# Towards UK Circular Supply Chains for Automotive Aluminium

Cents
Circular Economy Network+ in Transportation Systems

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Partnerships with

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# Executive Summary

In the UK the automotive industry contributes a significant amount to the total GDP and accounts for 8.5% of manufacturing.

In 2022 nearly 800,000 vehicles were manufactured within the UK with a significant percentage then being exported.

In the same year there were over 1.6 million new vehicle registrations in the UK, the majority of these being imported. Over this same period over 1 million vehicles were scrapped.

With the current shift in technology towards lightweighting of vehicles and new electric vehicles, the amount of aluminium used within the UK is forecast to increase significantly. The combination of current aluminium use, forecasted increased use, and the fact the UK is a net importer of vehicles means that the UK has a surplus of aluminium from end of life vehicles to establish new circular supply chains able to meet all of the UKs manufacturing needs.

Establishing circular supply chains for recycled aluminium in automotive applications will allow the UK to maintain the value of the materials, and to keep this value within the UK rather than the current system of downgrading alloys and offshoring materials for further processing. There is already significant infrastructure in place within the UK which could be used within this circular supply chain, with recyclers and secondary smelters already producing recycled aluminium, however there are still critical areas of infrastructure missing to enable production of wrought aluminium within the UK.

To establish this new circular supply chain there are three broad areas which would need to be addressed:

- **Infrastructure investment**
  The most significant requirement is establishing a new rolling mill within the UK, as there are no facilities capable of producing wrought secondary aluminium for automotive within the UK. Investment is also required in sorting technologies to produce a "clean" recovered product.
- **Research**
  Important areas of research are that of improving sorting technologies to increase efficiency, and into developing a new universal alloy which can be more easily recycled.
- **Legislation**
  Government incentives and legislation are required to make recyclers better sort recovered aluminium, to do this financial support and incentives are required, to support the smaller recyclers.

# 1. Introduction

**Aluminium is an important material within the automotive industry, enabling the lightweighting and improved efficiency of both internal combustion engine vehicles and electric vehicles whilst increasing sustainability.**

Aluminium is the second-most used metal by mass in automotive applications. Current trends in the automotive industry indicate this is set to steadily increase, with the market for aluminium sheet predicted to expand by at least 50% by 2050[1,2].

This increased demand will necessitate the use of primary aluminium as well as recycled material. Aluminium is highly recyclable and, in some specific instances, nearly infinitely so[3]. This means that improvements within the recycling process and an expansion of the recycling industry can reduce the dependence on primary production. The implementation of improved recycling techniques, combined with the development of new circular supply networks of specific grades of aluminium, will enable increased scrap value to be retained within the UK.

The reduced environmental impact of recycled aluminium compared to primary aluminium has clear benefits to mitigate the impact of internal combustion engine and electric vehicles on the climate crisis. Increasing the use of recycled aluminium will help the UK to meet its net-zero emissions targets, which will not be possible if solely reliant on primary production. Recycling aluminium uses 95% less energy and emits significantly less greenhouse gasses than primary production from bauxite[4]. Recycling 1 tonne of aluminium saves 9 tons of $CO_2$ emissions, the equivalent of driving over 30,000 miles[5].

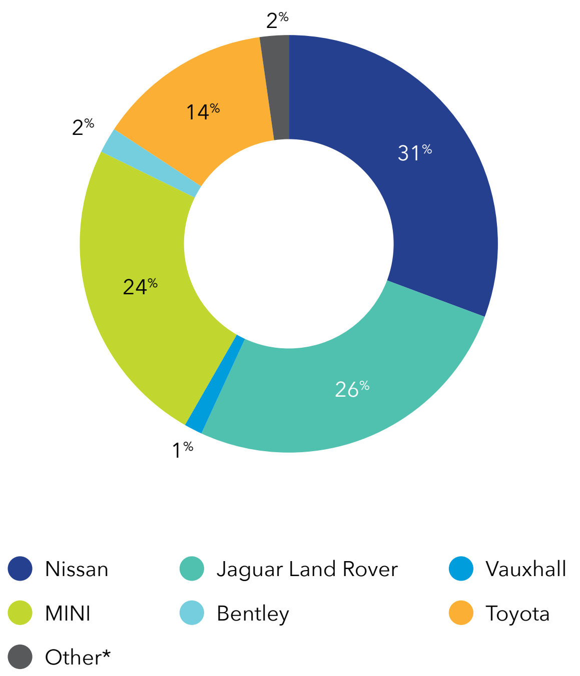
This paper looks at the potential for establishing new circular supply chains for aluminium within the UK, with a focus on automotive applications; in particular, wrought alloys, a higher value material than cast alloys. The size of the automotive industry within the UK, and the use of aluminium within the industry is presented, the difference between primary and secondary aluminium, and current recycling techniques alongside the current infrastructure in the UK is discussed. Potential issues with recycling, primarily greenwashing, and the outcomes of meetings with industrial partners throughout the supply chain are presented. Finally, opinions and recommendations are set out on areas for research and investment to increase the usage of recycled material within the UK automotive industry.

# 2. UK Automotive Industry

The UK automotive industry has a turnover of around £67 billion, contributing £14 billion of added value to the UK economy, this accounts for nearly 1% of total GDP and 8.5% of UK manufacturing[6].

In 2022 775,014 cars were manufactured in the UK, dominated by four main manufacturers but also including nearly 17,000 produced by "niche" manufacturers that are associated with higher usage of aluminium alloys[7].

UK Automotive Production 2022




UK Automotive Sales 2022

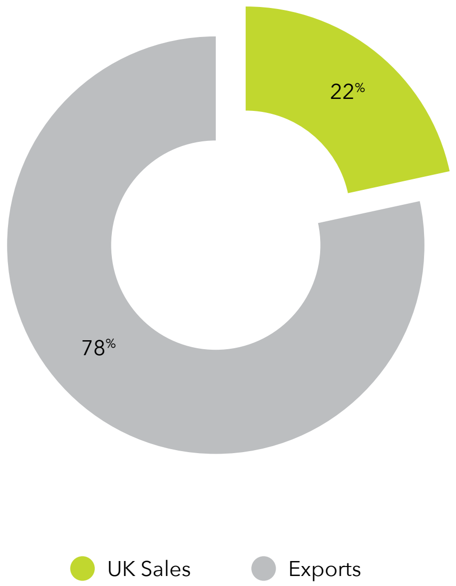



Fig.1 UK automotive industry production volumes and sales locations 2022, *other manufactures includes Aston Martin, Caterham, Lotus, McLaren, Morgan and Rolls Royce (Source: SMMT7 ).

A significant number of vehicles produced in the UK are exported, with nearly three out of four vehicles produced going overseas.

In 2022 there were over 1.61 million new vehicles were registered in the UK, with the vast majority being imported[8].

UK Vehicle Production & Scrap Volumes

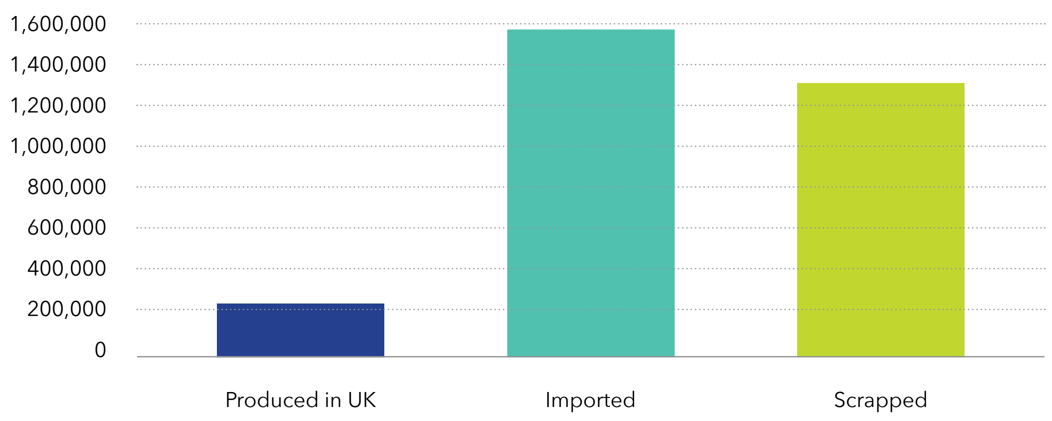



Fig.2. Volumes of vehicles produced, imported, and scrapped in the UK (Source: Statista8).

