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Asia's path to a greener future

Six technologies with decarbonising potential

invested in insights.

Written by

ECONOMIST IMPACT

Content

Acknowledgements

Asia's path to a greener future: Six technologies with decarbonising potential is a report written by Economist Impact and sponsored by Eastspring Investments. The findings are based on an extensive literature review, an interview programme, and analysis conducted between October 2022 and March 2023.

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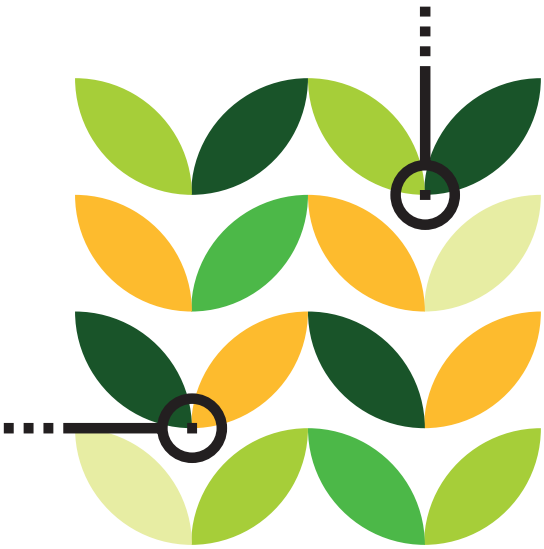
Our thanks are due to the following people for their time and insights throughout the project's duration:

- **Jean-Christophe P Gabriel**, Nanosciences Research Director, CEA (Alternative Energy and Atomic Energy Commission); Visiting Professor, Nanyang Technology University; Co-Director, SCARCE Laboratory
- **Siddharth Jadhav**, Chief Executive Officer, Polybee
- **Alok Jain**, Chief Executive Officer, Trans Consult; Expert Member, Council for Decarbonizing Transport in Asia
- **Edwin Keh**, Chief Executive Officer, The Hong Kong Research Institute of Textiles and Apparel
- **Jolene Lum**, Client Development Manager, Nurasa
- **Steve Melhuish**, Founding Partner, Wavemaker Impact; Founder, PropertyGuru Group
- **Bryan Oh**, Chief Executive Officer, NEU Battery Materials
- **Vishal Tolambia**, Founder and Chief Executive Officer, Humanity Centred Designs
- **Tonny Xie**, Director, Bluetech Clean Air Alliance
- **Rebecca Mikula Wright**, Chief Executive Officer, AIGCC (Asia Investor Group on Climate Change)



Foreword

Stuart Wilson, Head of Sustainability, Eastspring Investments

Identifying opportunities for investment is key to helping raise the capital needed to solve the climate challenge in Asia and to support the energy transition to one that is just and inclusive. Decarbonising Asian economies requires a multi-faceted approach, combining swift and incisive policy responses that reduce carbon emissions while ensuring that the emerging middle class continues to have access to affordable energy and transport.

For Asian investors, continued decarbonisation and progress matters. With targets enunciated in country net zero pledges, governments are increasingly emboldened to advance climate ambitions. The onus is also on corporations to support these ambitions by taking action to make their operations more sustainable.

Technological innovation is key to hitting the region's climate targets. As decarbonisation technologies continue to develop and become a salient part of just transition efforts in the region, identifying investable opportunities to scale these innovations will allow investors to make the most impact with their capital. The development of an investable ecosystem will also help to attract and retain a significant base of domestic and international capital.

This whitepaper, written by Economist Impact, explores meaningful emerging technologies in agriculture, transport, and waste, with the potential to be impactful, scalable and fundable. This research hopes to shed light on the significance these up-and-coming technologies have on the region's path to a cleaner future. Armed with the right information, we can empower populations and investors to make choices that will propel us towards a net zero world.

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Executive summary

Asia, home to vast engines of economic growth, is at the centre of the climate debate. In the past two decades, global carbon emissions from fossil fuel combustion have risen by 45%, primarily driven by Asia, for which this figure stood at 135%.[1] The region's ongoing dependence on coal has driven its per-head carbon emissions to equal that of the global average.[2] Asia's carbon emissions are likely to rise by 16% over the next decade.[3]

Meanwhile, the effects of climate change are becoming more pronounced in parts of the region. In the past year, unprecedented floods in Pakistan wiped out a significant share of its crops;[4] India recorded its highest-ever temperatures, with meteorologists sounding the alarm for more to come this year;[5] and a severe heatwave in China exacerbated a drought that impacted food production and the power supply.[6]

The continent is facing significant human and economic costs arising from intense greenhouse gas (GHG) emissions. Under pressure to set ambitious net zero targets and reduce emissions, technologies that enhance efficiencies and help industries decarbonise will be crucial pieces of the climate puzzle in Asia.

Asia's path to a greener future: Six technologies with decarbonising potential, sponsored by Eastspring Investments, explores promising innovations that can support the region's journey to a cleaner, greener future.

The report's findings are intended to act as a springboard for discussions to support the development of technologies that have decarbonising potential and identify the roadblocks to their progress.

Key findings:

- **Technologies that are driving significant gains in Europe or the Americas need to be adapted to the Asian market.** For example, the majority of alternative protein products are tailored to suit Western preferences and are prohibitively costly for the more price-sensitive Asian market. Alternative proteins would likely see broader adoption and create more impact if adapted to specific market preferences and price conditions.

- **Decarbonisation efforts should aim to address emissions and waste across the entire lifecycle of production and use.** Most of the hydrogen currently consumed is grey, which is produced from natural gas. The decarbonisation potential of hydrogen-powered vehicles will significantly increase with the use of renewable energy to produce hydrogen fuel. Likewise, using food waste for manufacturing textiles moves away from the current highly polluting linear model of production to a circular economy.

- **Developing supporting infrastructure can enhance technology development.** The growth of technologies such as hydrogen vehicles and battery recycling is currently limited due to insufficient supporting infrastructure. Spurring hydrogen vehicle uptake depends on installing a network of refuelling stations and green hydrogen production plants. To diminish end-of-life impacts of batteries, well-designed and managed disposable and collection mechanisms are necessary. Implementing policies that support the development of necessary infrastructure will ensure a conducive environment for the growth and expansion of these technologies.

- **Addressing poor consumer sentiment will be key in scaling up technologies.** Negative perceptions impede new technology adoption. In the case of alternative proteins, consumers can be deterred by concerns about taste and nutritional value.

With hydrogen vehicles, safety is a key issue, while recycled batteries can be perceived as lower quality. Investigations into safety incidents can help curb concerns. In other cases, public awareness and better communication by businesses and governments can go a long way to address common misperceptions.

- **Recycling and reuse can present opportunities to overcome supply chain disruptions owing to changing global dynamics.** The prices of critical minerals are on the rise because of growth in demand and fluctuations in supply. Recycling products, such as electric vehicle (EV) batteries, could ease the dependence on expensive raw materials, improve affordability and facilitate the transition away from a linear take-make-waste economy.
- **Policy support in the form of subsidies and financial incentives can reduce technology costs.** At present, many new technologies are expensive, which is hindering their adoption and development. Government support through subsidies, grants and other financial incentives can help reduce production costs and enable economies of scale. Lower production costs could translate into lower purchase prices for end consumers and foster greater adoption.
- **Greater public and private investments are needed.** While climate technology is attracting investment, more financial support is needed to scale-up the next wave of innovation. Funding is also needed to help install essential infrastructure to support the uptake of climate technologies such as hydrogen production plants and EV charging stations.

EASTSPRING INVESTMENTS PERSPECTIVE

Growing and scaling the market of decarbonisation technologies is necessary to enable a credible climate transition in Asia. It is also essential for developing an investable ecosystem that attracts and retains a significant base of domestic and international capital. To attract more private capital, enabling regulations that target the ease of lending and investment as well as industry-level incentives are equally important. Identifying where the investable opportunity exists across private and public equity and debt markets for investors to make the most impact for their capital will also be critical.

Joanne Khew,
Director, ESG Specialist,
Eastspring Investments

Introduction

Asia sits in the epicentre of the climate challenge. The latest Intergovernmental Panel on Climate Change (IPCC) report warns that risks such as dangerously high heat and humidity levels, along with rising seas and flooding, will beset the entire continent.[7] Climate events will cause massive damage to Asian infrastructure, supply chains, natural capital and labour capacity.

