# Sustainable Edge
# Sector Brief: Aluminum

Year 2020

## Sector definition

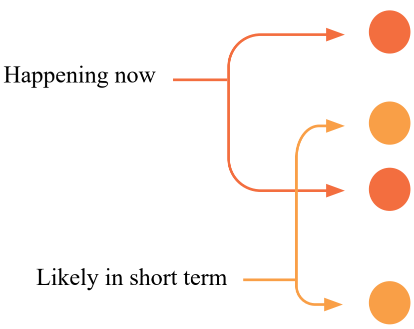
NACE Code C24.4.2 Aluminum Production.

This document outlines the aluminum production activities related to alumina smelting and fabrication of aluminum into the end products. The aluminum industry is highly consolidated. There are less than 300 aluminum production sites globally, supplied by around 40 bauxite mines (Carbon Trust, 2011). This sector brief therefore has a global scope and is best applied to vertically integrated producers.

## Summary

Aluminium production is a necessary sector in the low carbon future. The end products are used in a wide range of industries. Aluminium does not corrode and can reduce weight when replacing heavier metals, potentially improving energy efficiency and electrification in some industries (ex. vehicles). The largest share of the sector Greenhouse Gases (GHG) emissions come from the smelting of alumina (aluminium oxide) into primary aluminium due to the high electricity demand and process emissions. The single largest source of emissions is electricity use. A large proportion of the energy generation in aluminium production relies on fossil fuel and shifting towards renewables has vast potential for emissions reductions. Aluminium can be recycled, and aluminium produced through recycling emits only a fraction of the emissions from primary production. R&D is ongoing on continuous and disruptive technology developments (see Fact box), with the potential to reduce GHG emissions considerably.

### Main climate and environmental risks[1]




1. Increased precipitation leading to environmental contamination from bauxite mining operations.
2. Extreme weather events disrupting supply chain (mining operations).
3. New and tightened carbon pricing policies and border tax adjustment policies could increase costs[2].
4. Lock-in of uncompetitive technologies.

[1] The selection of key risks and categorization of those is based on expert judgement. Short-term refers to impacts that are likely in the next decade.
[2] This might also be an opportunity for low-carbon producers.

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### Physical risk exposure

- Greatest physical risk would occur under high-emission scenarios, causing extreme weather events and their impacts to increase.
- Mining operations are increasingly exposed to extreme weather events (e.g. cyclones, flooding and droughts) (ICMM, 2013).
- Extreme precipitation (CICERO, 2017) can impact surface structures designed to contain (liquid) waste. The run-off can cause harmful environmental impacts and may require additional investments in water management facilities and reinforcement of deposit structures for waste and materials (e.g. bauxite/red mud tailings)
- Heat stress and draughts are observed in all regions (CICERO, 2017) and can affect power supply, water supply, human health and the functioning of machinery (ICMM, 2013).
- Low-lying coastal and off-shore mining may be impaired by rising sea levels and storms, causing storm surges (ICMM 2013) (e.g. bauxite mine in Kaloum, Conakry, Guinea).

### Transition risk exposure

- The sector will increasingly be exposed to policies that seek to impose a cost of carbon on GHG-emissions, through the development of new and tightening of existing carbon pricing mechanisms (ICCM, 2013; EU, 2020). This is likely to increase aluminum prices, benefitting the low-cost, low-carbon producers but putting greater pressure on coal-based refineries (TCFD, 2019).
- Metal Exchanges (e.g. London Metal Exchange) may impose disclosure regulations regarding the carbon footprint of aluminum producers.
- Aluminium producers should be prepared to report alignment with relevant thresholds in the EU taxonomy from 2022. The threshold criteria will be subject to periodical updates.
- Risk of lock-in to technologies that become uncompetitive during the smelters' lifetime. Current investments in R&D for lower-carbon technologies will lead to increased market accessibility of new tech and may lead to the phase-out of outdated technologies (TCFD, 2019)

