

The background of the cover features a large, semi-transparent image of an industrial manufacturing facility. It shows several orange robotic arms (likely KUKA) working on a car chassis on an assembly line. The scene is overlaid with a diagonal red and white geometric pattern that covers the entire page.

AN ASSESSMENT OF GLOBAL MEGATRENDS AND REGIONAL AND MARKET SECTOR GROWTH OUTLOOK FOR **ALUMINIUM** DEMAND

FEBRUARY 2020

A REPORT PREPARED BY **CM GROUP**

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February 2020

A Report Prepared by **CM Group**

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This project has drawn deeply on the time of many people. The authors would like to thank those who took the time to complete the surveys, especially individuals who completed it and agreed to speak to us in more detail about the future of the industry and its growth trajectory as they see it.

What follows is one view amongst many, based on the analysis of survey data and the knowledge of hundreds of cumulative years of industry experience.

EXECUTIVE SUMMARY

Study Background and Overview Forecast

This report has been prepared by the CM Group (CM) for the international Aluminium institute (IAI). The key findings are based on an analysis of the views gathered through an independent survey and subsequent follow-up discussions conducted specifically for this project over a four-month period during Q4 2019 and Q1 2020. The surveys and discussions targeted key leaders, thinkers, researchers, influencers and technologists, as well as other individuals, both inside and outside the global aluminium industry, who we believe could make meaningful and insightful contributions to the conversation. The survey results were also supplemented by CM's own research on key market sectors and applications such as vehicle transport, electric cabling, beverage containers, and heat exchangers.

The survey was structured around global megatrends. The influence of each megatrend on global aluminium demand growth, by region and by key market sector, has been estimated based on its impact on aluminium demand according to the survey results. Demand growth is considered throughout the report as total demand growth, rather than differentiated between primary and secondary demand.

Key Findings

We conclude the 30-year outlook for aluminium demand to be **strongly positive**. We forecast a global CAGR of 4.2% over the 30-year period to 2050, resulting in annual demand of **approximately 335 million tonnes per year (mtpy) by 2050**.

Aluminium is viewed overwhelmingly as a 'green' and 'environmentally friendly' material, with a unique reputation amongst peer materials and with the potential to play a major role in established and emerging industries of the future. This strong perception of aluminium as a green and attractive material of choice can be best summarised by one response, which concisely reflects the views of many

"the future of aluminium is linked to greener aluminium."

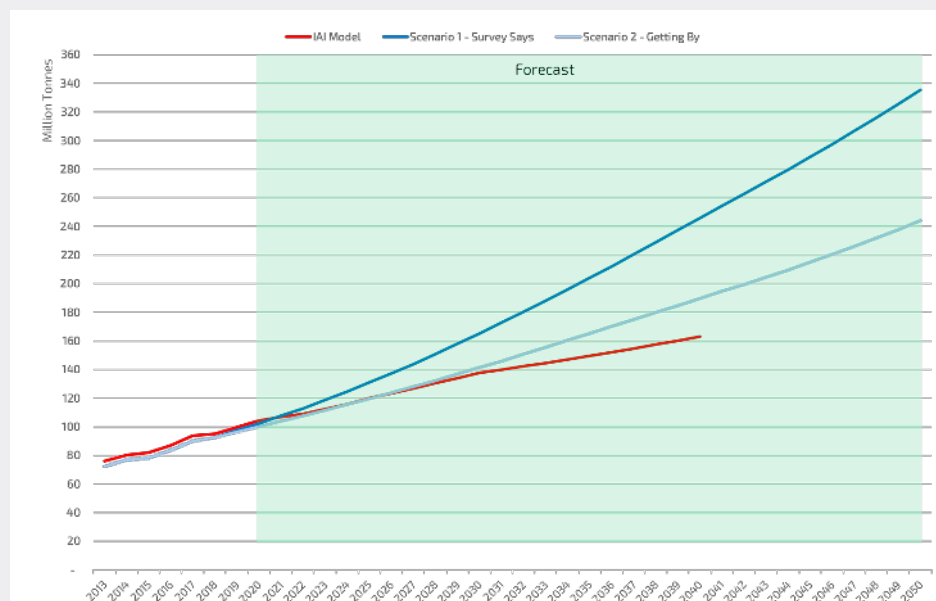
Our survey results also indicated that in order to reach its true demand potential, promotion and development by the industry will be essential in maintaining and nurturing the positive and prevailing global view of aluminium as a low-cost, versatile, highly recyclable and environmentally friendly material, often considered a material of first choice.

According to respondents, segregating the industry into 'green' and (presumably) 'non-green' metal could potentially confuse customers and, in our view, damage the aluminium 'brand'. This could negatively impact CM's growth projections. In this sense, we conclude demand and supply to be correlated; a low CO₂e primary supply base implies stronger demand growth and vice versa.

FIGURE 1

Forecast aluminium demand growth to 2050 - Scenario 1 (Survey Says), Scenario 2 (Getting By), IAI Model forecast (MTPY)

Source: CM Group, IAI



Aluminium's Unique Properties

Critical also to aluminium demand growth reaching its full potential is the ease by which users can fully utilise aluminium's unique combination of physical properties, thereby maximising its uptake over a wide range of existing and new applications, with demand spread across the full gamut of market sectors. This unique combination of properties is presented below:

- High ductility
- High strength to weight ratio
- Low density
- Good corrosion resistance, and
- High electrical and thermal conductivity.

With a wide variety of commercially available alloy systems at their disposal, materials engineers can make use of aluminium tailored to suit growing applications. The ability to easily cast, extrude, draw, forge and roll aluminium enables it to take a wide variety of shapes and forms across a diverse range of applications. This diversity sits at the core of aluminium demand growth and compares favourably with alternative materials.

Respondents to the survey were overwhelmingly optimistic about the future for global aluminium growth in a world increasingly likely to make materials choices based on fundamental physical properties, but also the increasingly important quality attribute of carbon footprint. In this sense, aluminium is a clear frontrunner amongst peers, despite the obvious exposures of the primary production process. Respondents across the survey recognised the attractiveness of aluminium as a highly recyclable and environmentally friendly material.

Study Methodology

GDP Trends

Technology enabled productivity growth has lifted the living standards of billions of people worldwide. In the process, absolute and per capita demand for a wide variety of materials has increased. Previous IAI modelling work has shown that, historically, aluminium demand growth was strongly correlated with 'stock-in-use' and GDP per capita growth. As GDP per capita increases, so too does stock-in-use, creating demand. In other circumstances we would expect this overall trend to continue. For this study, CM used OECD GDP forecasts as a baseline, together with its own research, then varied major market and regional growth rates based on survey responses.

The impact of megatrends such as climate change are forecast to positively impact demand growth in key market sectors such as transport, renewable energy infrastructure and electrical cabling. Not surprisingly, transport was identified by 90% of our survey respondents as the highest growth market sector of the future. We forecast deviation, mostly positive, around forecast GDP growth rates in many global markets and within most market sectors.

Some clear messages emerged from the survey, indicating a strong preference for aluminium over other competing materials, such as

- A move to replace plastics in packaging with aluminium.
- Rapid urbanization in undeveloped regions boosting key market sector growth beyond GDP growth forecasts.
- Aluminium improving energy efficiency in transport systems.
- Electrical grid expansions, required to incorporate renewables.

Based on the combination of survey results and CM's primary research, CM estimated an average growth delta higher than forecast OECD GDP growth rate figures for every region and market sector.

What is a Megatrend?

Megatrends are impacting almost every aspect of the human existence; trends such as rapid urbanisation, climate change and shifting economic power are redefining markets, disrupting supply chains and reshaping global manufacturing demographics.

Megatrends are significantly influencing aluminium demand growth today and will be critical in shaping the demand trajectory of the industry in the future.

At its core, this project has taken the idea of global megatrends and quantified their potential impact on aluminium demand by seeking the views of a wide range of aluminium and non-aluminium industry experts. Our analysis considered each of the megatrends identified and formed an assessment of the impact of each on major aluminium market sectors in key global regions.

The study examined the following megatrends.