Home to over 60% of the world's population and most of the world's megacities and manufacturing hubs, the region is also becoming a growing part of the climate problem. The proportion of global GHG emissions that it produces is, for the first time, nearly equal to its share of the world population.[8] Therefore, the region's economic titans must play a significant role in slashing carbon emissions and accelerating the journey to net zero.

A growing number of Asian countries have set net zero targets, but the level of commitment varies. According to the 2023 Net Zero Scorecard, eight Asian countries have either set their net zero carbon emissions targets in law or in policy documents, while another two have declared them.[9] Net zero targets are under discussion in several other countries. Accelerating the development and application of innovative decarbonisation technologies can help meet country targets and tackle the climate change crisis.

This report explores six technologies that show considerable potential for reducing Asia's carbon footprint, as well as improving sustainability and security in the region. As outlined in this paper, each technology has its own set of unique challenges.

METHODOLOGY

An assessment model was developed for *Asia's path to a greener future: Six technologies with decarbonising potential*. To determine which technologies were analysed in the first place, we identified the top three industries relevant to the specific challenges and ambitions of the region that also offer significant scope for emissions reductions. These are agriculture, transportation and the waste industries. A series of interviews with knowledgeable professionals and in-depth research—looking into new investments, innovations and policy direction—led us to refine the study to two technologies within each industry that are considered to have significant potential and are gaining traction among policymakers and the private sector. The research is based on a detailed literature review and several rounds of interviews with professionals knowledgeable in the field and technology.

We have evaluated the potential of the six identified technologies based on 12 indicators that are categorised into three pillars: impact, scalability and funding. The impact pillar assesses the technology's potential for reducing emissions as well as any additional benefits or harms it may cause to the environment or society. The scalability pillar assesses the current development and production capabilities for the technology in Asia, while considering consumer perception and existing policy support to enable it to scale. Lastly, the funding pillar provides a regional snapshot of the level of funding and the government's financial support, such as subsidies and grants, that each technology has received or is currently getting. A detailed breakdown of the indicators and the technologies' decarbonising potentials is provided in the appendix together with an accompanying workbook.

Each technology is assessed on a scale of 0-4 and all indicators are weighted equally to provide an outcome which reflects the technology's potential. A higher score indicates higher potential. To assess the scalability of the technology, evidence from seven countries that are representative of the region in terms of development levels, population and economic size was considered. These markets are China, India, Indonesia, Japan, Malaysia, Singapore and Vietnam. This is not a comparative analysis as we have considered each technology on its own merit.

Agriculture

Globally, agriculture represents 24% of total GHG emissions owing to existing carbon-intensive farming methods and land use changes.[10] Asia accounts for the lion's share of these emissions, which significantly contribute to climate change and its related risks. It is the largest producer of rice, a crop that is responsible for 12% of global methane emissions.[11] Excessive use of synthetic fertilisers and energy in agricultural production is also common, leading to considerable nitrous oxide and carbon dioxide (CO_2) emissions. Moreover, rapid economic growth has created a booming middle class, which in turn has increased per-head demand for animal proteins, a GHG intensive product.[12]

This sector is extremely vulnerable to climate change. Adverse climatic conditions, such as heatwaves, heavy rainfall, droughts and destructive storms, threaten food supply chains in the region.[13] About 6.5m acres of crops and orchards were affected by the 2022 floods in Pakistan.[14] Technological innovations that boost climate-resilient farming, meat and dairy alternatives, and agro-ecological practices are becoming necessary to decarbonise the sector.

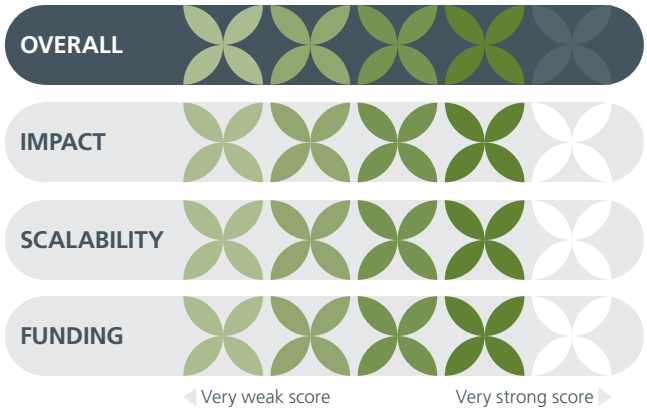
ALTERNATIVE PROTEINS

Alternative proteins are derived from sources like plants, fungi, algae and insects. This term can also refer to meat grown in laboratories using animal cells (also known as cultivated or cultured meat).[15,16]

Home to a population of 4.7bn people and a growing middle class, Asia is expected to determine the global protein growth trajectory.[17] Estimates suggest that the alternative meat market in Asia will grow from 1% of the global market share in 2019 to 10% in 2029. By 2040 about 60% of meat consumption in the region is expected to come from alternative proteins, with 35% from cultivated meat and 25% from plant-based meat.[18]

Alternative proteins provide a promising solution for Asia's food security challenges, reducing the burden of growing grains to feed livestock.[19] They are not as resource intensive, using 38-91% less land, 53-95% less water and releasing 69-92% less carbon emissions, than meat-based products.[20] These products also have a longer shelf life, reducing the risk of food poisoning and spoilage, and eliminate concerns regarding the use of antibiotics for livestock.

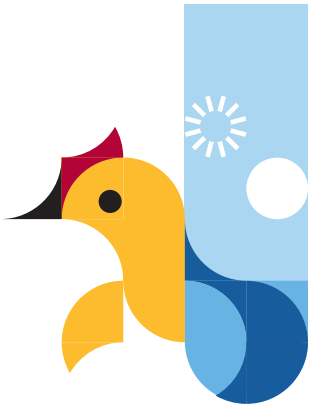
Despite multiple benefits, consumer perception remains a barrier in scaling this technology to its full potential, remarks Jolene Lum, Client Development Manager at Nurasa. She says that high costs, unappealing taste and formats for Asian consumers, and their highly processed nature pose hurdles in scaling the technology. "Asia is a highly price sensitive market and so consumers would choose the cheaper, less-processed option", she says. Ms Lum also notes that the current format of alternative products makes them less appealing to Asians, as they are designed to cater to a more Western-centric diet, featuring items such as burgers and sausages. Moreover, there is resistance to specific alternative proteins in Asia. For example, consumers in some markets find insect proteins unappetising, which hinders marketability.[21] Concerns about the nutritional value of alternative proteins are driven by the fact that they can be highly processed and lack key nutrients such as iron, zinc and B12.[22] However, some companies in Asia are working on products with fewer additives.



Regulatory support to address high costs and consumer awareness is lacking in the region. "It's still not clear if alternative proteins make up a big part of many people's diets, which is why it may not be on most health authorities' radar yet. Potentially governments still think that people are eating the products for novelty, so that's also a big perception [issue]," Ms Lum says.

Alternative proteins have received moderate investments of around US$312m[23] in the region, with plant-based proteins accounting for the largest share, at 70%, followed by cultivated meat, at 20%, and fermentation-based foods, at 10%.[24] However, the fragmented nature of Asian markets, due to diverse geographies and cultures, poses barriers to investment, says Ms Lum. "Consumer insights, logistics, cost and other related aspects vary significantly across Singapore and Indonesia, even though they are geographically close. Unlike the US, Asia is a huge market with many different fragments that need to be worked on individually."

The alternative protein space in Asia is constantly evolving with new technologies and processes. Start-ups in the region are now using innovative fermentation processes to develop alternatives from mushrooms that are flavourful and nutritional.[25] Asia is also set to become home to the world's first hybrid meat (alternative protein which includes both meat and plant-based ingredients) innovation centre, which is opening in Singapore in 2023.[26] The opportunity is there, but governments and businesses need to work together to give the market what it wants.



"Consumer insights, logistics, cost and other related aspects vary significantly across Singapore and Indonesia, even though they are geographically close. Unlike the US, Asia is a huge market with many different fragments that need to be worked on individually."