There are more vehicles imported than produced annually, and over 1 million cars scrapped per year[9].

This offers potential to recover and recycle end-of-life vehicles and create a new circular supply chain of recycled material which can more than adequately meet the UK's automotive aluminium needs.

Establishing this circular supply chain would allow the industry to retain value of end-of-life materials rather than losing value through exports.

# 3. Automotive Aluminium Usage

Aluminium usage within automotive applications has steadily increased over the past decades, driven by stringent legislation to deal with the need to reduce vehicle emissions[10].

Since the early 1990s new car models in the UK followed the European emissions (EURO) standard for vehicle emissions in line with other EU member states. A recent white paper commissioned by the UK Government indicates that following Brexit the UK is targeting zero emissions from vehicles at an accelerated rate compared to the EU[11].

The first stage of this will see the end of new petrol and diesel vehicle sales by 2030, with all new cars and vans being zero tailpipe emission by 2035[12].

Legislation is driven by the Climate Change Act (2008) (2050 Target Amendment) which sets a legally binding target for reducing greenhouse gas emissions, in particular carbon dioxide by 100% (on 1990 levels) by 2050[13]. To achieve these goals automotive manufacturers are increasingly looking towards aluminium to replace steel in their vehicles due to its low density and high relative strength.

Various studies indicate an increase in aluminium usage of 50%, with one recent study suggesting up to a fourfold increase in aluminium usage in passenger vehicles[14].

During the preparation of this report Rishi Sunak announced that the ban on new petrol and diesel vehicles will be pushed back from 2030 to 2035[15]. The UK is still legally bound to meet the 2050 emissions targets, however popularist policies such as these will make meeting these targets more difficult. There has been an industry backlash following this announcement, with many manufactures including Nissan stating that they will stay committed to the 2030 target previously set out[16].

**Worldwide Vehicle Emission Standards & Average Aluminium Content**

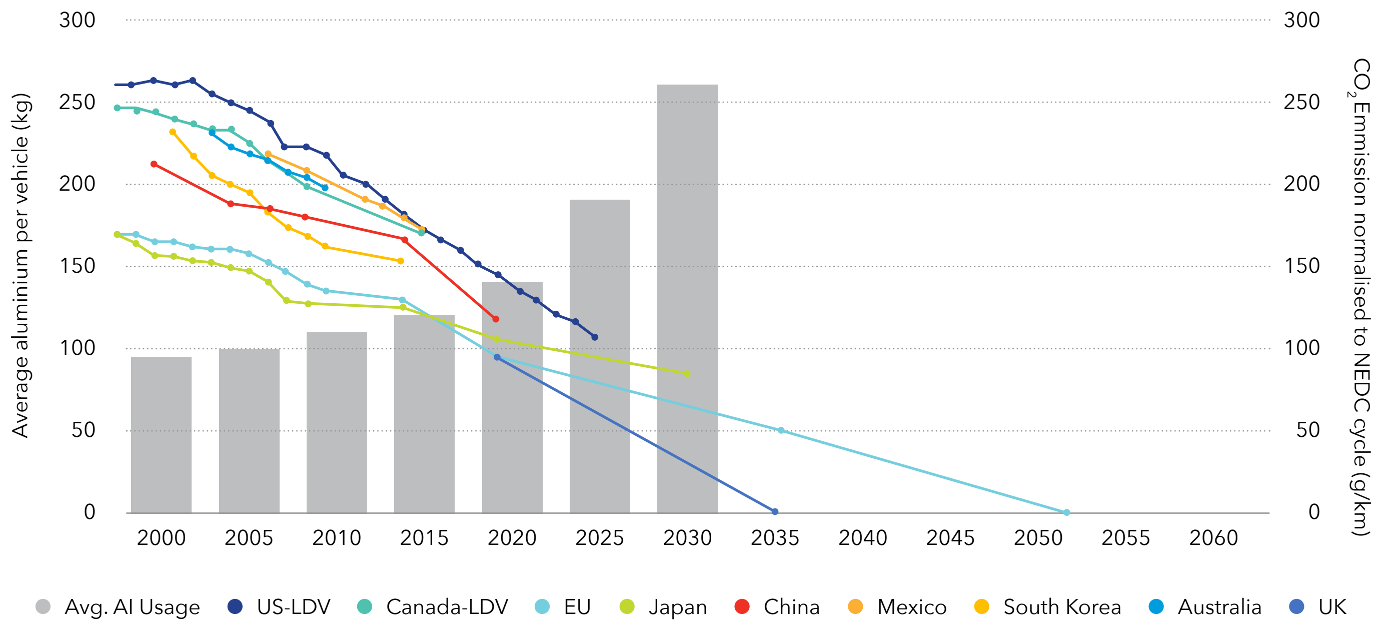


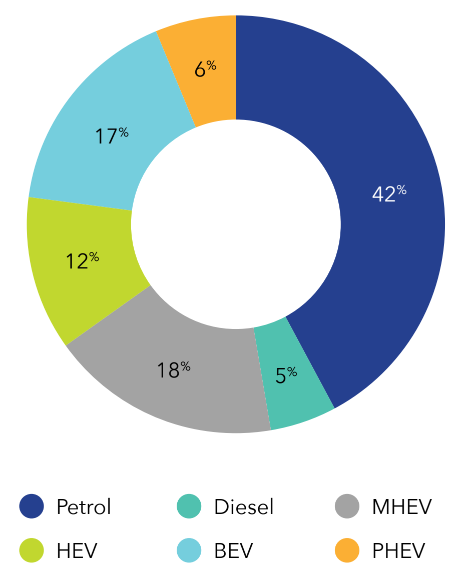

**Fig.3.** Trends in worldwide emission standards compared to average aluminium content in vehicles (Source: ICCT[17]).



Through lightweighting and mass reduction by using lower density materials it is possible to improve the efficiency of internal combustion engine and hybrid vehicles. It can also help to offset the substantial mass of batteries (typically 500-800kg) within electric vehicles, whose market share is rapidly increasing and will continue to expand to help achieve zero tailpipe emission obligations.

In 2022, the UK saw hybrid and electric vehicles representing over 50% of new vehicle registrations[18].

**UK Vehicle registrations by engine type**




**UK Vehicle registrations Total**

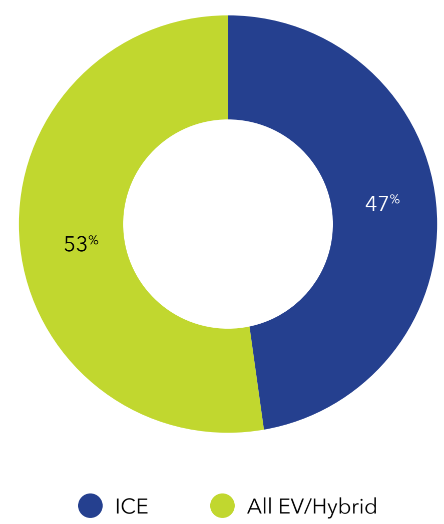



**Fig.4.** UK vehicle registrations by engine type (Source: HM Government[18]).

The current average aluminium content of vehicles in Europe is around 150kg, although this is forecast to be in the region of 250kg by 2030 due to the shift towards replacement of steel with aluminium components[19]. Traditionally most aluminium components in vehicles such as wheels, engine blocks, and suspension components, have been cast, but the push for lightweighting has seen a steady increase in wrought and extruded products being utilised. Many automotive manufactures now produce aluminium intensive vehicles, with large amounts of body in white and outer panels being formed out of high strength wrought aluminium alloys.