- **Rapid urbanisation** – The continuing migration from rural to urban areas around the globe and resulting growth of mega-cities (>10 million populace)
- **Resource scarcity** – Increasing strain on the world's resources including water, food, metals & energy
- **Emerging economic power and globalisation** – Increasing economic power in developing regions e.g. India & Africa
- **Demographics and social change** – Population growth, aging population, growing middle class, individualisation, concentration of wealth, sharing economy, mass migration, populism
- **Technological disrupters and breakthroughs** – such as Internet of Things, increased use of AI, Industry 4 and big data, new materials and energy storage systems etc.
- **Pollution & environmental degradation** – increasing pollution and environmental degradation
- **Diversifying modes of governance** – fragmentation of countries and states, increased transparency, increasing influence of NGOs
- **Energy demand & sources** – decline of fossil fuels and growth of renewables
- **Climate change** – rising temperatures, sea levels etc in response to human green house gas emissions and the societal response to climate change such as move to renewables, increased transport energy efficiency and climate change induced migration

Full details of the survey and responses are presented in Appendix A. A total of 18 questions were asked about global mega trends and their potential impact on specific application and market sector growth prospects. The survey also elicited views from respondents about uncertainty, risks and sources of disruption, such as new technology, and how they may impact aluminium growth prospects.

Research by Application

In addition to GDP growth driven demand and the analysis of GMT effects, CM conducted research on the prospects for current and future high-volume applications, such as automotive body sheet, EV battery housings, internal combustion engines (ICEs), heat exchangers, power cables, personal mobility, beverage packaging and other transport applications (marine and trains).

Material Substitutes

To complete the demand assessment, CM also considered the never-ending battle for market share against other materials, for which aluminium may substitute for or be substituted by. The substitutes considered in the analysis were plastics, glass, copper, magnesium, high-strength steel and composites.

Megatrend Consequences

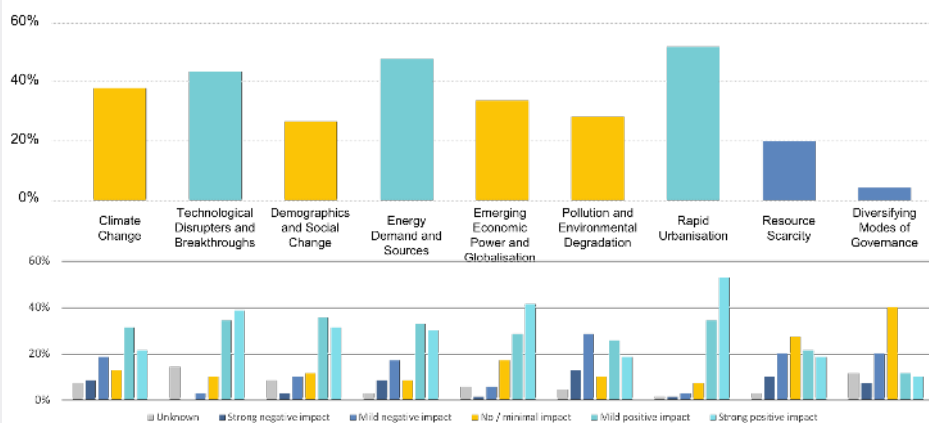
The Mega trends were ranked by survey respondents in the following order of impact on aluminium demand (Figure 2)

1. Rapid Urbanisation
2. Energy Demand and Sources
3. Technological disrupters
4. Climate Change
5. Emerging Economic Power
6. Pollution and Environmental Degradation
7. Demographics and social change
8. Resource scarcity and
9. Diversifying modes of governance

Critically, survey respondents considered most of the mega-trends as likely to have a positive impact (increase demand), although 'resource scarcity' and 'modes of governance' were considered possible sources of negative impact. Most survey respondents considered climate change as positive on global aluminium demand growth, although a fair proportion indicated the potential for a negative impact.

FIGURE 2
Impact of megatrends on aluminium

Source: CM Group



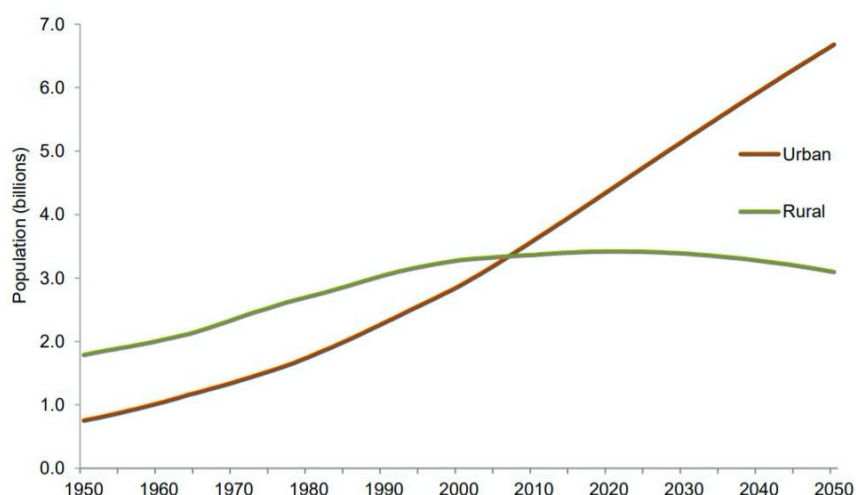
1. Rapid Urbanisation

The history of humanity is a history of urbanisation and the rapid growth of cities. The UN estimated that 55% of the world's population as urbanised in 2018, up from 30% in 1950. By 2050, the UN forecasts 68% of people will live in cities (Figure 3).

Some regions are already heavily urbanised, such as North America (82%), Latin America and the Caribbean (81%), and Europe (74%). Urbanization in Asia currently approximates 50 %. Africa remains mostly rural, with 43 % of its population currently living in urban areas. However, 90% of the growth in urbanisation to 2050 is forecast to be in Africa and Asia (mostly India). China is forecast to reach 80% urbanisation by 2050.

FIGURE 3
1950-2050 Urbanisation rate

Source: UN

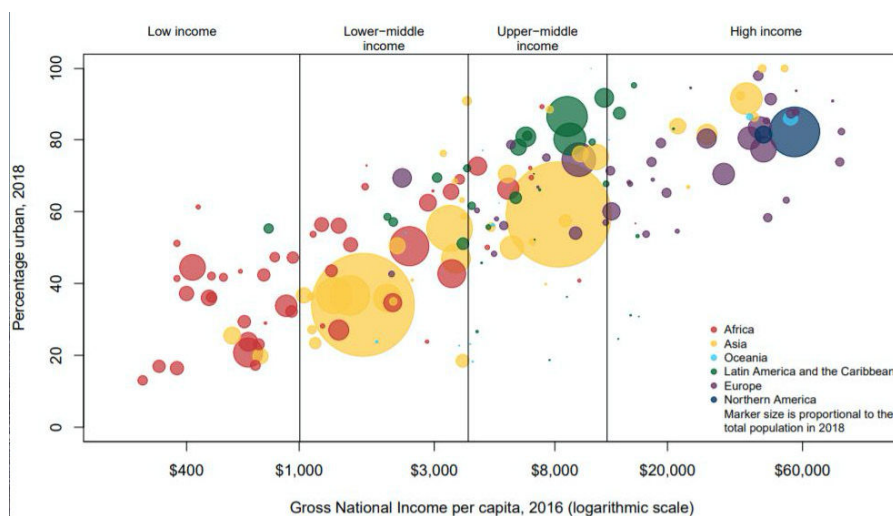


Urbanisation encourages economic activity in general (Figure 4) and, as a result, growing demand for materials.