Jolene Lum,
Client Development Manager, Nurasa

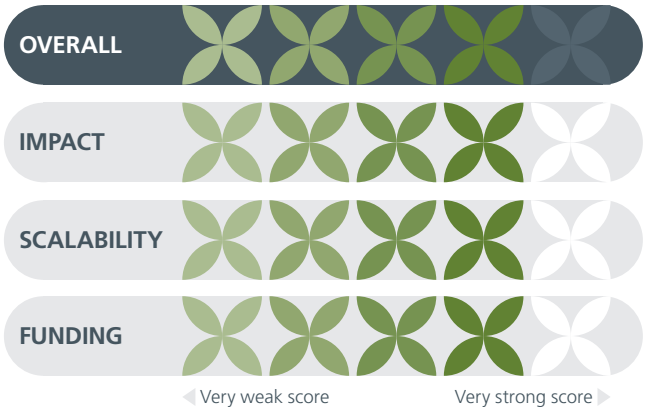
PRECISION FARMING

Precision farming is a management concept that uses technologies to gather and analyse data to improve crop efficiency and quality.[27]

Precision farming is proving to be an innovative decarbonising tool for Asia's agriculture industry. It makes use of a diverse set of tools, such as sensor-based technologies, satellites, and farm automation like robots, the Internet of Things (IoT) and drones, which enable better yields with fewer resources.[28] The World Economic Forum estimates that, if 15-25% of farms adopted precision farming, GHG emissions could be reduced by 10% by 2030. The tools used also provide farmers with other benefits such as automating recurring tasks and minimising error rates.

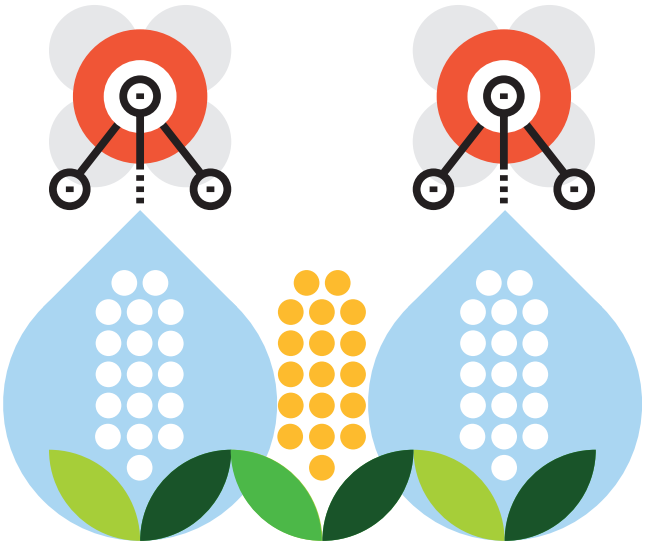
Despite these advantages, only 9% of farmers in Asia are currently using or planning to use at least one precision agriculture technology. This is a significantly lower rate than Europe (62%), North America (61%) and South America (50%).[29] Uptake is especially low among small and marginal farmers, who represent the majority of the farming community and produce 80% of the food consumed in the region. Barriers to adoption include high initial infrastructure set-up costs for solutions such as IoT to monitor and analyse data.[30,31] Globally, 47% of farmers cite high costs as a major barrier to adopting innovative agricultural technologies.[32] While there is an intent to adopt advanced precision farming technologies, farmers in the region have more fundamental problems to address like "access to credit, high quality inputs, market and equipment", says Siddharth Jadhav, who is the CEO of Polybee, a Singapore-based tech firm that aims to improve food security.

The lagging investments for precision farming technologies in Asia reflect these challenges. While the US and Europe



make up 58% and 23% of global investments respectively, Asia accounts for only 8%, at US$500m.[33] Today, relatively few strategic investors and accelerators provide the support and capital, and most are international. For example, about 80% of the capital invested in India's agritech in 2019 came from international investors. Such investors often prefer to channel their capital into more established ventures to avoid the perceived high risks of start-ups. These challenges are expected to persist in parts of the region that have insufficiently developed smart agriculture ecosystems to attract investments.[34]

Some countries in the region have made inroads in innovating agricultural practices. Japan is focusing on driverless tractors.[35] Farmers in China are extensively making use of agricultural drones—with recent estimates suggesting that more than 120,000 were used for precisely applying pesticides in the country.[36] Support from the government and agricultural co-operatives will be key in moving past fundamental farmer problems and preparing the industry for more automation.



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Siddharth Jadhav,
Chief Executive Officer, Polybee

Transport

Transport, including both passenger and freight, is responsible for 37% of all CO_2 emissions.[37] Among all mobility emissions, road transport alone accounts for about 75%.[38] This presents a major challenge for regions like Asia, where 44m people move to urban centres each year, doubling the number of vehicles every six years.[39] Aside from producing carbon emissions, transport drives poor air quality.[40] The top ten most polluted cities in the world with deteriorating air quality are all in Asia, and 80% of their air pollution can be attributed to transport.[41]

Decarbonisation efforts are likely to involve replacing internal combustion engine (ICE) vehicles with those powered by electricity or hydrogen, which is a nascent but emerging technology. Rebecca Mikula-Wright, CEO of the Asia Investor Group on Climate Change, says "EV sales represented less than 10% of total vehicle sales [in 2019], however, auto companies have made strong commitments to an EV line-up and a shift away from ICE development in some markets. This signals opportunities for investment not just in low-carbon vehicles, but also in the enabling ecosystem; including chargers, and upgrades to the electricity grid." In 2022, EVs accounted for about 14% of global passenger vehicle sales.[42]

EV BATTERIES

Batteries are central to the electrification of transport. They increasingly require innovations to ensure range and price competitiveness against traditional fuel combustion vehicles.[43,44]A variety of battery chemistries are used to run EVs such as nickel metal hydride batteries, lead acid batteries and ultracapacitors.[45] The most popular is lithium-ion (Li-ion), which accounts for more than 70% of the rechargeable battery market.[46] Li-ion batteries have high energy density, are recyclable and exhibit good performance even at high temperatures. In addition, they last around 1,000 charge cycles.[47]

The average price of a Li-ion EV battery pack rose for the first time in 2022 after falling from US$1,200 per kilowatt-hour (kWh) a decade ago to just US$132/kWh in 2021.[48] This price increase reflects rising demand for energy storage and electric mobility globally. Furthermore, the battery is composed of minerals such as lithium, nickel and manganese, which are prone to market fluctuations and supply chain disruptions.[49,50]

Besides costs, extracting lithium poses its own set of social and environmental challenges, such as soil degradation and air contamination.[51] The process also puts pressure on resources like water and has been linked to human rights violations and abuse.[52]

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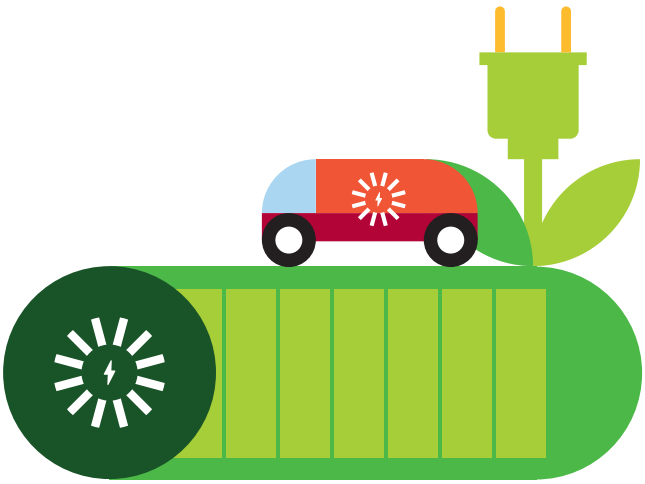
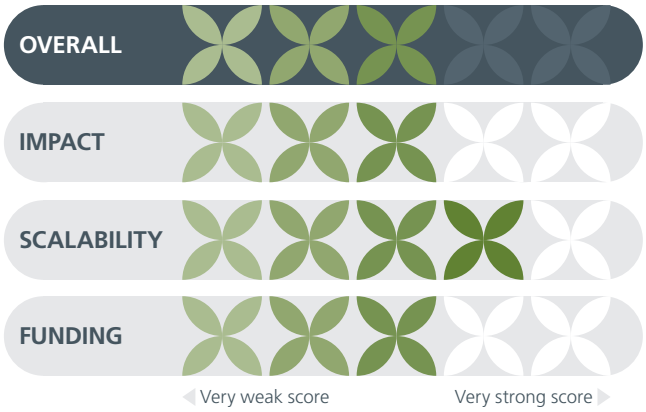
Alok Jain,
Chief Executive Officer, Trans Consult; Expert Member, Council for Decarbonizing Transport in Asia





Limitations to using lithium are driving battery innovation. While there are innovations, such as graphene and sodium ion batteries, and supercapacitors, none of them offer a viable replacement solution yet, states Alok Jain, CEO of Trans Consult and an expert member of the Council for Decarbonizing Transport in Asia. He says that "applications in a moving vehicle are restricted by the size, volume and weight, which makes it hard at the moment to give a competitive replacement to Li-ion batteries." He highlights solid state batteries as a potential alternative but recognises that they are still a decade away from full development.[53]

Asia has a strong regulatory framework for adopting and rolling out EVs in a bid to decarbonise their transport sectors. But specific policies for EV batteries are limited in the region, according to our research.