### Key statistics & background figures

- The aluminium sector accounts for about 2% of global GHG-emissions or approximately 1 Gt CO2 (Saevarsdottir, 2019).
- Aluminium production requires large amounts of electricity. Emissions from the generation of electricity represents the major source of emissions for the industry as a whole. The use of carbon anodes during production represent the second largest source of emissions.
- Emissions intensity (CO2eq/ton aluminium) vary widely, depending on the mode of electricity production, whether the aluminium is virgin or recycled, and the technologies used in the different stages of production. The global average for total CO2-emissions from aluminium production is 14,4 t CO2eq/t Al produced. However, a total emission of about 3,5 t CO2eq/t Al is possible using modern technology and renewable power production (Saevarsdottir, 2019).
- Demand for primary aluminium is projected to grow by 50 % by 2050, reaching approximately 100 million tons. Demand is driven by key sectors including automotive, buildings and packaging. (European Aluminium, 2019).
- China is the largest market for aluminium, representing over half of all global primary demand. High demand growth is expected in India, other Asian countries and Africa, whereas European demand is expected to remain stable. (European Aluminium, 2019).
- The largest companies in this sector are listed in OECD countries and several are diversified with major operations in e.g. mining of other commodities. By contrast, more than half of global primary aluminium production is located in China. (TPI, 2019b).
- The Transition Pathway Initiative (TPI) assessed 12 of the world's largest, publicly listed companies involved in aluminium production. Three of them align with the Paris Agreement benchmarks in terms of emission intensity: Alcoa, Norsk Hydro and Rio Tinto (TPI, 2019b).

## Contents



## About this brief

This sector brief was developed by CICERO as a part of the Sustainable Edge research project. The purpose of the brief is to outline the key material climate-related issues for the sector. The audience for the brief is the financial sector, either as potential investors or lenders to the sector. The reader is expected to have background knowledge of the sector and of climate risk assessment. The analysis methodology is rooted in CICERO's climate science and build on CICERO Shades of Green's methodology for green bond frameworks. This brief is to be considered a science-based opinion.

CICERO Shades of Green AS is a subsidiary of CICERO established in November 2018. CICERO Shades of Green AS has commercialized a corporate climate risk assessment based partially on the Sustainable Edge research, in addition to their own methodological development.

The Sustainable Edge project is financed by ENOVA SF and our financial sector partners: Oslo Pensjonsforsikring, CICERO Shades of Green AS, Nysnø, Sparebank 1 SMN, Sparebank 1 Nord-Norge, SR-Bank, Samspar and Sparebank 1 Østlandet. Thank you also to our partners Finans Norge and Schjødt.

Please note this assessment focuses on climate-related issues and risks.  Other environmental and social aspects may be noted, but assessing material social, ethical and governance issues are outside the scope of the assessment. We discuss governance specifically in the context of climate governance, this should not be viewed as a substitute for a full evaluation of the governance of the sector and does not cover, e.g., corruption.

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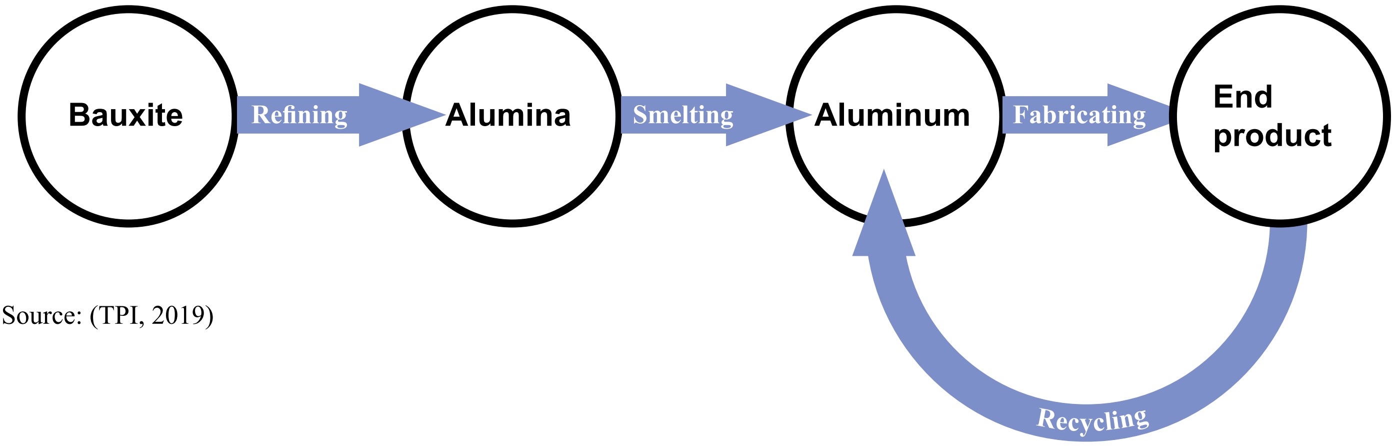
# Emissions