FIGURE 4

2018 Urban population versus GDP per capita

Source: UN

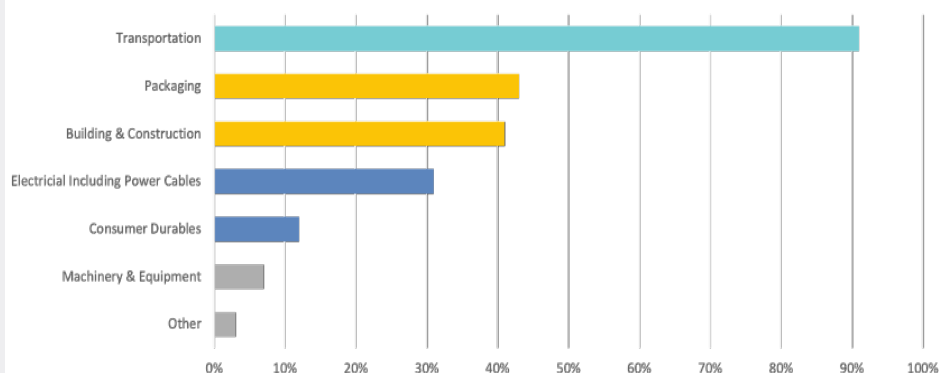


Urban populations are rising around the world, but cities are struggling to keep up. New solutions to emerging problems caused by rapid urbanisation will be required. Increasing urbanisation naturally creates growing aluminium demand mainly through construction, electrical grid expansion, infrastructure and transport. With urbanisation rates growing fastest in Asia and Africa, stronger growth is forecast in these regions. After transport, building and construction was ranked as the equal second market sector along with packaging for demand growth by survey respondents (Figure 5).

FIGURE 5

Survey response to question 11. "Which key aluminium market sectors do you expect to show strongest global aluminium demand growth over the next 30 years? "

Source: CM Group



The motorisation rate (number of cars per 1,000 people) increases as urbanisation increases along with GDP per capita (Figure 6) following an S curve. China, having the largest auto sales of any country, has the greatest influence on demand in this sector. Chinese auto production and sales fell by around 10% in 2019 compared with 2018, however, we expect growth rates to rebound as the Chinese economy continues to grow and uncertainties regarding EVs are addressed.

Although this could be taken as a sign a plateau has been reached, based on long-term trends, China's strong auto demand growth is likely to resume, then plateau at approximately 400 vehicles per 1,000 people around 2040. China's current motorisation rate is less than 200 per 1,000 people compared with around 800 per 1,000 for the USA. Taken together with replacement of old vehicles, we forecast a CAGR of 4.7% for Chinese auto and light truck growth, reaching 36 million tonnes of aluminium demand, contributing half the global auto aluminium demand.

Private cars are still the most common means of transport in cities, with 60% of trips for personal travel and commuting.

Ride sharing is an emerging trend with the potential to reduce automotive demand; urbanisation facilitates sharing, as does autonomous driving, bringing the cost per km down. Future generations may prefer not to own a vehicle, preferring ride-share options and deploying capital elsewhere.

Ride sharing is already popular in India e.g. Ola and Uber, because cars are comparatively expensive items. Similarly, online vehicle sharing platforms in China, such as Didi (450 million users) and Mobike (a provider of shared bicycles - 100 million users) are gaining greater acceptance.

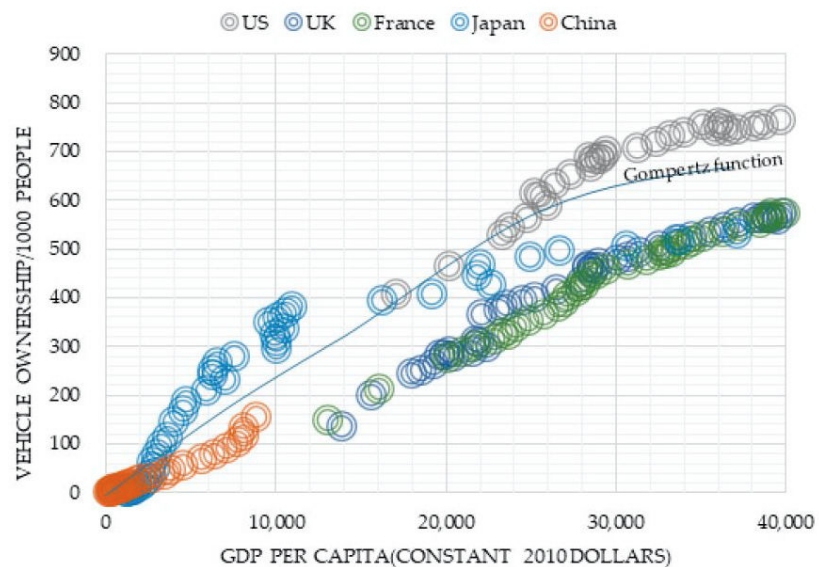
Our research suggests that ride sharing is likely to have an impact on demand and that modern public transport systems will become a more attractive option in dense cities. However, as the EU commission has stated "..... the car is so linked to ideas of individualism, freedom, private space and personal identity that people will be unlikely to give up private car ownership in the short term".

We have assumed the split between private and public transport to have a neutral effect on aluminium demand, given public transport systems such as buses and rail drive high demand for aluminium.

FIGURE 6

Growth in motorisation as a function of GDP per capita and country

Source: Sustainability Journal 2019.



The vehicle market, which we forecast to comprise mostly NEVs over the long-term, is forecast to become aluminium's largest market sector. The transport market, in most part driven by urbanisation, was rated by 90% of survey respondents as the highest growth rate sector. Specific transport applications rated by survey respondents were EV battery housings (66%) as the highest growth potential followed closely by auto body sheet (59%).

The mix of NEV and ICE vehicles will be affected by other megatrends such as climate change. Since NEVs are likely to be more aluminium intensive than ICE vehicles, the switch to NEVs will further boost aluminium demand.

The aluminium heat exchanger (HEX) market has been growing rapidly, as aluminium makes significant inroads to replacing more expensive copper. Applications include coolers in automotive and air conditioners in commercial, residential, data centres and manufacturing.

Almost every survey respondent rated transport as the sector most likely to experience the strongest demand growth to 2050 (Figure 6). Our research supports this view. Our research also supports the view that the consumer durable sector is likely to experience equally strong demand growth, although off a significantly lower base. Growth will be driven by strong demand for heat exchangers, mostly air conditioners, in emerging regions. The IEA forecasts growth in air conditioner sales alone to average 4.3% CAGR to 2050.

CM's estimate is 6.4% CAGR in the global consumer durables sector that includes air conditioners.

Many of the GMTs tend to have some overlapping consequences. In this case, air conditioners increase energy demand, which increases grid and aluminium electrical cable demand. We forecast aluminium to continue to take share from copper in this market. Furthermore, the switch to EVs will increase HEX demand in auto.

2. Energy Demand and Sources

Energy demand and sources was rated through the survey as the second most important GMT in terms of impact on aluminium demand. Much of the influence of energy demand overlaps with other GMTs such as climate change, for example in the growth of renewable energy. These issues are discussed further below.

Power cabling has long been a major and established market for aluminium and is currently around 6.5 million tonnes per annum. The amount of aluminium needed per km depends on the voltage and the distance.

Power grid infrastructure is forecast grow faster than GDP growth in key regions due to the need to

- Refurbish older cables in developed regions,
- Expand the grid in developing regions
- Further integration of renewables into existing grids to reduce variability
- Extend existing grids into global grids eg MENA to the EU
- Carry more energy for a growing demand
- Greater integration of EVs and charging points

The transmission line sector is growing at 7% in India, Germany plans to install another 4,0600 km of grid by 2030 to connect renewable resources to the grid and for the EU as a whole, a four-fold increase to 2050 is forecast (McKinsey's).

CM's forecast for aluminium cable is 4.3% CAGR to 2050.

The renewable energy sector uses aluminium in both solar and wind systems and represents a strong growth application. The World Bank estimates aluminium demand in this sector to reach 5.5 million tonnes by 2050.

3. Technological Disrupters

Technological change is accelerating and the impacts continue to mount. Survey respondents appear all too aware of the potential for technological disruption and believe technological change will have a large influence on aluminium demand. The outcomes are difficult to forecast such as the future for autonomous vehicles, developments in AI and the impact of additive manufacturing.

Technological disrupters could potentially push aluminium demand growth in either direction. For example, a new low-cost aluminium smelting process would make the material significantly more cost competitive against substitutes, but conversely new material developments for substitute materials could make aluminium less competitive.