Nevertheless, the world's largest EV battery manufacturers are all headquartered in Asia. EV batteries attract the largest investments out of the technologies covered in this research—with a total of US$4.4bn.[54] China is the leader on this front, as it has an abundance of the rare earth materials used in battery manufacturing. In 2021 China possessed 1.5m tonnes of lithium, accounting for 6.8% of the market size globally. Chinese companies also hold large shares in the world's largest lithium mines, which are concentrated in South America and Australia. Meanwhile, China's homegrown battery company CATL accounts for a 35% market share among the world's top EV battery manufacturers.[55]

Problems associated with lithium extraction call for greater regulatory support to develop alternatives to Li-ion batteries that are sustainable and scalable. In the shorter term, greater visibility in existing supply chains and policies to liberalise global lithium trade would help stabilise access, and address existing environmental and social concerns.

HYDROGEN VEHICLES

Hydrogen is a highly efficient fuel source, offering a greater energy density per unit mass than any other fuel.[56] When used to power vehicles, it emits only water vapour, providing a much-needed solution to the emissions caused by the transport industry.

Hydrogen can be produced using wind, hydro and solar power, which produces green hydrogen; gas, resulting in blue and grey hydrogen; and coal, which is known as black and brown hydrogen. The various forms of hydrogen make it a fuel that can be produced anywhere in the world.

Currently, the majority of global hydrogen is produced using fossil fuels.[57] Mr Jain says it is too expensive to produce green hydrogen, while "dirty" hydrogen is not viable as it introduces fossil fuels into the energy chain. Grey hydrogen costs US$1.5/kg while green hydrogen costs US$5/kg.[58,59]

Governments in the region have a mixed outlook on the current potential of hydrogen vehicles. While some countries such as

> "Hydrogen holds a lot of promise and if we are able to solve the energy cycle equation [to prevent energy loss], that would be wonderful because it packs a punch and solves the biggest problems of currently prevalent batteries."
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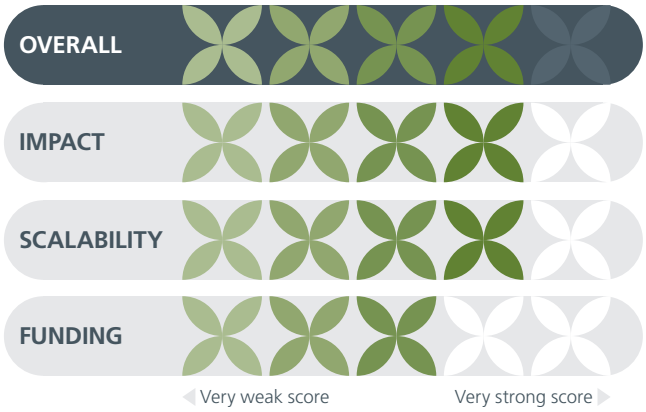


China, Japan and South Korea are betting on hydrogen vehicles for greater energy security, others like Singapore prefer to monitor developments for now due to the technology's lack of maturity in terms of cost, infrastructure availability and vehicle model options.[60,61] Mr Jain suggests that the former countries' bullish nature stems from their desire to reconfigure their value chains to become less dependent on imported fossil fuels and more focused on hydrogen, a resource that they have in abundance as an industrial by-product.

But these plans are slow to be realised due to safety-related criticisms and expensive infrastructural requirements.[62] Japanese and South Korean citizens have expressed concerns about the refuelling stations following a fatal explosion of a hydrogen storage tank and a gas leak in 2019.[63] Due to its chemical properties, storing hydrogen poses challenges that necessitate the use of low-temperature, high-pressure tanks.[64]

While these incidents warrant an investigation, it is generally acknowledged that hydrogen and hydrogen-powered vehicles are safe. Mr Jain says that "poor safety perceptions are something that we are also trying to address. People often bring up the Hindenburg aircraft explosion and hydrogen bombs, but nothing of this sort occurs in a fuel cell vehicle. These analogies are generally misplaced."

Hydrogen vehicles have enormous potential for decarbonising transport, although high production costs, energy loss during production and supply, difficulties in storage and lack of complementary infrastructure are hindering their widespread usage.[65] Mr Jain says "hydrogen holds a lot of promise and if we are able to solve the energy cycle equation [to prevent energy loss], that would be wonderful because it packs a punch and solves the biggest problems of currently prevalent batteries."

Companies in Asia are now racing towards green hydrogen projects as an increasing number of people recognise it as the fuel of the future. For example, India has approved a green hydrogen mission and Vietnam is set to construct its first green hydrogen plant.[66,67] Investments in hydrogen vehicles in the region have surpassed US$1bn[68] and are likely to continue growing as hydrogen production increases. Further advancements in storage and transport technologies will be instrumental in addressing safety concerns and fuelling the transition.

Waste

Globally, the waste industry[69] accounts for 20% of methane and 3.3% of GHG emissions.[70] Asia is expected to play a significant role in these emissions, as the World Bank predicts that South Asia, East Asia and the Pacific will be the world's leading waste-generating regions by 2050.[71]

Textiles and electronics are two major industries in Asia that generate considerable waste. The mismanagement[72] of these two waste streams can have adverse impacts on human, animal and environmental health. The mismanaged disposal of textiles releases GHG into the atmosphere, as well as chemicals and dyes into the soil and groundwater.[73] The region is also responsible for 40% of global e-waste, which accounts for 70% of all hazardous waste.[74] Batteries, a key component of this, pose a fire hazard, costing tens of thousands of dollars in property damage and loss of life.[75]

Implementing circular technologies[76] and waste management strategies will be imperative to addressing the waste problem in Asia.

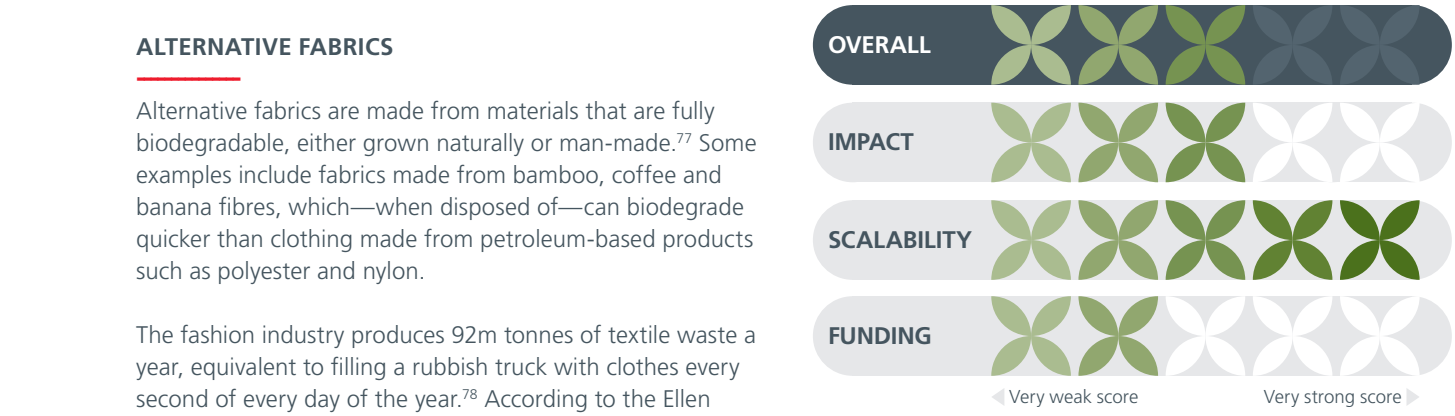
ALTERNATIVE FABRICS

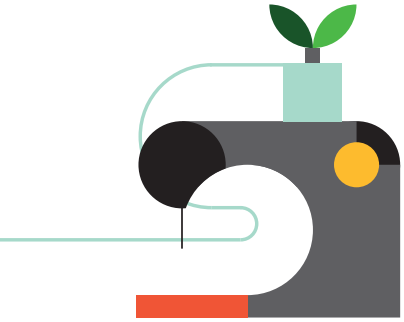
Alternative fabrics are made from materials that are fully biodegradable, either grown naturally or man-made.[77] Some examples include fabrics made from bamboo, coffee and banana fibres, which—when disposed of—can biodegrade quicker than clothing made from petroleum-based products such as polyester and nylon.