# 4. Primary vs Secondary Aluminium

Primary aluminium involves the mining and processing of bauxite a highly energy intensive and polluting process that, despite efficiency improvements, remains largely unchanged since the 1800s.

Primary production utilizing coal-derived electricity emits nearly 20 tonnes of $CO_2$ per tonne of aluminium[20] As there is no commercial bauxite mining in the UK and most of the primary aluminium is imported, this transportation adds to the total $CO_2$ associated with the lifecycle of the aluminium.

According to various studies secondary aluminium production uses up to 95% less energy and emits significantly less $CO_2$ than primary production[21]. A significant factor in the $CO_2$ emissions of both primary and secondary production is the nature of the energy source relied on in production. Countries such as China and India, which remain heavily reliant on coal-fired powered plants for electricity, produce more carbon intensive aluminium than that of European producers where the electricity supply benefits from a higher proportion of energy from renewable and low carbon sources. In this context the UK is well placed to produce low $CO_2$ secondary aluminium due to a lower carbon energy mix where around 50% of energy is already produced by renewable sources [22,23].



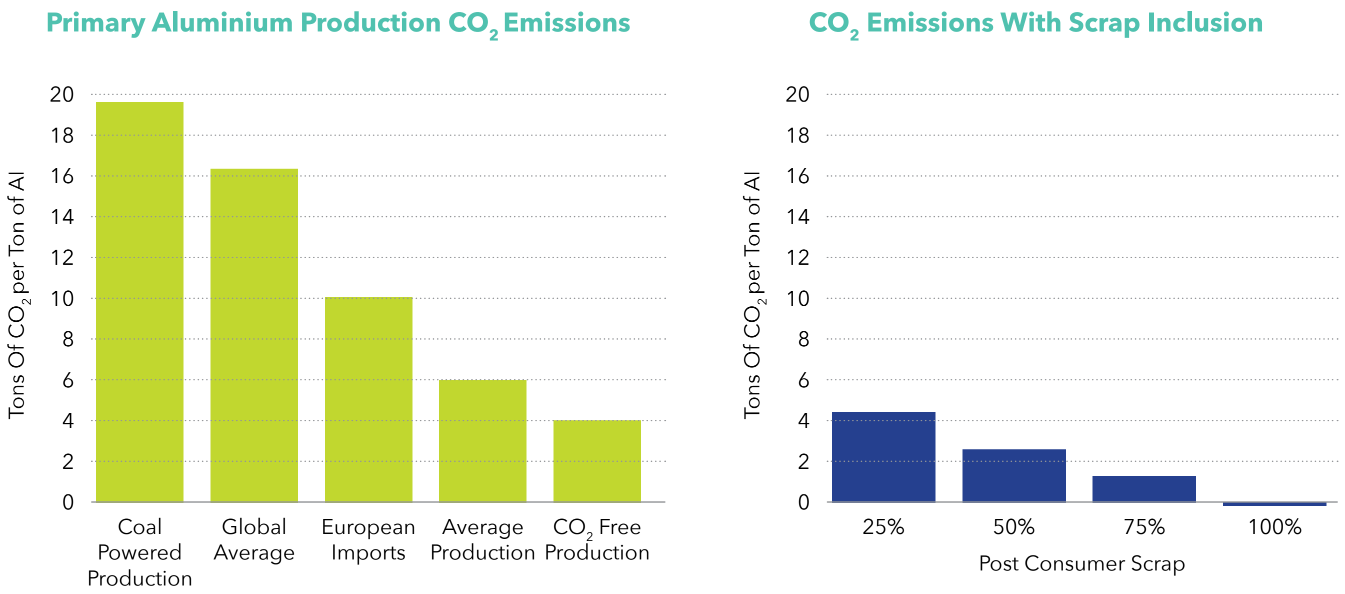



**Fig.5.** $CO_2$ emissions associated with aluminium production for various sources of electricity (Source: BEIS22).

Even without accounting for potentially significant $CO_2$ emissions from the transport of raw the materials primary aluminium production involves multiple energy intensive stages. Firstly, bauxite is mined and processed, after which the Bayer process is employed, using a caustic soda solution to separate the aluminium oxide from within the bauxite.

The Hall-Heroult process then uses electrolysis to reduce the alumina into aluminium, and oxygen is then used to produce pure aluminium. The aluminium is then smelted, and alloying elements are added to achieve the desired alloy. Thereafter the alloy is subjected to specific thermomechanical processing via heat treatments and rolling to achieve the required sheet thickness and temper.



The use of recovered and recycled aluminium reduces the requirement for primary aluminium, and the "cleaner" the recycled feedstock the less primary aluminium is required. Establishing streams of clean segregated aluminium alloys would enable the UK to form a circular supply chain around this material, significantly reducing the dependence on higher cost and more carbon intensive imports. The recycled material would act as the feedstock for smelting, eliminating the mining and primary processing stages listed above, thereby reducing the energy demand and greenhouse gas emissions associated with primary aluminium production.

A report compiled by Innoval showed that recycling saves between 90-97% of the energy required for primary production and that between 1908-2007 833MT of aluminium was produced, with 530MT still in use[24]. This demonstrates the availability of a significant aluminium resource which could be utilised, almost eliminating the need for primary production. This is illustrated in figure 6 from Brunel University showing that in a circular supply network, once primary aluminium reaches its end-of-life stage it can be recovered, recycled, remanufactured, and then reused. The secondary material can then remain in the circular network almost indefinitely if it can be recovered at end-of-life.