Similarly, new aluminium alloys open up new applications and markets, while new alternative materials, such as high-strength wood products and lightweight ceramics, could take market share from aluminium. There is work underway on high strength power cable alloys that could potentially reduce the volume of aluminium required to carry the same current.

The aluminium battery remains a very active area of research and one with the potential to drive significantly higher demand growth.

Driverless vehicle technology may have an impact on aluminium demand by promoting ride sharing but may also boost aluminium vehicle intensity to achieve greater safety eg with aluminium foam.

Despite the potential for significant disruptions either way driven by technological disruption, CM takes the view that technology will be overall balanced in its impact of aluminium demand growth.

The one area that we see a major overhaul is in the energy cost for smelting. Our base case assumes renewable hydrogen from solar water splitting will bring smelter power costs to below <3 cents/kWhr within 15 years, making aluminium more attractive and more competitive against alternative materials.

4. Climate Change

In terms of impact on aluminium demand, climate change ranked equal third with technology by survey respondents. However, almost 60% of respondents rated climate change as the most important to our world (Figure 8). Our analysis, supported by survey results, tells us that aluminium has a key role to play in combating climate change, largely through light-weighting in transport, particularly in vehicles, but also in renewable energy infrastructure and power cabling demand.

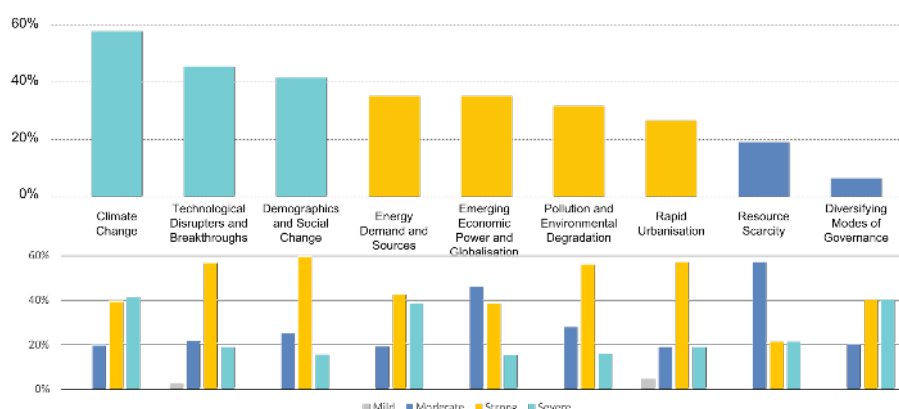
Critically, through the climate change mega-trend, survey respondents highlighted that aluminium demand and supply are inextricably linked, by way of the primary production process. Carbon footprint is rapidly becoming a key product quality attribute for all materials. Primary aluminium production is highly CO₂ intensive when using fossil fuel for electricity, which damages its reputation as a material of choice over the long-term and affects its candidacy as a material of choice. The aluminium industry clearly needs to respond decisively to reduce average CO₂e emissions to avoid some potentially significant demand headwinds, as a result of not just consumer backlash, but also increasingly strong government-imposed restrictions on heavy CO₂ emitters.

Survey respondents, and subsequent follow-up discussions with aluminium industry leaders, believe the aluminium industry can, and will, address CO₂e emissions during primary production and, as a result, will see aluminium realise substantial growth over the long term. Aluminium company sustainability reports increasingly express plans to achieve zero carbon by 2050.

FIGURE 7

Response to question 7.
"Which three GMTs do you feel will have the most impact in our world over the next 30 years?"

Source: CM Group

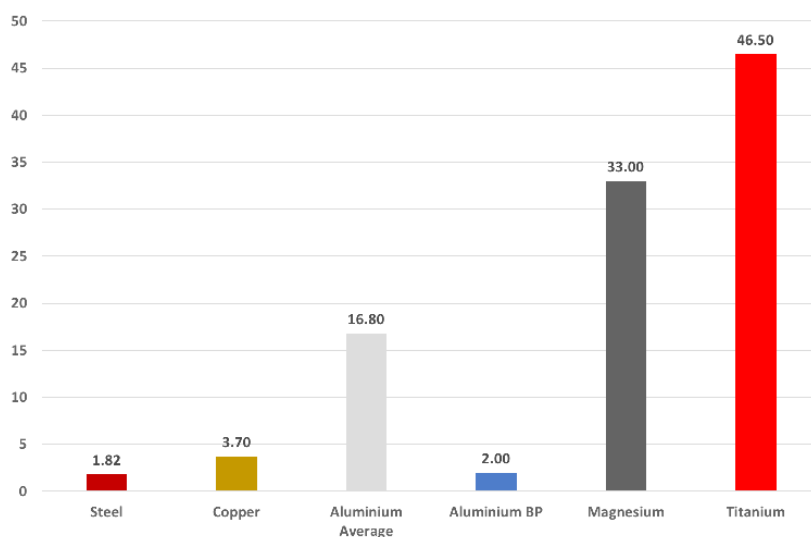


The global response to climate change, as of 2020, remains largely uncoordinated, although some positive signs are emerging, such as flat growth in coal emissions, strong growth in renewable energy generation, light-weighting in the transport sector and growth of EVs. It may transpire that 2019 may represent the peak in global emissions according to the IAE.

FIGURE 8

Scope 1 and 2 emissions by metal (Unit: CO₂et/t)

Source: World Steel, Dartmouth University



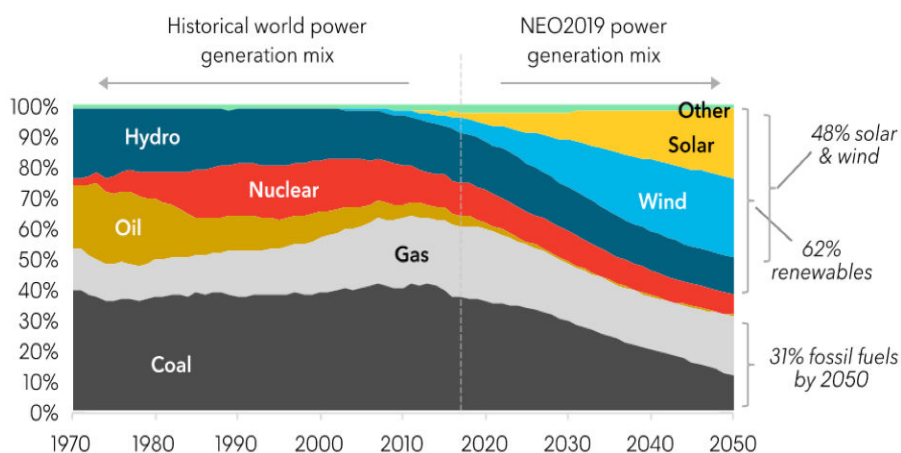
5. Renewable Energy

The world is decarbonizing in response to global warming; the decline of coal and the rise of renewable energy generation is well-established. The International Renewable Energy Agency reports total global renewable capacity reached around one third of total installed capacity by the end of 2018. Two thirds of installed new capacity was renewable. BloombergNEF forecasts renewables will represent 62% of total energy source by 2050. Irena forecast that by 2050, two thirds of the world's energy will be renewable. The cost of renewables is now cheaper than either coal or natural gas.