The fashion industry produces 92m tonnes of textile waste a year, equivalent to filling a rubbish truck with clothes every second of every day of the year.[78] According to the Ellen MacArthur Foundation, 73% of clothes end up in landfill or are incinerated at the end of their life. Just 1% are recycled.[79] Edwin Keh, CEO of The Hong Kong Research Institute of Textiles and Apparel, says that replacing petroleum-based textiles with cellulose ones—ie, those made from biodegradable plant material—has the potential to reduce carbon emissions associated with both clothes production and waste.

Alternative fabrics have the potential to halve the fashion industry's current 2.1bn tonnes of CO_2 emissions and significantly contribute towards meeting the industry's Paris targets.[80,81] Alternative fabrics require fewer resources, especially if they are made from by-products, such as banana peels and spent coffee grounds. Some materials such as organic cotton use less water compared with the 2,700 litres required to produce the non-organic cotton for a single t-shirt.[82] Moreover, alternative fabrics offer a more ethical choice by eliminating the reliance on animal products. Most sustainability-focused alternative fabrics also use non-toxic chemicals and dyes, reducing the harm to human health and the environment.[83]

Our research shows that alternative fabrics are commercially available and manufactured across Asia, but are not widely scaled. There are four reasons for this. First, organic and natural fibres are costly. Only 1% of global cotton production is organic because of the high cost of organic seeds.[84] Second, the industry is relatively conservative. Mr Keh notes that "materials haven't changed much since the industrial revolution. Cotton was at one point a new world, high technology material and innovation stopped there." Third, existing business models often label such materials as luxury items, leading to higher price margins.[85] Finally, the region has low levels of investment and investor interest. According to Crunchbase, Asia represents approximately 2% of global investment in this area.[86] Policy could help accelerate efforts to decarbonise the highly polluting textile industry by promoting the use of alternatives and encouraging greater scrutiny of sourcing materials. Europe is ahead with its recent Strategy for Sustainable and Circular Textiles, which promotes eco-friendly textile design and environmentally sustainable sourcing of fibres.[87]





"Materials haven't changed much since the industrial revolution. Cotton was at one point a new world, high technology material and innovation stopped there."

Edwin Keh,
Chief Executive Officer, The Hong Kong Research Institute of Textiles and Apparel

According to our research, while there is evidence of policies that back alternative fabrics, governments have yet to provide significant monetary and policy support in this area compared to other decarbonisation technologies. However, Mr Keh believes that investment will increase as everyone looks to fulfil their sustainability criteria. He expects institutional funds such as retirement and sovereign wealth funds to drive more long-term investments into this space.

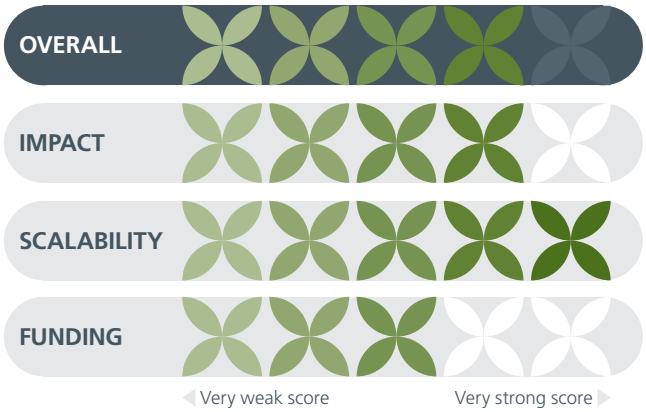
There is a growing sustainability awareness among consumers in the region and embracing sustainable fashion is found to enhance brand image. A survey showed that 90%, 71% and 49% of people in Shanghai, Hong Kong and Tokyo, respectively, are in favour of sustainable fashion.[88,89] Asia has both the market and manufacturing capacity, but scaling these requires greater investments and policy alignment.

BATTERY RECYCLING

Battery recycling has undergone significant technological advancements over the years. While the pyrometallurgical (dry thermal methods) and hydrometallurgical (aqueous methods) recycling methods remain prevalent, more energy-efficient techniques such as direct recycling, biological recycling and electrolyte recovery have emerged. According to the International Energy Agency (IEA), the global capacity for battery recycling is approximately 200,000 tonnes per year, with China accounting for half. Despite these developments, a vast number of batteries continue to be discarded. The estimated retired lithium batteries in China reached about 512,000 tonnes in 2021, of which only 299,000 tonnes were recycled.[90]

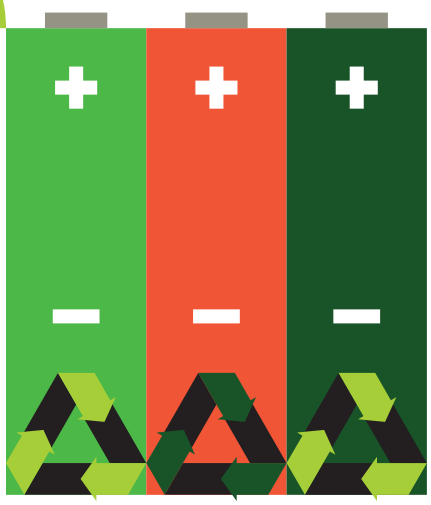
As the world moves towards widespread uptake of battery-powered vehicles, which will make up an estimated 60% of all vehicles sold by 2030, demand for the minerals critical for their batteries will inevitably surge.[91] Battery recycling can help ease the stress on non-renewable raw materials and minimise the amount of waste deposited in landfills. Bryan Oh, CEO of NEU Battery Materials, says that "the industry's aim is to innovate technologies that are highly efficient to ensure as much of the metals are recycled and used to create new batteries, helping to conserve finite resources and reduce pollution."

Battery recycling efforts are picking up in Asia and globally, especially in major EV markets that are facing metal shortages. For instance, Japan and China are providing subsidies associated with battery recycling equipment and EV battery recycling respectively. India has recently passed battery waste management rules that mandate the collection and recycling of all waste batteries by producers, and promote entrepreneurship.[92] However, several impediments persist, including the lack of standardisation of chemical compositions of batteries, inadequate labelling of battery components, and the absence of extensive tracking



mechanisms for the disposal and collection of batteries.[93,94] "Significant infrastructure support is required to recycle batteries on a large scale. In some cases, there may also be a lack of economic incentives for recyclers, making it less profitable to recycle batteries. This is especially so for lower value batteries," says Mr Oh. Another challenge is people's perception that recycled batteries may be inferior and defective.[95,96,] "Recycled batteries can be just as good as newly manufactured batteries, depending on the quality of the recycling process," says Mr Oh. Newer methods such as direct recycling are found to produce batteries that last longer and charge faster.[97]

To improve the scale of battery recycling, it is imperative for the government to provide support, not only in the form of subsidies, but also in improving the infrastructure for collection and recycling. Regulatory support to ensure accurate battery labelling can further facilitate the process. Furthermore, companies must establish appropriate guidelines for returning and replacing batteries, alongside disposal protocols—akin to an extended producer responsibility scheme. Ultimately, there needs to be a behavioural change among people regarding the importance of recycling e-waste such as household batteries and laptops.



"Significant infrastructure support is required to recycle batteries on a large scale. In some cases, there may also be a lack of economic incentives for recyclers, making it less profitable to recycle batteries. This is especially so for lower value batteries."

Bryan Oh,
Chief Executive Officer, NEU Battery Materials

Conclusion

The technologies assessed in this research could significantly reduce GHG emissions in Asia. In most cases, they offer additional benefits such as better product quality, less waste and more environmental safeguards.

Despite their potential for decarbonisation, barriers remain to scaling. Moving past them requires strong regulatory and policy support. Investment incentives, such as tax breaks and subsidies, will also be impactful in driving investments into these technologies.

