The race to achieve net-zero emissions by 2050 presents interesting challenges and opportunities for economic sustainability objectives. These factors identify the connection between the different sections of the economy, society and environment and the integration of silo scenarios and all factors.

The modern ESG framework was implemented in 2009 after several investors, businesses, and governments needed to realise the impact of climate change, human rights, governance, and social well-being. ESG considerations are increasingly playing a larger role in influencing the decision-making of financiers, banks, and investors.Moore Global's 2022 research paper, The $4-trillion ESG Dividend, found that "businesses placing greater emphasis on ESG over the last three years have seen revenues increased by almost 10% in that time. This compares to revenue growth of just 4.5% for businesses with a comparatively lower commitment to ESG."

With ESG investing gaining momentum, all companies, big and small, will, in future, need to disclose any environmental risks to which they are contributing in their ESG reporting. Therefore, failure to mitigate against the ESG risks could adversely affect the attraction of skilled employees, customers, financers, investors, and could ultimately affect financial performance and share pricing.

The crux of the matter is in today's world, firms within the EMR sector, involved in the production of lithium batteries, wishing to continue on a trajectory of economic growth, can no longer ignore ESG factors in their modelling and reporting.

IN CONCLUSION

Li-ion batteries provide EMR organisations with a sustainable solution to complex energy provision expectations. There are risks and challenges to be overcome to ensure that their ESG impact is mitigated and that they do realistically provide a sustainable means to an end, but with these concerns in mind there is scope to translate challenges into potential.

The following short-term objectives can be implemented to ensure the long-term sustainability of these batteries:

1. More environmentally friendly extraction techniques.
2. Communities must be consulted and be equitably involved.
3. Processing technologies need to be more efficient.
4. Standardised CO2 boundary limits and measurement methodologies.
5. Fast-track second-life and battery recycling.
6. EMR companies to focus on ESG accounting and reporting.
7. Governments must be unwavering in achieving CO2 emission targets.

There is no one perfect solution to the energy crisis, nor is there a silver bullet that will instantly solve the many problems inherent in the proposed solutions available on the market today. Sustainable energy investment into solutions such as Li-ion batteries should be managed coherently, while keeping both the risks and the rewards in mind. This technology is changing the direction of the sustainable energy conversation and, as global controls and regulations evolve, within tighter regulation and legislation to ensure it upholds the principles of sustainability and ESG.

ABOUT MOORE GLOBAL

Moore Global and our member firms have been helping international clients with professional accountancy and advisory services for over 100 years. With our global family of almost 30,000 people in more than 100 countries, we have the local knowledge to meet your needs wherever your work might take you. From tax efficiency to auditing to business consultancy, people are always at the heart of what we do.

When you work with Moore firms, you'll work with people who care deeply about your success and have the drive and dedication to deliver results for you and your business. You'll have greater access to senior expertise than with many firms. We'll be here for you whenever you need us—to help you see through the maze of information, guide you in your decisions, and ensure you take advantage of every opportunity. To help you thrive in a changing world.

Organisations in the energy, mining, and renewables industry are currently operating in an extremely volatile market, with geopolitical pressures, depleting natural resources, commodity price risks, supply chain disruptions and an ever-increasing expectation to meet environmental, social and governance demands within an interconnected global economy.

Sustainability is a key challenge facing the EMR sector. At Moore Global, we understand the sector's complex issues, the key industry drivers, the technical operating processes, and the regulatory considerations that apply.

Moore Global can help your business meet its ESG and financial goals through our unique ESG Framework. Our framework is easy to implement and understand and can help you create fundamental change within your business.

With a wealth of international knowledge and experience, Moore Global ESG has the expertise to make sure your company can be transparent about social responsibility requirements and become the business you aspire to be.

At Moore Global, we are here to help you thrive in a changing world.

USEFUL SOURCES

1. https://www.iea.org/reports/world-energy-outlook-2022
2. https://www.un.org/en/actnow/ten-actions
3. https://www.moore-global.com/intelligence/articles/november-2021/it-is-not-easy-going-green,-so-let%E2%80%99s-focus-on-prac
4. https://www.weforum.org/agenda/2019/01/batteries-can-power-sustainable- development-heres-how/
5. https://www.mdpi.com/2071-1050/14/19/12879
6. https://lithiumcongress.com/what-s-behind-lithium-mining-here-s-all-you-need-to-know/#:~:text=In%20Nevada%2C%20the%20research%20found,soil%20and%20causes%20air%20contamination
7. https://www.transportenvironment.org/wp-content/uploads/2021/07/2019_11_Analysis_CO2_footprint_lithium-ion_batteries.pdf
8. 2019_11_Analysis_CO2_footprint_lithium-ion_batteries.pdf
9. Environmental Impact of a Battery.pptx
10. https://www.moore-global.com/MediaLibsAndFiles/media/MooreStephens2020/Documents/Moore_ESG_White-Paper_FINAL.pdf
11. Nov 22 - Johannesburg ESG Mining supply and demand.pdf
12. Oct 22 - Johannesburg What we Can do for your ESG business.docx
13. https://www.td.com/ca/en/asset-management/documents/investor/PDF/news-insight/Lithium-A-Circular-Economy-Perspective.pdf
14. https://www.thecorporategovernanceinstitute.com/insights/guides/10-esg-trends-to-watch/
15. https://www.sfa-oxford.com/battery-metals-and-materials/market-reports/lithium-battery-recycling-value-chain-and-esg/
16. https://www.mining.com/esg-to-assume-center-stage-in-lithium-extraction-report/
17. https://www.wired.co.uk/article/lithium-batteries-environment-impact
18. https://www.azocleantech.com/article.aspx?ArticleID=1520
19. https://ul.org/research/electrochemical-safety/getting-started-electrochemical-safety/environmental-impacts
20. https://www.reuters.com/business/sustainable-business/new-lithium-technology-can-help-world-go-green-if-it-works-2022-04-07/
21. https://www.materials-talks.com/sustainable-lithium-mining-with-xrd/
22. https://www.economist.com/science-and-technology/2022/09/05/heatwaves-and-floods-around-the-world-may-be-a-taste-of-years-to-come
23. https://pages.eiu.com/rs/753-RIQ-438/images/energy-in-2023.pdf?mkt_tok=NzUzLVJJUS00MzgAAAGJK0dyLna6DPjs7zVtDN9lXrO15pNKgnopkBVrsZ0m1oKSdkH-lqY0NT6ogixaoWbsfl_kbbKQUVdvQIxfecEOFKjQkl5ZJdhZYLdk7pGZW0Bvag

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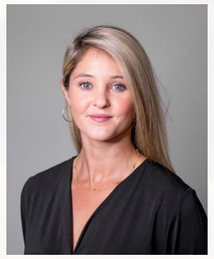

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