FIGURE 9

BloombergNEF forecast split of energy to 2050

Source: BloombergNEF

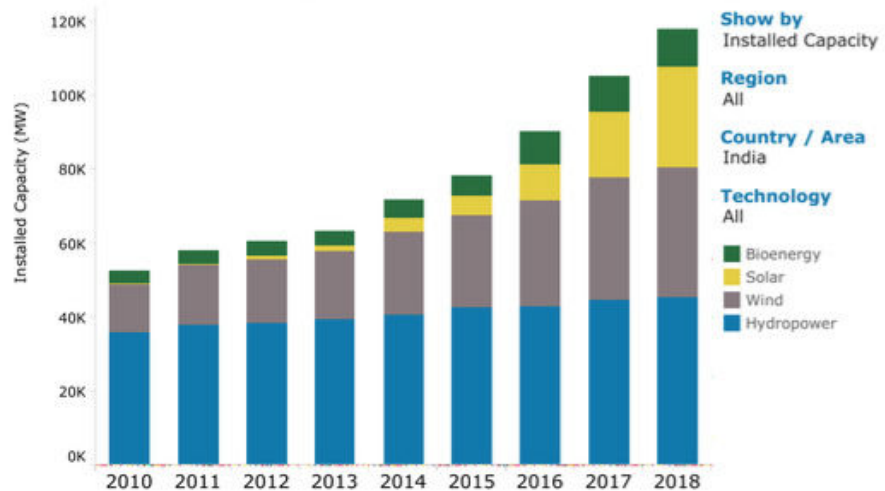


India's per capita renewable energy capacity is growing rapidly (Figure 10), although coming off a low base. Investments in renewable overtook investments in coal in India in 2018 (Reuters). Solar and wind generation now cost less than half the price of coal in India. The electrification of India is rapidly expanding. This has implications for India's economic growth and obviously aluminium power cable demand.

FIGURE 10

Growth in global Indian energy capacity

Source: IRENA



Increased aluminium demand growth in electricity grids and renewable energy infrastructure is a consequence of the switch to renewables. The other major impact is in automotive.

Automotive

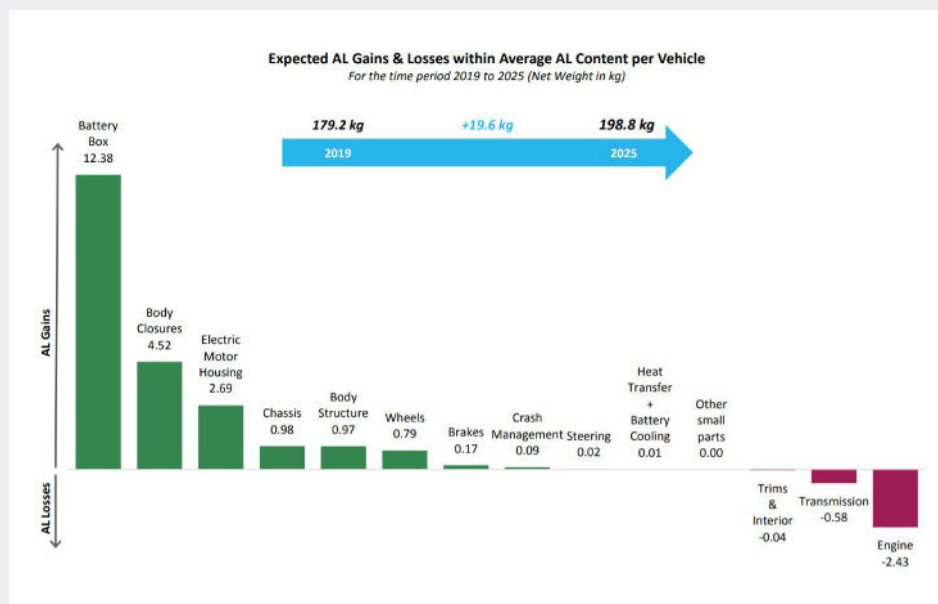
Energy mix, urbanisation and transport are closely linked. The aim to de-carbonize, and the rise of renewable energy naturally leads to the adoption of NEVS. Conventional ICE vehicles have different light weighting priorities. Producers of conventional vehicles need to meet fuel efficiency and GHG emission statutory requirements such as CAFE and fleet averages etc. Light weighting including adoption of aluminium is one way to achieve these goals. Further, NEVs need to be made lighter to increase their range.

Most studies indicate NEVS will have greater aluminium intensity than ICE vehicles. Therefore, an increasing proportion of NEVs will increase aluminium demand in the automotive sector. However, it's not a clear case for a net gain. On the one hand, the elimination of ICEs means significantly reduced tonnages of Al-Si casting alloys for engine manufacture; on the other, major increases in extrusions for battery housings drives higher volumes for EVs. Ducker's latest study on European auto aluminium use suggests battery housings will more than offset the reduction in aluminium content arising from replacement of ICEs (Figure 11).

FIGURE 11

Change in average aluminium content of European automotive

Source: Drucker 2019



The light weighting of ICE vehicles to meet CAFE and other regulations on emissions has been underway for many years. The automotive sector, which includes auto body sheet (ABS), extrusions and Al-Si castings, is currently a strong growth market for aluminium.

Ducker further forecasts aluminium content in vehicles in the EU to average 3-4% CAGR to 2028 to 4.2 MTPY. For North America, Ducker reports growth in aluminium intensity for all vehicles of more than 5 kg/vehicle per year. Over 30 years this represents an additional 150 kg per vehicle.

The decline of ICEs and rise of NEVs is clear to all, however a precise forecast of the true impact on demand growth remains elusive.

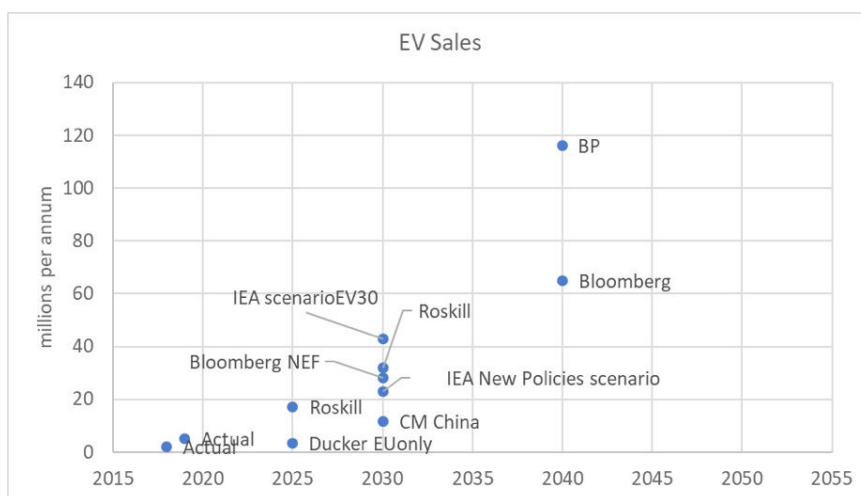
The U.K., Norway, Austria, France and the Netherlands have all proposed to ban internal combustion engines within 10 to 20 years in order to reduce greenhouse gas emissions. Norway has already achieved 46% NEV vehicles.

A comparison of EV sales, historical and forecast, indicates the world is on the brink of major growth, which could accelerate to around 30 million units per year by 2030, nearly 100 million units by 2040 and more than 140 million units by 2050.

FIGURE 12

Various EV growth forecasts to 2040

Source: CM Group



India sees the EV as a crucial tool in the fight against climate change. Even though EVs take electricity from coal power stations, the total emissions per km are less than ICEs because electric motors are more efficient than ICEs.

China's total automobile production reached an estimated 31.4 million units in 2017, up 4.7% from 2016. In 2018, however, China witnessed the first fall in 28 years in auto production, as a result of the country's general economic slowdown. Total production was 29.8 million units, broken down into 23.2 million passenger vehicles, 4.0 million trucks, 0.4 million buses and 2.2 million special-duty vehicles. In 2019 conventional vehicle sales dropped again to 24.6 million.

Meanwhile, China's NEV numbers grew to 1.25 million units in 2018, representing 50% of the global market for NEVs. In 2019 sales of EVs in China dropped to 1.2 million units, mostly due to the reduction in government rebates.

The global auto market has been in decline since 2017 (Bloomberg) but the EV market share has increased to almost 5% of the total.

EVs will also require heat exchangers as do conventional vehicles and the shift towards electric vehicles will drive demand for compact liquid-filled heat exchangers. The need is greater for highly efficient compact exchangers that do not reduce vehicle range resulting in an increase in aluminium demand.

Many commentators assume NEVs will be BEV (battery electric vehicles) or plug-in hybrid electric vehicles (PHEVs). The mix by 2050, however is far from certain, with FCEV (Fuel Cell Electric Vehicles based on hydrogen) developing rapidly. If hydrogen from solar energy water splitting becomes more commercially viable, as forecast by some, then hydrogen-fuelled vehicles will likely prove popular. Such vehicles are likely to have similar aluminium intensity of use as BEVs and PHEVs.