According to Steve Melhuish, Founding Partner of Wavemaker Impact and Founder of PropertyGuru Group, the focus in Asia needs to shift towards adapting business models that accelerate the widescale adoption of existing, tried and tested green technologies. These greentech solutions can rapidly deliver significant emission reductions, as well as efficiencies that improve top and/or bottom line.

Consumers can support decarbonisation efforts by making informed, selective purchasing decisions. For example, they can choose more sustainable foods and textiles, switch to EVs and ensure the proper disposal of their electronics, if available.

Technology is a critical enabler of decarbonisation efforts and, as it continues to advance, it brings greater scope to address emissions in hard-to-abate sectors. As this research demonstrates, innovation plays a crucial role in improving energy efficiency and reducing waste, but challenges remain to the broader uptake of each technology. Investment in research, development and deployment of nascent technologies will be essential to achieving our climate goals.

Appendix

The assessment model evaluates the decarbonising potential of technologies based on 12 indicators:

Impact

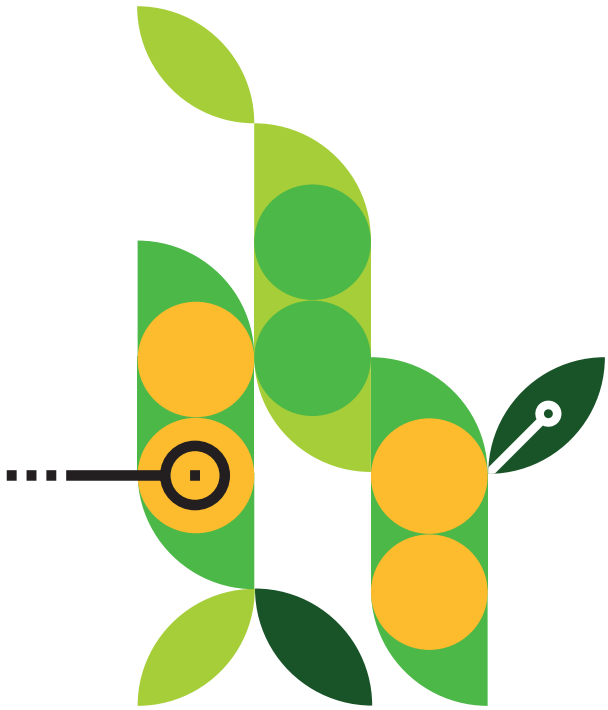
- How well does the technology function in comparison to the traditional alternative?
- Is there evidence showing that the application of this technology will help reduce GHG emissions directly? If yes, by how much is this technology expected to reduce GHG emissions?
- Is there evidence that the application of this technology offers additional benefits beyond cutting emissions?
- Is there evidence that the application of this technology could cause harm or other unintended consequences?

Scalability

- What is the current state of development/maturity of the technology in Asia?
- What is the technology's ease of integration with existing infrastructure? Is more infrastructure needed?
- Is there evidence of policy or regulatory support for the development and use of this technology in Asia?
- Is there evidence of manufacturing/production capacity for this technology in Asia?
- What is the social perception of the technology in Asia? Is there evidence of negative discussions/connotations around it?

Funding

- What is the total investment for companies producing this technology in Asia (in US$)?
- What is the total number of investment firms and individual investors investing in companies that produce this technology in Asia?
- Is there evidence of government support for investments in this technology in Asia?



The workbook provides a comprehensive breakdown of technology potentials, along with justifications and references. For a quick summary, refer to the table below.

Decarbonising potential of technologies

	Alternative fabrics	Alternative proteins	Battery recycling	EV batteries	Hydrogen vehicles	Precision farming
OVERALL	**2.1**	**2.9**	**2.9**	**2.4**	**2.5**	**3**
1) IMPACT	**1.8**	**2.8**	**2.8**	**2**	**3**	**2.5**
1.1) Performance relative to traditional alternative	1	2	4	0	4	4
1.2) GHG emissions reduction	2	3	2	2	4	1
1.3) Additional benefits beyond GHG emissions reduction	2	4	3	4	2	2
1.4) Potential unintended adverse consequences	2	2	2	2	2	3
2) SCALABILITY	**3.6**	**3.4**	**3.6**	**3**	**2.6**	**3.4**
2.1) State of development/ maturity in Asia	4	4	4	4	3	4
2.2) Ease of integration with existing infrastructure	4	4	3	3	2	2
2.3) Policy/regulatory support in Asia	3	2	4	2	3	4
2.4) Manufacturing/production capacity in Asia	3	4	4	3	2	3
2.5) Social perception in Asia	4	3	3	3	3	4
3) FUNDING	**1**	**2.7**	**2.3**	**2.3**	**2**	**3**
3.1) Investment for companies producing the technology in Asia	1	2	3	3	3	2
3.2) Level of investor interest in Asia	1	3	1	2	1	4
3.3) Government support for investments in Asia	1	3	3	2	2	3

Note: This is not a comparative analysis as we have considered each technology on its own merit.

Legend:
Score 0-4, where 4= best score

Very weak score (0-0.49)
Weak score (0.5-1.49)
Moderate score (1.5-2.49)
Strong score (2.5-3.49)
Very strong score (3.5-4)

References

1 Global Carbon Atlas. "Emissions". http://www.globalcarbonatlas.org/en/content/welcome-carbon-atlas

2 Ritchie, H, Roser, M & Rosado, P. "Per capita CO2 emissions". Our World in Data. 2020. https://ourworldindata.org/co2-emissions.

3 Economist Intelligence Unit forecast.

4 Syed Raza Hassan. "First heat, then floods wipe out farms in Pakistan's chilli capital". Reuters. November 2022. https://www.reuters.com/business/cop/first-heat-then-floods-wipe-out-farms-pakistans-chilli-capital-2022-11-02/

5 Karishma Mehrotra. "High February temperatures have India already bracing for more heat waves". *The Washington Post*. February 2023. https://www.washingtonpost.com/world/2023/02/20/india-heat-wave-climate-change/

6 Srinivas Mazumdaru and Jose Qian Shanghai. "Drought, power cuts worsen China's supply snarl". DW. August 2022. https://www.dw.com/en/drought-and-power-shortages-worsen-chinas-supply-chain-snags/a-62928037

7 IPCC. "Fact sheet - Asia". 2022. https://www.ipcc.ch/report/ar6/wg2/downloads/outreach/IPCC_AR6_WGII_FactSheet_Asia.pdf

8 Ritchie, Hannah, Max Roser, and Pablo Rosado. n.d. "CO_2 and Greenhouse Gas Emissions". Our World in Data. Accessed February 22nd 2023. See: https://ourworldindata.org/co2-and-greenhouse-gas-emissions

9 Energy & Climate Intelligence Unit. "Net Zero Tracker". https://eciu.net/netzerotracker

10 Anna Locke. "Why agricultural reform is needed to achieve net zero emissions". ODI. April 2022. https://odi.org/en/insights/why-agricultural-reform-is-needed-to-achieve-net-zero-emissions/

11 Julia Kurnik and Katherine Devine. "Innovation in Reducing Methane Emissions from the Food Sector: Side of rice, hold the methane". World Wildlife Fund. April 2022. https://www.worldwildlife.org/blogs/sustainability-works/posts/innovation-in-reducing-methane-emissions-from-the-food-sector-side-of-rice-hold-the-methane

12 Jeetendra Prakash Aryal. "Contribution of Agriculture to Climate Change and Low-Emission Agricultural Development in Asia and the Pacific". ADBI Working Paper. Asian Development Bank Institute. September 2022. https://www.adb.org/sites/default/files/publication/829581/adbi-wp1340.pdf

13 Climate Analytics. "Decarbonising South and South East Asia: Shifting energy supply in South Asia and South East Asia to non-fossil fuel-based energy systems in line with the Paris Agreement long-term temperature goal and achievement of Sustainable Development Goals". 2019. https://climateanalytics.org/media/decarbonisingasia2019-fullreport-climateanalytics.pdf

14 Peer Muhammad Baigal. "Farmers who lost crops in Pakistan floods struggle without compensation". Eco-Business. January 2023. https://www.eco-business.com/news/farmers-who-lost-crops-in-pakistan-floods-struggle-without-compensation

15 The University of Melbourne. "Alternative proteins: Testing the claimed benefits". https://sustainablecampus.unimelb.edu.au/sustainable-research/case-studies/alternative-proteins