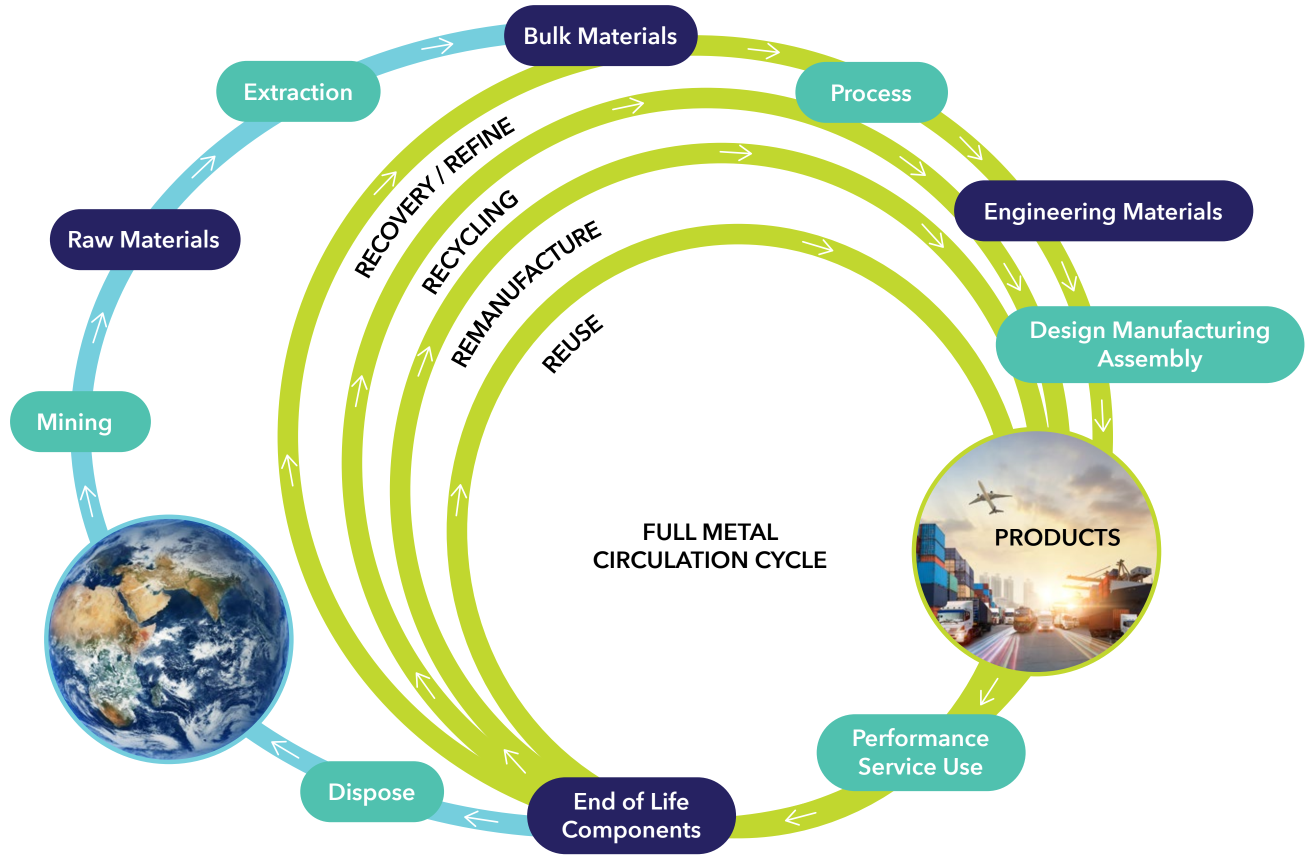



**Fig.6.** Example of a UK circular supply chain for automotive aluminium (Source: BCAST[24]).

With limited primary production on shore and insufficient facilities to process the full volume of recovered material the UK is a net importer of aluminium, importing 1.25M tonnes a year while exporting 1.1M tonnes [25]. The UK has the ability to process secondary aluminium, but the current capacity for doing so is insufficient with respect to the volume of secondary aluminium that is actually or potentially available. This affects a surplus of secondary aluminium that must be exported, and a deficit in value, with imported material costing around £3000 per tonne compared to of the £2000 per tonne value of exported material[26].

Increasing secondary processing infrastructure will reduce the need to export, allowing the UK to retain higher value material on-shore and decreasing the reliance on higher-cost and more carbon intensive primary aluminium imports. Transitioning towards the utilisation of secondary aluminium would also allow the UK to take a lead in the production of 'sustainable aluminium' which displaces the emissions and energy associated with primary production utilising the high percentage of renewable and low-carbon power generation in the UK.

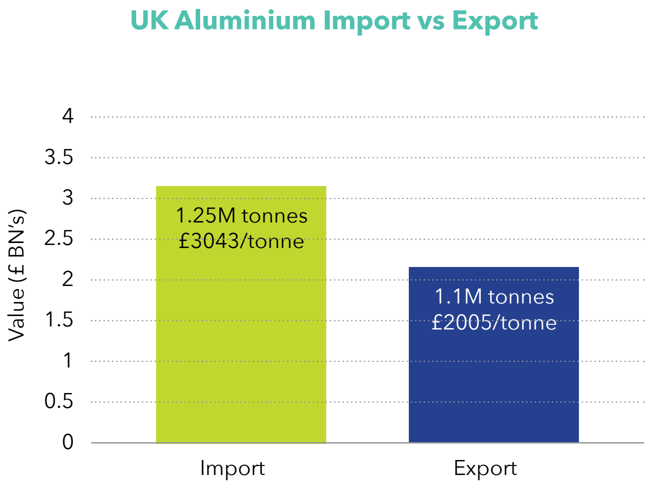



**Fig.7.** Values and volumes of UK imports and exports of aluminium (Source: Alfed[25]).



# 5. Current Recycling

Cast alloys have a much greater alloying content than wrought, and as such are less sensitive to contamination and mixing of alloys during the recycling process.

Mixed alloys can be shredded and remelted to achieve the required composition of the cast alloy. Wrought alloys, due to their lower alloying content, are far more sensitive; even small levels of contamination can lead to the alloys being out of specification and unusable, meaning greater care is required to accurately sort scrap materials.

Wrought alloys are also typically more expensive than cast alloys. Due to their comparatively higher value and sensitivity to recycling, better design for disassembly and recycling and improved sorting methods are critical.

At present typical recycling techniques for aluminium involve pre-sorting materials to a level deemed reasonable to the recycler, depending on the materials, and joining techniques between dissimilar materials this can lead to varied levels of mixed materials. This can mean simply sorting all metal into one mixed feedstock of metal.

Following this, the source materials are shredded to leave a smaller size suitable for sorting, various sorting techniques as detailed in fig.8 are applied to remove contaminants such as iron, copper, rubber etc., which then produce a final aluminium product of varying purity depending on which techniques are used. Pre-sorting of aluminium from other metals prior to shredding will produce one general stream of aluminium scrap, whereas if the aluminium were further sorted into specific grades the recovered material could then be used to produce specific grades of wrought material with a higher value.