6. Emerging Economic Power

China has been the growth engine of the global economy for decades; it is now the second biggest economy after the USA. India has the world's seventh biggest economy and is forecast to overtake the USA after 2030.

Of the 2 billion people to be added to the global population from 2019 to 2050, more than half will be in sub-Saharan Africa. The ability to improve living standards of sub-Saharan Africa will be critical to achieving strong demand growth for aluminium. Survey respondents identified India (80% of respondents) and China (72% of respondents) in this region to show the strongest demand growth over the outlook period. Africa was ranked third, closely followed by Other Asia.

On our assessment, African demand for aluminium will remain low relative to other regions. Although demand growth is forecast at a healthy ~5% pa the low starting base means it will remain a small portion of total global demand for a significant period.

Asia (ex-China) on the other hand is likely to be the main growth engine for aluminium demand but with India contributing significantly.

7. Pollution and Environmental Degradation

Although India is forecast to become an increasingly important economic power, its influence is impeded by a variety of factors, one of which is pollution. Threats to water supply, poor sanitation, heavy traffic and industrially-generated air pollution are pressing concerns. Recent outbreaks of severe air pollution took place across India and at the same time climate change induced bushfires in Australia created similar air pollution (Figure 13).

In the past, Europe and North America suffered from severe pollution problems such as acid rain and solved them. India has the same ability. However, climate change induced pollution presents a more difficult problem.

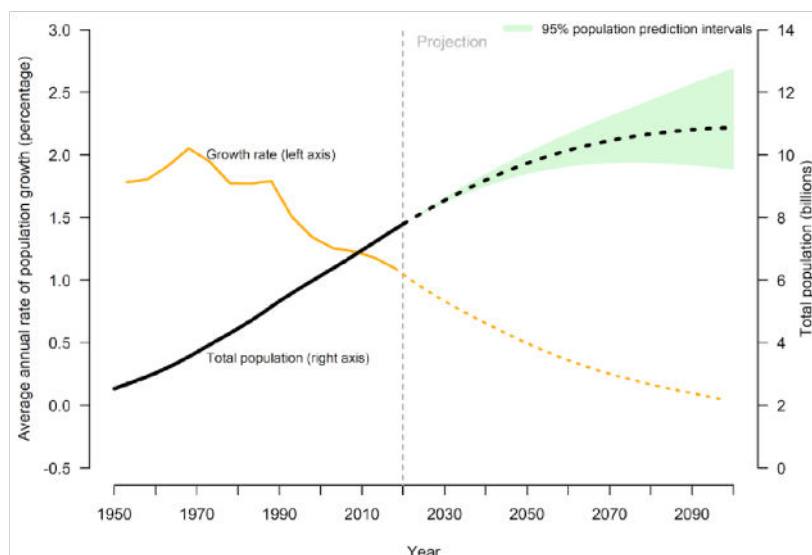
8. Demographics and Social Change

Population growth (or decline) strongly reflects underlying changes in demand. If unit demand per person remains the same, demand mostly reflects the population growth rate (or decline). However, for most nations, GDP grows faster than population growth and the GDP per capita grows increasing unit material demand. The UN estimates the current population of 7.7 billion will grow at a slowing rate to about 8.5 billion in 2030 and 9.7 billion in 2050.

FIGURE 13

UN forecast global population growth

Source: UN



The UN projects India will surpass China as the world's most populous country around 2027. China's population on the other hand is projected to peak around 2030 at 1.3 billion. Over the same period, North America and Europe will slightly decrease in population. Of the 2 billion people to enter the world between 2019 to 2050, more than half will be born in sub-Saharan Africa.

Reducing numbers of people per household leads to more appliances per head, and higher intensity-of-aluminium use. Overlaps with Urbanisation trends are obvious.

By 2050 there will be more than twice as many people aged over 65 as under 5 years old (UN). There is then a large opportunity in the assisted personal mobility sector; such as powered suits.

Movements based on social trends as they relate to clean and green, socially responsible and sustainable lifestyles are growing in influence. Although such movements have the potential to reduce aluminium demand growth, our conclusion is that any direct impact would be minimal, relative to other growth drivers.

Resource Scarcity

Although resource scarcity is often cited as a growing issue in the popular press for many commodities eg peak oil, peak lithium etc, the reality is that resource scarcity is seldom a driver of growth and, in almost all cases, is not rated as an issue by those with a solid understanding of the industries. This became evident in the survey results. Its impact on aluminium demand is not considered a factor affecting global aluminium demand.

Scenario 1 - 'The Survey says....'

CM's Base Case Scenario, 'The Survey says', assumes an industry-wide, global aluminium demand growth forecast to 2050 based on the impact on aluminium demand growth of major global megatrends. Fundamental to this base case scenario is the assumption that the global primary Al industry successfully addresses its CO₂e emissions challenges and, by 2035, achieves an average net carbon emissions target of <4 tCO₂e /t.

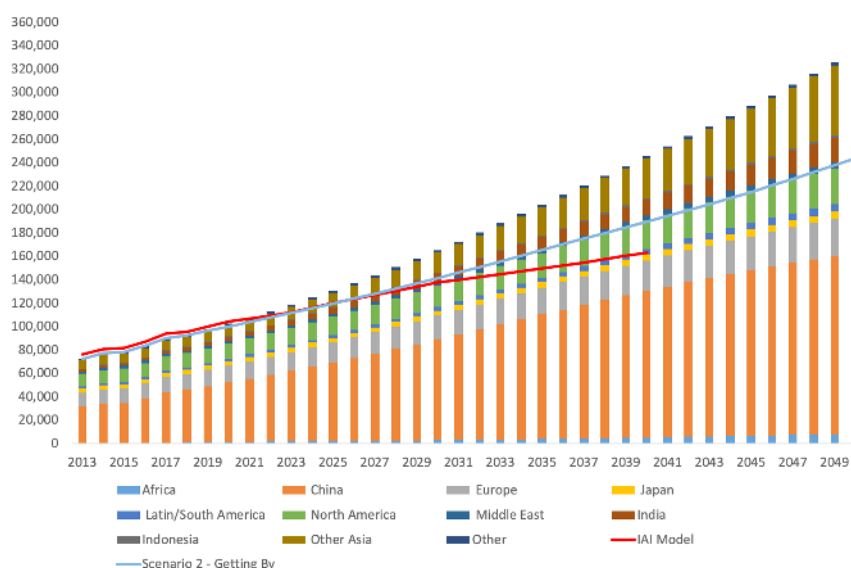
With this as a critical base assumption and within the context of the megatrend framework, CM forecasts a global CAGR of 4.2% over the 30-year period to 2050, resulting in an annual demand of 335 million tonnes per year (MTPY) by 2050 (Figure 14).

For reference, the OECD global forecast GDP growth is 2.6% pa, for the period 2020 to 2050 declining to 2% pa in 2050.

FIGURE 14

Forecast aluminium demand to 2050 for Scenario 1 by region (the Survey Says) and Scenario 2 and the IAI model forecast

Source: CM Group, IAI



Our base case scenario, “The Survey says...” assumes growth will be driven not just by population and GDP per capita growth in both established and emerging economies, but also by the growing influence of GMTs in key market sectors.

Critical growth drivers emerging from the survey and incorporated into CM’s Scenario 1 long-term projections are presented below

- A major global shift in the transport sector is underway, away from ICEs to EVs; penetration rates will increase over the decades ahead. This is a fundamental response to climate change that will result in higher volumes of aluminium per vehicle.
- Globally, the number of vehicles per 1,000 people (motorisation rate) will increase, due to increasing urbanisation rates.
- Social backlash against materials perceived as non-recyclable, such as plastics, will continue. Aluminium, which is considered a natural replacement material, will take market share as a result.
- Consumer durables, particularly devices incorporating heat exchangers, will demonstrate strong regional growth. Urbanisation and changes in demographic patterns result in fewer people per household and therefore higher numbers of appliances per capita.
- Infrastructure expansion, particularly in the form of regional power grids and replacement, and the need to integrate renewable energy generation into the grid provides a significant boost to demand. The creation of global intercontinental grids will also add to the growth in cable demand.
- Other potentially high-volume emerging applications, such as powered suits for the aged and disabled and renewable energy infrastructure, are also assumed to positively impact demand.