16 GCFGlobal. "What is Lab-Grown Meat". https://edu.gcfglobal.org/en/thenow/what-is-labgrown-meat/1/

17 Tony Hunter. "The future of alternative proteins in Asia". Fi Global Insights. March 2022. https://insights.figlobal.com/opinion/future-alternative-proteins-asia

18 Green Queen Media. "The Asia Alternative Protein Industry Report". 2020. https://www.greenqueen.com.hk/wp-content/uploads/2020/02/The-Asia-Alternative-Protein-Industry-Report-2020-New-Decade-New-Protein.pdf

19 EDB Singapore. "How Singapore is using alternative proteins to boost food security". 2022. https://www.edb.gov.sg/en/business-insights/insights/how-singapore-is-using-alternative-proteins-to-boost-food-security.html

20 Food and Agriculture Organization of the United Nations (FAO). "Sustainable and circular bioeconomy for food systems transformation". May 2022. https://www.fao.org/in-action/sustainable-and-circular-bioeconomy/resources/news/details/en/c/1507553/

21 Pearly Neo. "Bugging the question: Asia insect protein sector cite upscaling and negative perceptions as negative hurdles". Food Navigator Asia. July 2022. https://www.foodnavigator-asia.com/Article/2022/07/12/asia-insect-protein-sector-cite-upscaling-and-negative-preconceptions-as-biggest-hurdles

22 Breda Gavin-Smith, Kesso Gabrielle van Zutchpen-Kuffer, Kris Woltering and Chiara Ferraboschi. "Alternative Proteins: The nutritionists' perspective". Sight and Life. https://sightandlife.org/resource-hub/blog/alternative-proteins-the-nutritionists-perspective

23 Based on external investments in companies producing the technology recorded on Crunchbase. Excludes internal corporate investments.

24 Good Food Institute. "The State of APAC's Alt Protein Industry in Four Graphs". https://gfi-apac.org/the-state-of-apacs-alt-protein-industry-in-four-graphs/

25 Pearly Neo. "Animal-free hits: The Top 10 APAC alternative protein stories in 2022". Food Navigator Asia. January 2023. https://www.foodnavigator-asia.com/Article/2023/01/11/animal-free-hits-the-top-10-apac-alternative-protein-stories-in-2022

26 Asia Food Journal. "World's first hybrid meat innovation centre to be built in Singapore by cultivated meat leader Meatable and plant-based butcher Love Handle". November 2022. https://asiafoodjournal.com/worlds-first-hybrid-meat-innovation-centre-singapore-cultivated-meat

27 International society of precision agriculture. "Precision Ag Definition". January 2021. https://www.ispag.org/about/definition

28 Medium. "Precision Farming — Technology infusion in agriculture".

April 2020. https://gramworkx.medium.com/precision-farming-technology-infusion-in-agriculture-83b72f336b2d

29 David Fiocco, Vasanth Ganesan, Maria Garcia de la Serrana Lozano, and Hussain Sharifi. "Agtech: Breaking down the farmer adoption dilemma". McKinsey. February 2023. https://www.mckinsey.com/industries/agriculture/our-insights/agtech-breaking-down-the-farmer-adoption-dilemma

30 Agrivi. "Precision Farming: Everything You Need to Know". https://www.agrivi.com/blog/precision-farming/

31 Alcimed. "Empowering smallholder farmers: How Asian Countries are building up their agriculture backbones". September 2022. https://www.alcimed.com/en/alcim-articles/empowering-smallholder-farmers-how-asian-countries-are-building-up-their-agriculture-backbones/

32 David Fiocco, Vasanth Ganesan, Maria Garcia de la Serrana Lozano, and Hussain Sharifi. "Agtech: Breaking down the farmer adoption dilemma". McKinsey. February 2023. https://www.mckinsey.com/industries/agriculture/our-insights/agtech-breaking-down-the-farmer-adoption-dilemma

33 Based on external investments in companies producing the technology recorded on Crunchbase. Excludes internal corporate investments.

34 Shruthi Baskaran-Makanju, Sonya Hoo, Chris Mitchell, Jim Larson, Shalini Unnikrishnan, Sushma Vasudevan, and Younès Zrikem. "The Digital Agriculture Revolution Will Take More Than Innovation". Boston Consulting Group. July 2021. https://www.bcg.com/publications/2021/digital-agriculture-and-development

35 Future Farming. "Yield monitoring technology to dominate precision ag market". September 2022. https://www.futurefarming.com/smart-farming/yield-monitoring-technology-to-dominate-precision-ag-market/

36 People's Daily Online. "China's agri-tech industry abuzz as agricultural drones facilitate domestic proliferation of smart farming". July 2022. http://en.people.cn/n3/2022/0701/c90000-10117605.html

37 IEA. "Transport: Improving the sustainability of passenger and freight transport". https://www.iea.org/topics/transport

38 Ellen MacArthur Foundation. "Climate change and a circular economy for transport". https://ellenmacarthurfoundation.org/climate-change-and-a-circular-economy-for-transport

39 Asian Development Bank. "ADB's Work in Sustainable Transport. Asian Development Bank". https://www.adb.org/what-we-do/sectors/transport/overview#urban-transport

40 IQAir. "World's most polluted cities (historical data 2017-2021)". https://www.iqair.com/in-en/world-most-polluted-cities

41 Asian Development Bank. "ADB's Work in Sustainable Transport". https://www.adb.org/what-we-do/sectors/transport/overview#urban-transport

42 Clarisa Diaz. "1 in 7 cars sold globally now is electric". World Economic Forum. March 2023. https://www.weforum.org/agenda/2023/03/ev-car-sales-energy-environment-gas

43 Nicolò Campagnol, Alexander Pfeiffer, and Christer Tryggestad. "Capturing the battery value-chain opportunity". McKinsey. January 2022. https://www.mckinsey.com/~/media/mckinsey/industries/electric%20power%20and%20natural%20gas/our%20insights/capturing%20the%20battery%20value%20chain%20opportunity/capturing-the-battery-value-chain-opportunity.pdf

44 Daniel Harrison. "Electric Vehicle Battery Supply Chain Analysis". ABB. March 2021. https://new.abb.com/docs/librariesprovider89/default-document-library/automotive-battery-supply-chain-analysis-2021-final_abb_ams---abridged-version-docx.pdf?sfvrsn=3bc9f708_2

45 U.S. Department of Energy. "Batteries for Electric Vehicles". https://afdc.energy.gov/vehicles/electric_batteries.html

46 Fortune Business Insights. "Electric Vehicle Battery Market Size, Share & Covid-19 Impact Analysis, By Battery Type (Lead Acid Battery, Nickel Metal Hydride, Lithium-ion battery, others), By Vehicle Type (BEV, PHEV, HEV) and Regional Forecast, 2021-28". https://www.fortunebusinessinsights.com/industry-reports/electric-vehicle-battery-market-101700

47 Electric vehicles.in. "EVs battery types & its components, advantages & disadvantages". December 2019. https://electricvehicles.in/evs-battery-types-its-components-advantages-disadvantages/

48 Govind Bhutada. "Breaking Down the Cost of an EV Battery Cell". Visual Capitalist. February 2022. https://www.visualcapitalist.com/breaking-down-the-cost-of-an-ev-battery-cell/

49 Innovation News Network. "Lithium prices continue to rise – LPI explains why". January 2023. https://www.innovationnewsnetwork.com/lithium-prices-continue-to-rise-lpi-explains-why/28852/

50 China Briefing. "China's Lithium-Ion Battery Industry – Overcoming Supply Chain Challenges". November 2022. https://www.china-briefing.com/news/chinas-lithium-ion-battery-industry-overcoming-supply-chain-challenges/

51 Amit Katwala. "The spiralling environmental cost of our lithium battery addiction". Wired. August 2018. https://www.wired.co.uk/article/lithium-batteries-environment-impact

52 Business and Human Rights Resource Centre. "Negative effects of lithium mining on indigenous communities in Chile & Argentina exposed by Washington Post investigation; includes company statements". https://www.business-humanrights.org/en/latest-news/negative-effects-of-lithium-mining-on-indigenous-communities-in-chile-argentina-exposed-by-washington-post-investigation-includes-company-statements/

53 Chris Chilton. "Solid State Batteries Still A Decade Away, Battery Company Boss Claims". Carscoops. November 2022. https://www.carscoops.com/2022/11/solid-state-batteries-still-a-decade-away-battery-boss-claims/

54 Based on external investments in companies producing the technology recorded on Crunchbase. Excludes internal corporate investments.