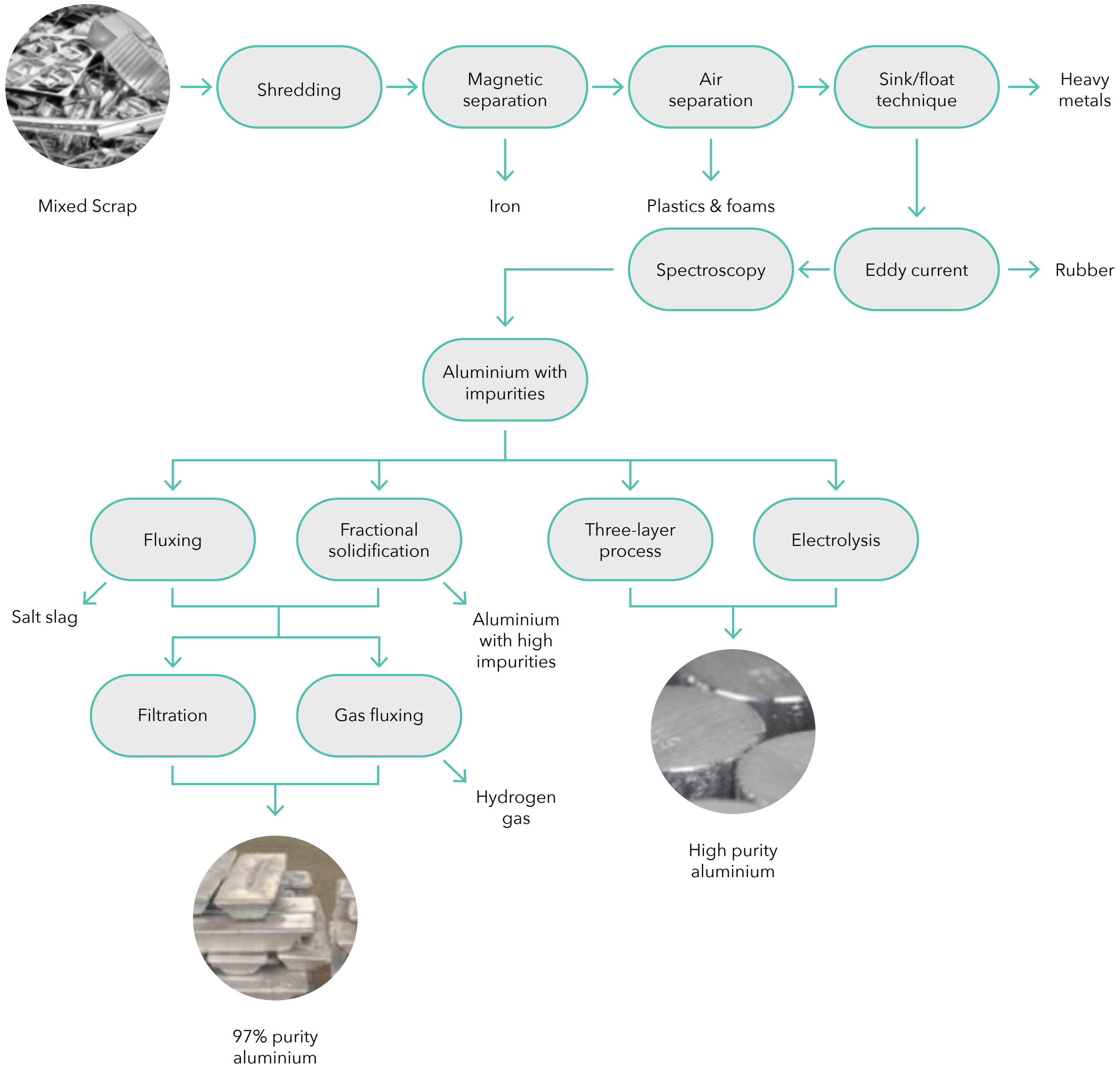



**Fig.8.** Current recycling processes for aluminium showing various by products.



The efficacy of sorting techniques leads to varied levels of undesired impurities, notably iron (Fe), silicon (Si), and copper (Cu), within the recovered aluminium. Among these alloying elements iron has a particularly detrimental effect on recycled aluminium alloys, its presence resulting in the formation of hard and brittle intermetallic compounds. These intermetallics have a substantial negative impact on mechanical properties, including reduced ductility and fatigue resistance, and increased susceptibility to pitting corrosion. One approach to reducing the prevalence of impurities and the occurrence of unwanted intermetallics is improving the means of sorting and processing recycled materials. However, employing more granular and robust sorting and processing techniques increases the cost of the recycled aluminium due to the higher costs of production, including increased energy demand,

A more specific form of contamination which particularly affects wrought alloys is the mixing of different sorts of aluminium during recycling. If a recycler simply collects all aluminium together for recovery and remelting then some of the value will be lost as it can no longer be reprocessed back into the original grades.

For example, there could be more value in separating 5000 series from 6000 series and recycling the individual alloys, than mixing them together to recover an alloy which meets neither specification. Accurate sorting prior to shredding is required to create individual streams of specific sustainable aluminium alloys to displace the high financial and carbon costs of a reliance on primary production.

Supporting this transition can be greatly improved by a 'design for disassembly' approach[27]. The principles of design for disassembly being to minimize end-of-life value loss to facilitate reuse, repair, remanufacture, and recycling. In the automotive industry a well thought out design for disassembly-led process considers factors such as efficient material selection, joining technology, mixed material joining, and mixed aluminium grade joining, and considers how these can be reversed and separated. Efficient design for disassembly will simplify the sorting process, leading to a reduction in impurities without increased costs and providing individual steams of specific alloy grades that can reduce the reliance on primary aluminium.

# 6. Current UK Infrastructure

## Recyclers

The ENF Recycling website is an international database of recycling companies which lists over 500 metal recyclers within the UK, while British Metals Recycling Association has a list of 450 companies involved in metal recycling, with 340 of these specified as handling aluminium[28,29]. Even considering companies going out of business, and websites not being updated, there are likely still at least around 300 active recycling businesses in the UK that deal with aluminium. These range from small-scale family run scrap yards to divisions of large multinational companies. This indicates that there is significant infrastructure already in place to recover and recycle aluminium within the UK.

## Smelters

Since the 2012 closure and subsequent demolition which was completed in 2018 of the Lynemouth smelter in Northumberland. there is only one aluminium smelter to produce primary aluminium in the UK. The Lochaber smelter at Fort William, which is operated by Alvance British Aluminium, part of the GFG Alliance group of companies.

The Lochaber smelter currently produces only primary aluminium after processing imported alumina, with a capacity of 48,000 tonnes per annum. In 2021 Alvance received planning permission to build a new facility on the site for the processing of secondary aluminium to enable the production of recycled aluminium billets which could be further processed into wrought products. The new facility is planned to have an operating capacity of 100,000 tonnes of secondary aluminium per annum in addition to the current primary production[30]. Both plants will operate using renewable energy from the adjoining hydroelectric powerplant, helping to reduce the carbon footprint of the produced materials.

The number of secondary aluminium smelters producing ingots of aluminium is harder to accurately ascertain. Light Metal Age a bi-monthly publication covering the aluminium industry worldwide, lists 45 companies producing secondary aluminium in the UK[31]. On further investigation, several of the companies have ceased trading, many are producing cast parts from secondary aluminium, or are using post-production scrap rather than post-consumer scrap.

The number of companies within the UK producing ingots of aluminium from secondary material is therefore likely to be fewer than the 45 listed.

## Rolling Mills

In addition to a limited number of aluminium smelters within the UK, there is also a lack of rolling mills, with only two large scale mills currently operating, both of which operate only for specific markets. Bridgnorth Aluminium operates a large rolling mill with a capacity of around 75000 tonnes per annum but specialises in lithographic and foil products and is not set up to produce wrought products for the automotive industry. Arconic Aluminium which operates a large rolling mill in Kitts Green specialises in wrought alloys for the aerospace industry, with its automotive products being produced in the United States. Plans are now in place to open a new recycled aluminium rolling facility within the UK through the BACALL project[32]. This is critical to forming a new circular network that can maintaining the value of the recycled material for use in the UK rather than exporting it and remaining reliant on imported primary aluminium.



# 7. Greenwashing

Greenwashing is a term for certain kinds of marketing that positions products or processes as environmentally friendly and is associated with the obfuscation of true social, economic, and environmental impacts.

Vague terms such as 'green' and 'sustainable' are used as buzzwords to oversell the benefits of using hydroelectric power during production, whilst it is an improvement over the use of coal, the production of aluminium is still polluting. Greenwashing that underplays greenhouse gas emissions occurs with both primary and secondary aluminium production. Although because secondary aluminium is more readily associated with sustainability, this report will focus on greenwashing issues specific to the latter.

A common example of greenwashing within the aluminium industry is the claim that aluminium is "infinitely" recyclable. Whilst this is theoretically possible, there is a 2-10% melt loss each time the aluminium is smelted, meaning that realistically aluminium can be recycled 10-15 times[33]. There is also an oversimplification of the process with this phrasing as the aluminium needs to retain its original specification and functional properties after recycling to maintain its value and usability[34]. Recyclers must dilute the melt with primary aluminium and add alloying elements to bring the recovered aluminium back up to these specifications. This will continue to be the case until better sorting techniques are developed to perfectly separate grades of aluminium during recovery. The dependency on dilution with primary aluminium undermines what is at least superficially implied in the 'infinitely recyclable' claim.

Another area of concern for aluminium recycling is the misrepresentation of the source of the recovered material. Some producers will declare the total recycled content within the aluminium but without specifying the source of the recycled content. This is relevant because post-consumer recycled scrap has a more positive environmental impact compared to post-industrial recycled scrap as it is derived from the end-of life of the specific application, after the aluminium-containing product has reached the end of its usability[35]. Post-industrial scrap should be minimised as a point of efficiency during the production process. and should be recovered and recycled, but merely making use of the offcuts or excess of primary materials does not have the same environmental benefits as recycling genuine end-of-life materials. Combining post-industrial and post-consumer scrap to give a total recycled content figure is a disingenuous representation because it suggests that they both have the same environmental impact.