Table 1 presents CM commentary on growth forecasts relative to GDP by major market sector, identifying which sectors have the highest likelihood of GDP+ growth (Table 1).

TABLE 1

Growth prospects and deviation from simple GDP growth for key aluminium market sectors.

Source: CM Group

Sector	Growth Prospect
Building and Construction	Rates faster than GDP due to urbanisation
Transportation - Auto & Lt Truck	"EV greater AI intensity than ICE urbanisation increases vehicles per head higher than GDP growth "
Transportation - Aerospace	Solid growth of 5% pa continues
Transportation - Rail, Bus, Marine & Other	"Rail grows greater than GDP growth Public transport growth Marine grows according to GDP growth"
Packaging - Cans	Boost from plastic replacement
Packaging - Other	Follows GDP per capita
Consumer Durables	Boost from HEX growth
Machinery & Equipment	GDP growth
Electrical - Cable	Global grid and China, Africa and India big drivers above GDP growth
Electrical - Other	GDP growth

Critical assumptions in achieving the Scenario 1 growth forecast are presented below:

- The global AI industry, on average meets a < 4 tCO₂e/t AI greenhouse gas emission target, (Scope 1,2&3) by 2035.
- Human GHG emissions are near zero by 2050
- Global EV sales reach 140 million per year by 2050 at 500kg AI per vehicle, resulting in approximately 70 MTPY demand by 2050.
- India reaches a similar intensity of use (~30kg/capita) as that reached by China in 2019
- Huge growth in heat exchangers in hot developing regions particularly India

Under Scenario 1, total global aluminium demand is forecast to grow at 4.2% to 335 MTPY by 2050. Forecasts by region and by market sector to 2050 are presented in Table. For reference, the global aluminium demand growth 2013 to 2018 averaged 5.1% pa.

The OECD GDP growth rate is forecast to average 2.6% in the outlook.

FIGURE 15

Forecast Regional CAGR for aluminium demand 2020 to 2050

Source: CM Group

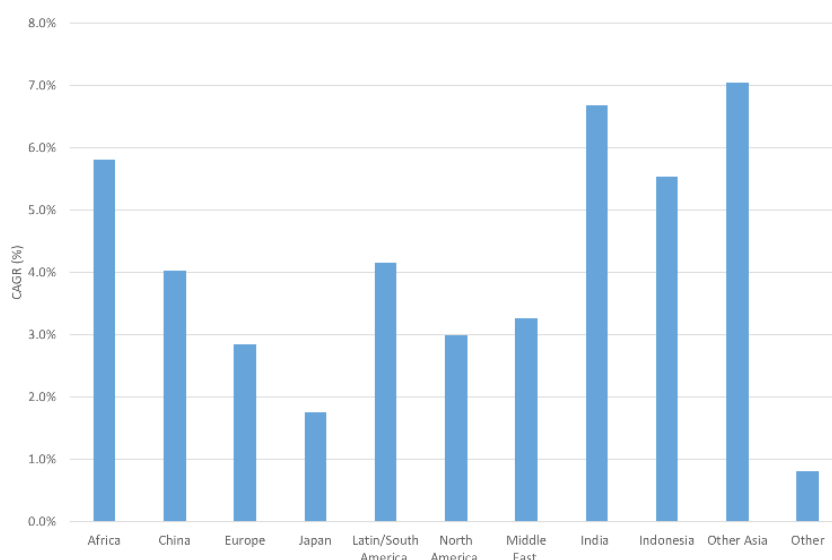


FIGURE 16

Forecast Sector CAGR for
aluminium demand 2020 to
2050

Source: CM Group

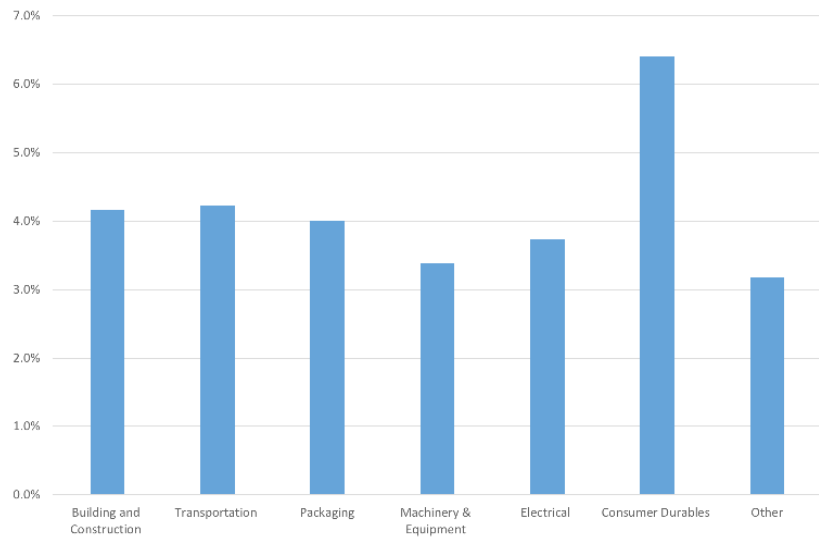


TABLE 2

30-year CAGR by region and
market sector for Scenario 1-1

Source: CM Group

	Building and Construction	Transportation - Auto & Lt Truck	Transportation - Aerospace	Transportation - Non Auto or Aero	Packaging - Cans
Africa	6.4%	5.2%	2.6%	3.8%	5.0%
China	3.9%	4.7%	2.8%	5.9%	7.5%
Europe	1.0%	3.1%	1.7%	3.2%	1.0%
Japan	0.3%	2.2%	6.1%	4.9%	1.3%
Latin/South America	1.1%	2.1%	-0.7%	1.8%	4.9%
North America	3.0%	3.8%	4.2%	2.7%	2.9%
Middle East	2.3%	2.3%	2.3%	2.3%	4.3%
India	7.3%	5.8%	7.4%	5.1%	5.1%
Indonesia	5.2%	3.9%	8.1%	4.0%	3.7%
Other Asia	6.2%	6.2%	4.4%	4.4%	4.3%

TABLE 3
30-year CAGR by region and
market sector for Scenario 1-2

Source: CM Group

	Packaging - Other	Machinery & Equipment	Electrical - Cable	Electrical - Other	Consumer Durables
Africa	3.8%	4.0%	8.2%	3.8%	5.7%
China	3.7%	2.8%	2.9%	2.8%	3.7%
Europe	1.7%	5.4%	2.9%	1.7%	1.5%
Japan	1.1%	1.1%	2.4%	1.1%	0.6%
Latin/South America	2.8%	1.0%	4.2%	2.3%	1.3%
North America	2.0%	2.0%	3.0%	2.0%	2.0%
Middle East	4.3%	2.3%	5.0%	2.3%	7.2%
India	5.1%	5.1%	6.9%	5.1%	9.0%
Indonesia	3.7%	4.0%	4.9%	4.0%	10.1%
Other Asia	4.3%	4.3%	6.4%	4.4%	12.5%

FIGURE 17

Demand by sector in 2018
(Unit: ktpa & %)