55 Daxue Consulting. "China's electric vehicle market, a rising global leader in EV technology". August 2022. https://daxueconsulting.com/electric-vehicle-market-in-china

56 U.S. Department of Energy. "Hydrogen Storage". www.energy.gov/eere/fuelcells/hydrogen-storage

57 IEA. "Hydrogen Supply". September 2022. https://www.iea.org/reports/hydrogen-supply

58 Catherine Clifford. "What is green hydrogen vs. blue hydrogen, and why it matters". CNBC, January 6th 2022. www.cnbc.com/2022/01/06/what-is-green-hydrogen-vs-blue-hydrogen-and-why-it-matters.html

59 Asian Business Review. "Reducing green hydrogen production costs hangs on govt support". January 21st 2022. www.asianbusinessreview.com/event-news/reducing-green-hydrogen-production-costs-hangs-govt-support

60 Kevin Buckland. "Explainer: How hydrogen could fuel the future of automobiles". Reuters. September 19th 2019. www.reuters.com/article/us-autos-hydrogen-explainer-idUSKBN1W22VQ

61 Ministry of Transport Singapore. "Written Reply to Parliamentary Question on Lesson Learnt from Compressed Natural Gas Scheme for Vehicles and Plans to Use Hydrogen Fuel Cell Technology". July 5th 2022. www.mot.gov.sg/news/details/written-reply-to-parliamentary-question-on-lesson-learnt-from-compressed-natural-gas-scheme-for-vehicles-and-plans-to-use-hydrogen-fuel-cell-technology

62 Nina Chestney. "$15 trillion global hydrogen investment needed by 2050: research". Reuters. April 27th 2021. www.reuters.com/business/energy/15-trillion-global-hydrogen-investment-needed-2050-research-2021-04-26/

63 Hyunjoo Jin, Jane Chung. "Hydrogen hurdles: a deadly blast hampers South Korea's big fuel cell car bet". Reuters. September 25th 2019. www.reuters.com/article/us-autos-hydrogen-southkorea-insight-idUKKBN1W936A

64 TWI Global. "What is Hydrogen Storage?". www.twi-global.com/technical-knowledge/faqs/what-is-hydrogen-storage

65 James Morris. "Why Are We Still Talking About Hydrogen?" Forbes, 6 February 2021, www.forbes.com/sites/jamesmorris/2021/02/06/why-are-we-still-talking-about-hydrogen/?sh=2d11df1b7f04.

66 Press Bureau of India. "Cabinet approves National Green Hydrogen Mission." January 4th 2023. https://pib.gov.in/PressReleasePage.aspx?PRID=1888547

67 Ayman Falak Medina. "Vietnam to Build First Hydrogen Plant, Coal to Still Be Dominant Power Source". ASEAN Briefing. June 15th 2022. www.aseanbriefing.com/news/vietnam-to-build-first-hydrogen-plant-coal-to-still-be-dominant-power-source/

68 Based on external investments in companies producing the technology recorded on Crunchbase. Excludes internal corporate investments.

69 Economist Impact defines the waste industry as the management—collection, transport, processing and disposal—of waste materials.

70 Stefan Ellerbeck. "This is how cities can reduce emissions with waste-reduction solutions". World Economic Forum. November 2022. https://www.weforum.org/agenda/2022/11/waste-emissions-methane-cities

71 *The Economist*. "Emerging economies are rapidly adding to the global pile of garbage". September 2018. https://www.economist.com/special-report/2018/09/27/emerging-economies-are-rapidly-adding-to-the-global-pile-of-garbage

72 Mismanaged waste is material that is not properly disposed of, stored or managed in a way that minimises its impact on human health and the environment.

73 Rachel Brown. "The Environmental Crisis Caused by Textile Waste". Roadrunner. January 2021. https://www.roadrunnerwm.com/blog/textile-waste-environmental-crisis

74 Eco-Business. "Forty per cent of global e-waste comes from Asia". January 2018. https://www.eco-business.com/news/forty-per-cent-of-global-e-waste-comes-from-asia/

75 Enterprise Singapore. "Enhancing safety for parked electric vehicles". https://xcite.innovation-challenge.sg/problem-statement/enhancing-safety-for-parked-electric-vehicles.html

76 Circular technologies are technologies that enable the implementation of circular economy principles. They can include a wide range of innovative solutions that help to reduce waste, increase resource efficiency and minimise the use of virgin materials.

77 Economist Impact has not included alternative fabrics made from recycled materials in the scope of this research.

78 Martina Igini. "Statistics about Fast Fashion Waste". Earth.Org. August 22nd 2022. www.earth.org/statistics-about-fast-fashion-waste.

79 Ellen MacArthur Foundation. "Who should be responsible for recycling clothes?". https://ellenmacarthurfoundation.org/videos/who-should-be-responsible-for-recycling-clothes

80 McKinsey. "Fashion on Climate". 2020. www.mckinsey.com/industries/retail/our-insights/fashion-on-climate

81 Nature Climate Change. "The price of fast fashion". January 2nd 2018. https://doi.org/10.1038/s41558-017-0058-9

82 Emily Chan. "How sustainable is organic cotton really?". Vogue India. October 16th 2019. https://www.vogue.in/fashion/content/how-sustainable-is-organic-cotton-really

83 S Aishwariya, J Jaisri. "Harmful Effects of Textile Waste". Fibre2Fashion. June 2020. https://www.fibre2fashion.com/industry-article/8696/harmful-effects-of-textile-waste

84 Organic Cotton Accelerator. "Organic vs Conventional". https://organiccottonaccelerator.org/why-organic-cotton/organic-vs-conventional/

85 Hasina Khatib. "Why Is Sustainable Fashion Expensive? The Cost of Ethically Produced Garments". Vogue India. May 13th 2021. https://www.vogue.in/fashion/content/why-is-sustainable-fashion-expensive-the-cost-of-ethically-produced-garments

86 Based on external investments in companies producing the technology recorded on Crunchbase. Excludes internal corporate investments.

87 EU. "EU Strategy for Sustainable and Circular Textiles". March 2022. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0141

88 KPMG China. "Sustainable Fashion: Committing to a More Sustainable Future". https://assets.kpmg/content/dam/kpmg/cn/pdf/en/2019/01/sustainable-fashion.pdf

89 IBM. "Meet the 2020 consumers driving change." https://www.ibm.com/downloads/cas/EXK4XKX8

90 Barry van Wyk. "China's first-generation electric cars are dying, and no one knows how to deal with their batteries". The China Project. July 28th 2022. https://thechinaproject.com/2022/07/28/chinas-first-generation-electric-cars-are-dying-and-no-one-knows-how-to-deal-with-their-batteries/

91 IEA. "Technology and innovation pathways for zero-carbon-ready buildings by 2030". September 2022. https://www.iea.org/reports/by-2030-evs-represent-more-than-60-of-vehicles-sold-globally-and-require-an-adequate-surge-in-chargers-installed-in-buildings

92 Press Bureau of India. "Government notifies Battery Waste Management Rules, 2022". August 25th 2022. https://pib.gov.in/PressReleasePage.aspx?PRID=1854433

93 Xiaotu M, Luqman Azhari, Yan Wang. "Li-ion battery recycling challenges". Science Direct. November 11th 2021. https://www.sciencedirect.com/science/article/pii/S2451929421004757

94 EPA. "Battery Collection Best Practices and Battery Labeling Guidelines". www.epa.gov/infrastructure/battery-collection-best-practices-and-battery-labeling-guidelines#guidelines

95 Kenichiro Chinen, Mitsutaka Matsumoto, Pingsheng Tong, Yongliang Stanley Han and Kuei-Hsien Jeff Niu. "Electric Vehicle Owners' Perception of Remanufactured Batteries: An Empirical Study in China". MDPI. August 31st 2022. https://www.mdpi.com/2071-1050/14/17/10846/pdf

96 Shibin Zhang, Chuhan Zhou, and Yanran Liu. "Consumer Purchasing Intentions and Marketing Segmentation of Remanufactured New-Energy Auto Parts in China". Hindawi. July 2nd 2020. https://doi.org/10.1155/2020/5647383

97 Jordan Wilkerson. "Can Perform Better Than New Ones". Scientific American. February 1st 2022. https://www.scientificamerican.com/article/recycled-lithium-ion-batteries-can-perform-better-than-new-ones

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