# 8. Industrial Discussions

During the compilation of this report senior staff at Ford UK, Impression Technologies, Polestar Cars, Speira Aluminium, ALFED and TMR total metal recovery were interviewed. These companies were selected to represent stakeholders across current and potential new circular supply chains for aluminium recycling and production.

Through these conversations the authors gained insights into prevailing limitations to developing new circular supply chains, and suggestions on how to advance.

A clear necessity for the establishment of a UK-based circular supply network for recycled aluminium is a means to deliver 'clean' material for reprocessing, i.e., material that has been sorted into specific grades of aluminium to avoid cross-contamination and downgrading of scrap. This is likely to require legislation and Government incentives for smaller recyclers to enable investment in facilities with sufficient sorting capability. Along with this, changes earlier on in the supply chain, in the design phase of automotive products, are required to facilitate easier disassembly and separation of specific aluminium grades.

The biggest hurdle to overcome is that of a lack of UK rolling facilities. Without a rolling mill capable of rolling sufficient recycled materials the establishment of a circular supply chain for wrought materials is impossible. The recent announcement of the BACALL project to open a new rolling mill dedicated to this task, is a positive step toward resolving this issue25. If resolved, the other major issue arising from discussions relates to a perceived lack of cohesion within the field of aluminium research, with multiple universities and companies working on the same area, but without a joined-up communicative approach. Finding ways to pool and focus working groups from industry, academia, and other stakeholders, has the potential to increase the speed at which sustainable aluminium objectives are achieved by reducing the repetition of research.

One aspect of the approach towards a circular network and the "cleanliness" of recycled alloys revealed a marked difference in opinion between industrial groups in relation to priorities. One school of thought, which is likely to be the route taken in the short term as it fits with the commercial focus of aluminium producing companies is that of highly efficient sorting methods. This coupled with specific design for disassembly and recycling to enable separation of specific alloys to allow for alloys with specific chemistries to be produced from end-of-life scrap material.

This approach allows for higher value to be retained within the recovered alloys and fits with the current methodology of vehicle production where specific alloys, with specific properties are formed in a suitable way to meet design requirements. The benefit of this approach is that it fits with current industrial approaches to aluminium production and shouldn't require any change in thinking. This approach does however require significant energy and time to accurately sort and process the various alloys, which partially negates the benefits of the recycling as well as increasing the cost of the recovered material.



The other approach, which would require a significant shift in the approach to alloy production and how aluminium producers compete within the market is the move towards a "universal" aluminium alloy. A universal alloy which can be utilized in both wrought and extruded automotive applications would lead to a simplification of the design process and enable improved recovery of the materials at end of life, reducing the reliance on sorting technologies. With only one stream of alloy scrap, the need to segregate alloys will be eliminated. The process of design for disassembly would also be simplified as the need to join dissimilar alloys would no longer exist meaning the method of joining becomes less critical as the alloys no longer need to be disassembled for recovery.

This approach would likely meet with significant push back from aluminium producers, as producing one single alloy with a specified chemistry and properties would eliminate their ability to tweak chemistries to produce higher performing versions of the same alloy which can then be marketed as such and command a higher price. The solution to this would be to shift the ownership of the aluminium from the purchaser of the vehicle to the initial producer, this retained ownership and responsibility throughout the lifecycle of the aluminium would then allow the maximum value to be recovered at end of life.

There is already a shift towards this thinking in terms of car ownership, with manufacturers now offering a subscription service for their vehicles where the customer effectively rents the vehicle for as long as required but the manufacturer retains ownership. With greater adoption this model could be applied to the materials used within the production of the vehicle. A recent report issued by Innovate UK detailing an action plan for a circular economy identified this area of retained ownership of the material throughout its lifespan as a long-term strategy, and something which will need to transitioned to rather than a short term solution.

# 9. Towards UK Circular Supply Chains

The path towards a UK circular supply chain for aluminium to increase the usage of scrap material within automotive applications is difficult but necessary.

Support throughout the supply chain through government and private investment coupled with better education around the need to recycle and legislation/regulation to improve the recycling process are all required. There is already significant infrastructure in place within the UK to move towards circular supply chains, and information from both the government and industry is that thinking, and strategy is looking towards this in the future.

There are already steps being taken towards establishing circular supply chains, with all aspects being looked at, from required infrastructure, to changes in the ownership of materials for suppliers. Following literature review, and discussions with industry and academics the authors have compiled the following list, which is not definitive, where we feel action is required and suggests actions which could be taken to enable the development of such supply chains.

## Policy and Regulations

The government already has policies in place regarding greenwashing, mandating that companies must be clear and transparent about their recycling and their environmental impact of activities. Whilst this ensures correct reporting of activities, further legislation and incentives are required, at both ends of the spectrum, regulations to ensure that recycling is being conducted to a specified standard, and incentives to allow companies to carry out the necessary processes to achieve this. Talks with smaller recyclers have indicated a willingness to conduct better shredding and sorting of materials, but that they are limited financially from doing so.

## Education

Education around the recycling of aluminium, and the importance of accurate separation is important so that recycling companies can better train staff to improve the sorting process leading to a cleaner material supply. More fundamentally there is the need for more education within the UK around aluminium specific and general metallurgy. Currently there is only one UK university offering one undergraduate course containing metallurgy. Without this fundamental academic understanding of metallurgy there is going to be a shortage of trained metallurgists within the UK to drive future research and development.



## Research

As highlighted by industrial partners, there are many research groups focused on recycling of aluminium and associated tasks and technologies. To improve the current research and advance the field there should be better communication between different universities to ensure there is no duplication of research which is a waste of limited resources. Funding calls specifically focussed on cross university research would help to tackle this issue.

Sorting technology is an important area of research, particularly in the early stage of establishing new circular supply chains as there will be large numbers of alloys as a feedstock which are joined in ways suboptimal to recovery and recycling. Research into improving sorting technology is then required to ensure accurate separation of these alloys for recycling and re-use.

The development of a new universal alloy which could be used in a wide variety of extruded and wrought applications was raised several times as an important factor in improving recycling and establishing a new circular supply chain. A single alloy versus multiple alloys would lead to a simplified design process as well as significantly improve efficiency of the recovery and recycling process.

## Investment

The largest single investment required to establish circular supply chains within the UK is that of a rolling mill with sufficient capacity to meet the UKs automotive needs. A new plant is planned with the BACALL group which will be focussed on the rolling of recycled materials, there are no details as yet as to whether the plant will be focussed on packaging materials, or whether automotive grades will be included, but this has the potential to meet the UKs current needs.

Outside of this large investment the other significant area for investment is in sorting technologies and improving the current infrastructure around sorting scrap feedstock to provide specific alloys for recycling. This will require large investments initially, but costs could be recovered in the future by increasing the value of the recycled materials and maintaining that value onshore.