Source: IAI

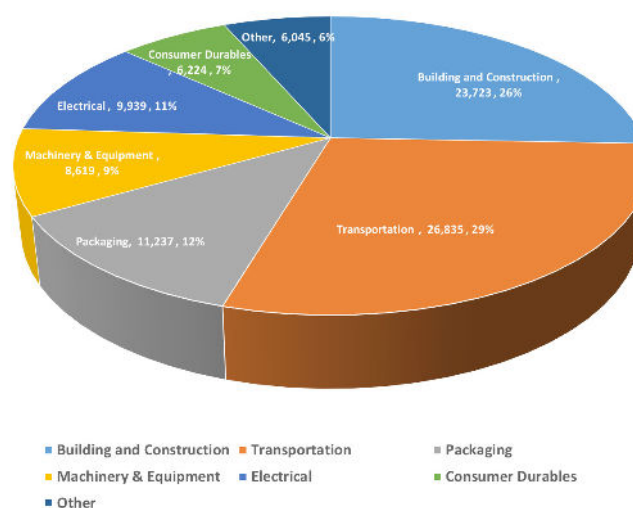
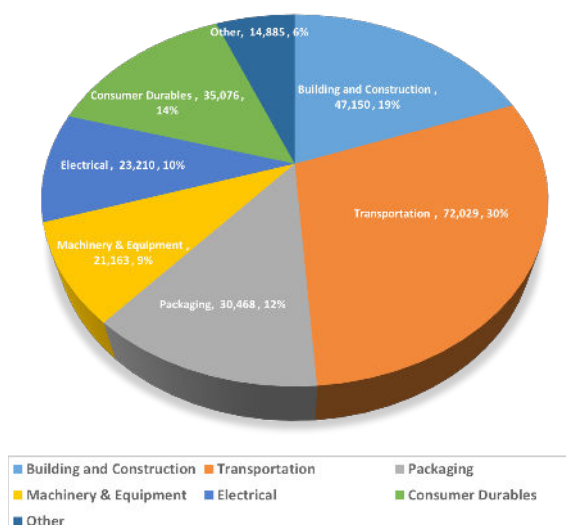


FIGURE 18

Demand by sector in 2050
(Unit: ktpa & %)

Source: IAI, CM Group



Scenario 2: "Getting by"

Scenario 2 assumes reduced growth based on lower levels of penetration and potentially significant inroads into markets made by competitor materials.

Our critical assumptions are

- Urbanisation and the rise of the sharing economy significantly reduces the number of vehicles per capita and automotive aluminium demand
- Steel producers make alloy development inroads in AHSS that continues to compete with aluminium in transport applications while turning to hydrogen as a reductant to reduce carbon footprint
- Regulators, the public and downstream manufacturers turn away from aluminium due to its high carbon footprint.
- Grid roll out in Africa and India is tempered by growth of mini-grids. A lack of political will to commit to large expenditures may also limit grid growth. The advent of the hydrogen economy could reduce the incentives for electric grid expansion
- The plastics industry responds to loss of market share with improved recyclable plastics, bio plastics and a method to convert plastics back to oil
- Indian and African GDP growth is much lower than forecast due to political and cultural problems
- Indian and Chinese coal fired power continues to grow
- The rate of decarbonisation is slower than expected and climate change impacts directly on economic growth due to severe storms, high temperatures, floods, fires, dust storms and sea level rise at a higher than expected rate

CM's 'Getting by' scenario assumes primary aluminium supply remains impeded by a slow rate of decarbonization and aluminium's high carbon footprint renders it less attractive compared with substitute materials, which successfully address their carbon footprint.

Additionally, climate induced extreme weather events, which are already reducing global GDP, continue to impede GDP growth. Political problems in emerging regions further slow the pace of development.

Despite these constraints, our survey results suggest global aluminium demand would more than double from its current demand, reaching 244 MTPY by 2050, at an estimated CAGR of 3.1%.

Black Swan Events

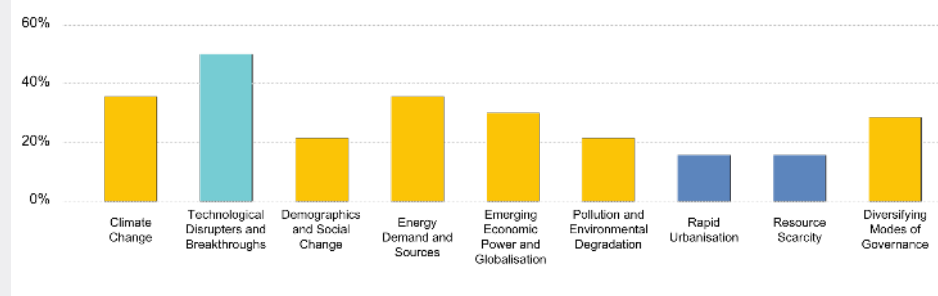
We asked survey respondents to identify potential 'black swan' events, meaning unforeseen events with the potential for major negative impact. The full list of responses is presented in Appendix A.

Major themes emerging from the black swan responses included war, regional or global economic crises (in particular China), political upheaval, technological disruption, extreme weather events, and societal responses to climate change.

FIGURE 19

Uncertainty of megatrends on aluminium demand

Source: CM Group



Overview of Survey Respondents

FIGURE 20

Survey respondents by organisation type

Source: CM Group

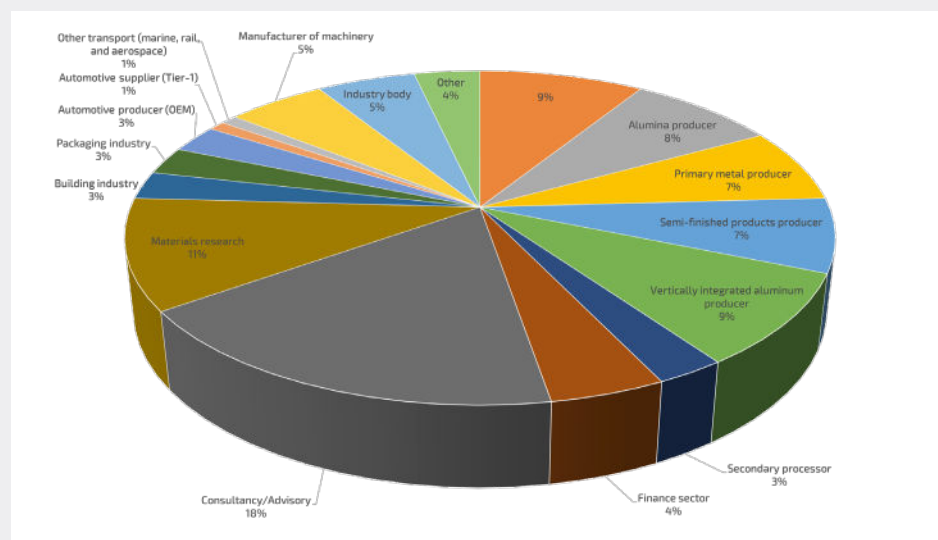
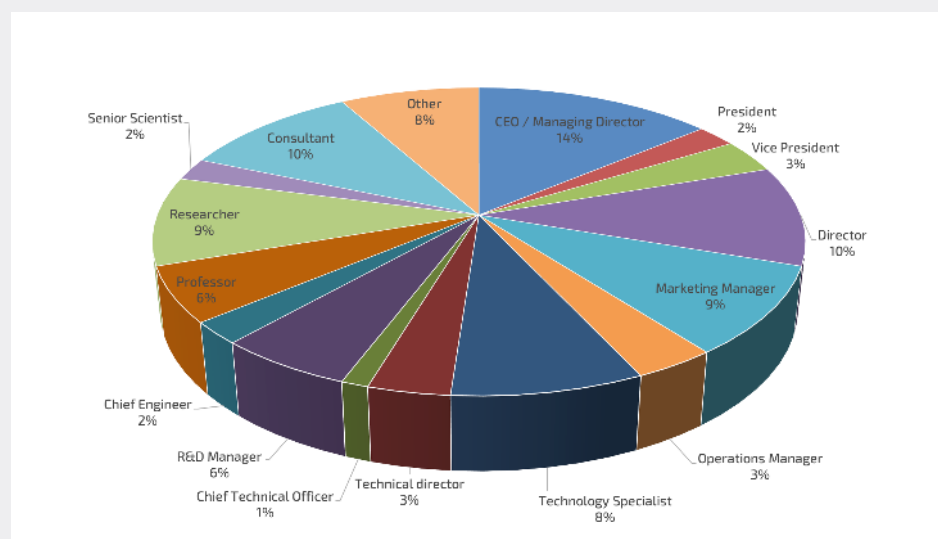


FIGURE 21

Survey respondents by position

Source: CM Group



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