# 10. References

**1.** An assessment of global megatrends and regional and market sector growth outlook for Aluminium demand, IAI, 2020. *https://international-aluminium.org/wp-content/uploads/2021/03/cm_2050_outlook_for_al_demand_20200528_4wycD18.pdf*

**2.** Advanced lightweight materials for Automobiles: A review, Materials & Design, 2022. *https://doi.org/10.1016/j.matdes.2022.110994*

**3.** Making sustainable aluminum by recycling scrap: The science of "dirty" alloys, Progress in Materials Science, 2022. *https://doi.org/10.1016/j.pmatsci.2022.100947*

**4.** Aluminium for Climate: Exploring pathways to decarbonize the aluminium industry, World Economic Forum, 2020. *https://www3.weforum.org/docs/WEF_Aluminium_for_Climate_2020.pdf*

**5.** Global Aluminium Recycling: A Cornerstone of Sustainable Development, International Aluminium Institute, 2021, *https://international-aluminium.org/media/filer_public/2013/01/15/fl0000181.pdf*

**6.** Motor industry contribution to UK economy 2021, Statista, 2022. *https://www.statista.com/statistics/299342/motor-industry-contribution-to-the-economy-of-the-united-kingdom/*

**7.** SMMT Motor Industry Facts 2023, SMMT, 2023. *https://www.smmt.co.uk/reports/smmt-motor-industry-facts/*

**8.** UK: new car registrations 2022, Statista, 2023. *https://www.statista.com/statistics/299240/volume-of-new-passenger-cars-registered-in-the-united-kingdom/*

**9.** One million cars scrapped each year – what does Britain expect from a vehicle recycler?, ATF Professional, 2021. *https://atfpro.co.uk/one-million-cars-scrapped-each-year-what-does-britain-expect-from-a-vehicle-recycler/*

**10.** Aluminium in Transport – Light-Weighting Studies, International Aluminium Institute, 2022, *https://transport.world-aluminium.org/facts/light-weighting-studies/*

**11.** The Benefits of Brexit: How the UK is taking advantage of leaving the EU, HM Government, 2022. *https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1054643/benefits-of-brexit.pdf*

**12** Net Zero Strategy: Build Back Greener, HM Government, 2021. *https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1033990/net-zero-strategy-beis.pdf*

**13.** Climate change targets: the road to net zero?, House of Lords Library, 2021. *https://lordslibrary.parliament.uk/climate-change-targets-the-road-to-net-zero/*

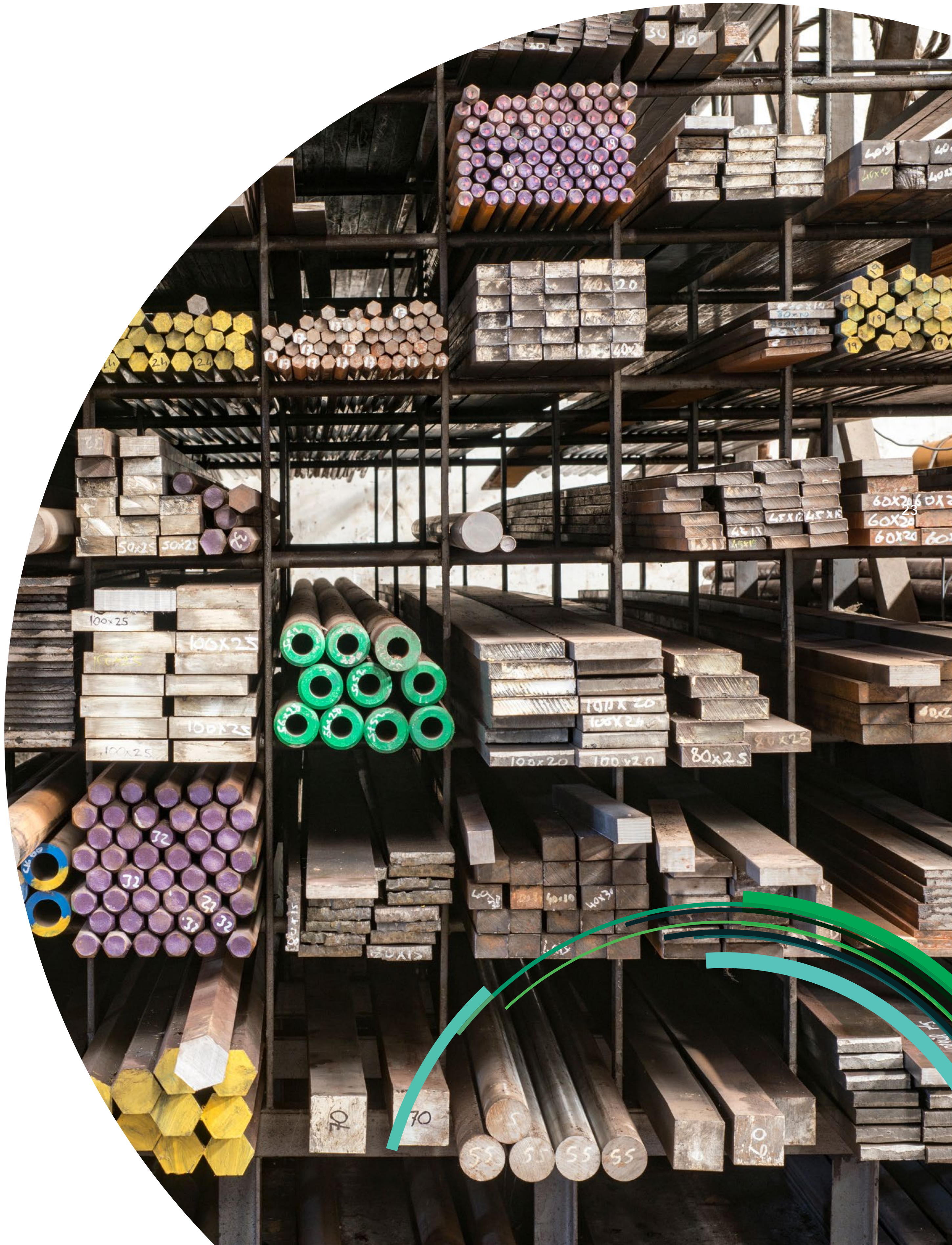
**14.** Aluminium use in passenger cars poses systemic challenges for recycling and GHG emissions, Resources, Conservation and Recycling, 2023. *https://doi.org/10.1016/j.resconrec.2022.106827*

**15.** Rishi Sunak's speech will make the UK harder to take seriously at COP28, Chatham House, 2023. *https://www.chathamhouse.org/2023/09/rishi-sunaks-speech-will-make-uk-harder-take-seriously-cop28*

**16.** Nissan vows to go all-electric by 2030 despite Sunak delay on petrol ban, The Guardian, 2023. *https://www.theguardian.com/business/2023/sep/25/nissan-all-electric-by-2030-rishi-sunak-petrol-ban-europe*

**17.** 2017 Global update: Light-duty vehicle greenhouse gas and fuel economy standards, ICCT, 2017. *https://theicct.org/publication/2017-global-update-light-duty-vehicle-greenhouse-gas-and-fuel-economy-standards/*

**18.** National statistics Vehicle licensing statistics: 2022, HM Government, 2023. *https://www.gov.uk/government/statistics/vehicle-licensing-statistics-2022/vehicle-licensing-statistics-2022*



**19.** Aluminium in cars, Unlocking the light-weighting potential, European Aluminium Association, 2022. *https://european-aluminium.eu/wp-content/uploads/2022/10/aluminium-in-cars-unlocking-the-lightweighting-potential.pdf*

**20.** Global Energy Review: $CO_2$ Emissions in 2021, International Energy Agency, 2022.

**21.** The energy required to produce materials: constraints on energy-intensity improvements, parameters of demand, The Royal Society, 2013. *https://doi.org/10.1098/rsta.2012.0003*

**22.** BEIS Review of Net-Zero Call for Evidence, BEIS, 2022. *https://www.gov.uk/government/calls-for-evidence/review-of-net-zero-call-for-evidence/net-zero-review-call-for-evidence*

**23.** Great Britain's monthly electricity stats, ESO, 2023. *https://www.nationalgrideso.com/electricity-explained/electricity-and-me/great-britains-monthly-electricity-stats*

**24.** Recycled aluminium and the Aluminium Age, Innoval, 2016. *https://www.innovaltec.com/recycled-aluminium-blog/*

**25.** UK-EU-trade-negotiations-position-paper, Alfed, 2020. *https://alfed.org.uk/policy-areas/trade/alfed-uk-eu-trade-negoitations-position-paper-february-2020/*

**26.** Innovation action plan for aluminium in a circular economy, Innovate UK 2023. *https://iuk.ktn-uk.org/programme/circular-economy-innovation-network/*

**27.** A review of advances in design for disassembly with active disassembly applications, Engineering, Science and Technology, 2020. *https://doi.org/10.1016/j.jestch.2019.07.003*

**28.** Recycling - World's Largest Directory of Recycling Companies, ENF, 2023. *https://www.enfrecycling.com/*

**29.** Service members directory, The British Metals Recycling Association, 2023. *https://www.recyclemetals.org/service-member-directory.html*

**30.** Alvance Aluminium's recycling plant next to the Lochaber smelter gets approval from Highland councillors, Al Circle, 2021. *https://www.alcircle.com/news/alvance-aluminiums-recycling-plant-next-to-the-lochaber-smelter-gets-approval-from-highland-councillors-70440*

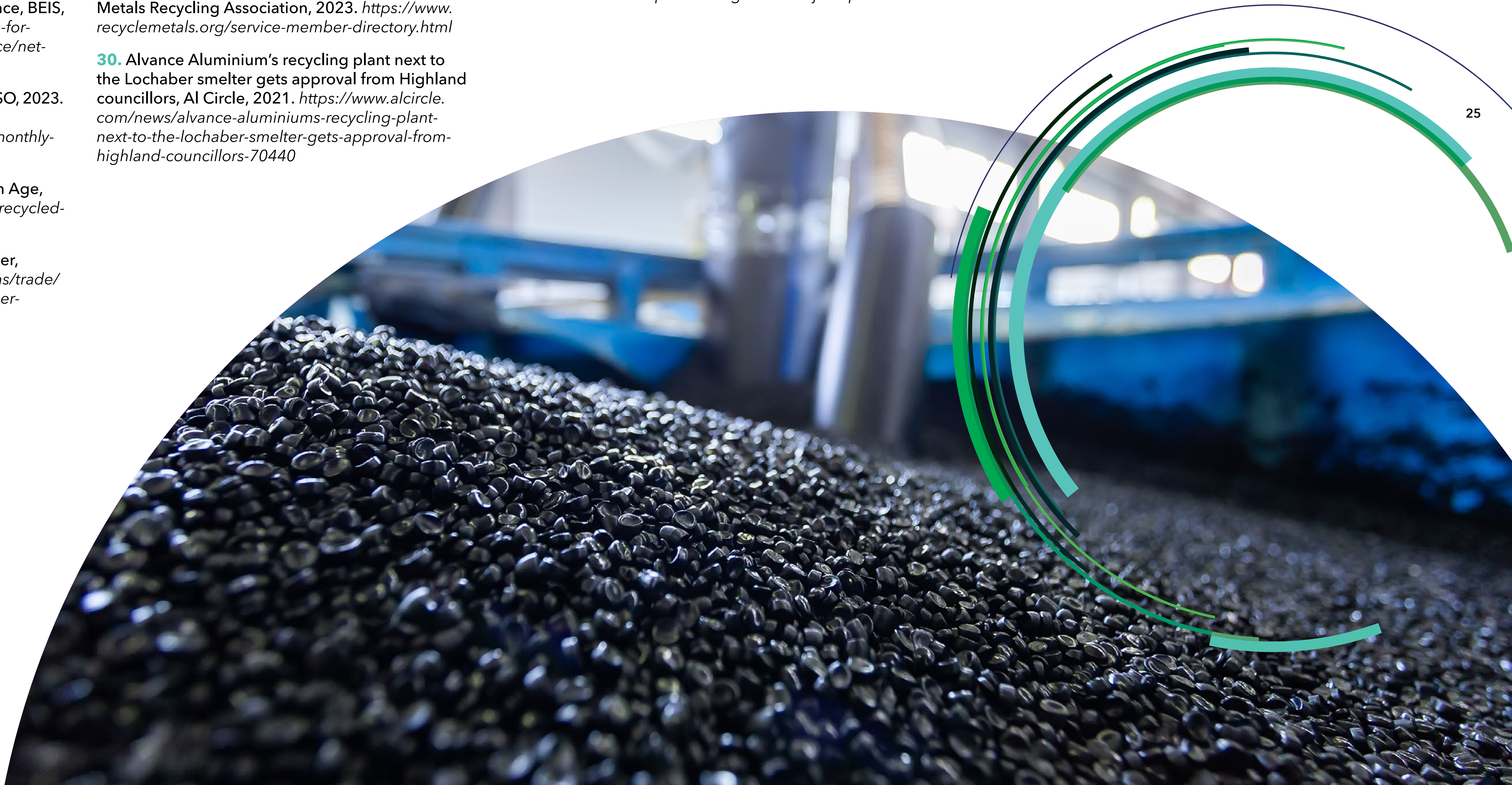
**31.** Secondary Aluminium Producers, Light Metal Age, 2023. *https://www.lightmetalage.com/resources-section/secondary-producers/*

**32.** Diageo Invests in Construction of Aluminum Can Recycling Plant in the U.K., Light Metal Age, 2023. *https://www.lightmetalage.com/news/industry-news/recycling-remelt/diageo-to-build-aluminum-can-recycling-plant-in-the-u-k/*

**33.** Aluminium scrap recycling in a production furnace: Minimizing dross formation for sustainable and efficient recovery, Materials Today, 2023. *https://doi.org/10.1016/j.matpr.2023.05.340*

**34.** The Quest for Low Carbon Aluminium: Developing a Sustainability Index, Light Metal Age, 2021. *https://store.lightmetalage.com/index.php?_a=product&product_id=1307*

**35.** Greenwashing: a potential credibility problem for aluminium, Hydro, 2011. *https://www.hydro.com/fr-FR/medias/news/2011/greenwashing-a-potential-credibility-problem-for-aluminium*



## 11. Working group members

The University of Warwick

### Dr Scott Taylor

Scott Taylor is an assistant professor in the Materials and Manufacturing directorate of WMG at the University of Warwick. He has a multidisciplinary background, completing his undergraduate in Mechanical Engineering, two post graduate master's degrees in Biosciences and Chemical Engineering and gained his EngD from WMG in Material Science. His current work focusses on aluminium alloy and advanced forming process development for lightweighting to reduce carbon emissions and he has a keen interest in the uptake of recycled aluminium alloys.

Liverpool John Moores University

### Dr Hiren Kotadia

Hiren Kotadia is a Senior Lecturer at the School of Engineering, Liverpool John Moores University, with 13 years of research experience in thenfield of functional and structural materials. After completing his PhD (2010) from Brunel University London, he has worked as a postdoctoral researcher at King's College London (2010-12), in the aluminium industry (Constellium Ltd., 2012-2015) and University of Warwick (2015-2021). His research focuses on microstructural design (under different conditions) and material sustainability, employing advanced research tools such as in-situ and ex-situ characterisation, and simulation. His work has resulted in over 63 peer reviewed scientific articles and has led to impactful real-world applications.

The University of Warwick

### Dr Paul Lansdell

Paul Lansdell is an innovation Manager within the SME support team at WMG, part of Warwick University. He completed his first degree in 1977 having studied at Birmingham University metallurgy department for 3 years, he went on to working in Industry for 18 years in technical and managerial roles covering, casting, plating, precious metal recovery, bathroom and shower products production and assembly. He undertook his PhD part time while holding down a technical development role in Mira Showers and went on to be co-director of a company specialising in the supply of metals powders and plated graphite products. Finally ending up at WMG seven years ago in 2016. His academic and industrial background has developed over the 46 years since his first degree and includes time supporting both manufacturing and supplier quality control establishment in Europe, the USA, China, India and Egypt. He is a chartered Engineer, a Fellow of IOM3 and the IMF, where he is one the board of Directors.

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