## Main sources[3]




Source: (TPI, 2019)

### Scope 1 emissions (S1)

#### Status:

- Direct emission arises mostly from anode degradation (ca. 80%) in the electrolytic cell, and to a lesser degree from Perfluorocarbons (PFC) gasses (ca. 19%) (Carbon Trust, 2011).
- Direct CO2 emissions represent ca. 27 % of emissions from mining to semi-finished end product (Carbon Trust 2011 based on data from 2007/2008. Other studies put the figure at 17%, e.g. GNCS fact sheet 2010).
- From 1990 – 2019, the direct GHG emissions per ton of European aluminum production was reduced by 55 percent. The driver of the emissions reduction was a 97 % reduction of PFC emissions. (European Aluminum, 2019).
- Note that we cover electricity in the section on Scope 2. Some aluminum producers own their energy sources, in these instances electricity use would be included in scope 1.

#### Potential and challenges: To reduce scope 1 emissions

- Worldwide deployment of best available technology could achieve significant emissions reductions. The current technology is reaching its theoretical limits for emissions improvement. Further improvements among the best-in-class plants will only be reached with breakthrough innovations. (European Aluminum, 2019).
- R&D on new technologies will, if implemented, reduce among others scope 1 emissions (see Fact box).

#### Targets

- Aluminum is included in the EU ETS and the ambitions are scheduled to increase in Phase 4.
- Aluminium is included in the EU Taxonomy (EU-TEG, 2020).
- Importers of aluminum to the EU may in the future be required to bear the cost of embedded emissions. According to the European Commission (2020) a carbon border adjustment mechanism is considered as an action to address carbon leakage.

[3] Scope 1: Direct emissions from owned or controlled sources; Scope 2: Indirect emissions from generation of purchased energy; Scope 3: All indirect emissions that occur in the value chain of the reporting company including up- and downstream emissions. See the GHG Protocol for more information on scopes https://ghgprotocol.org/

## Scope 2 emissions (S2)

### Status:

- Scope 2 emissions mainly originate from purchased electricity. Some aluminum producers also own their energy sources, complicating the separation of scope 1 and 2. In this section we consider electricity use.
- Currently, a large proportion of the energy use in aluminum production relies on fossil fuel (due to the energy mix of the regional grids at production sites).
- Emissions related to electricity demand represent around 65% of total (Scope 1 & 2) emissions from aluminum production (TPI, 2019).
- While aluminum energy intensity (kWh/t) is gradually decreasing (IEA, 2019), overall energy consumption for aluminum production has almost quadrupled since 1980.

### Potential and challenges:

- Replacing fossil fuel electricity production with renewable energy sources can significantly reduce Scope 2 emissions.
- Use of off-grid renewable electricity sources to power individual smelters is challenging due to the need for uninterrupted electricity supply.
- More than half of the global aluminum production is located in China. Over 80% of the electricity generation mix in China consists of coal and oil.
- Targets
- The IEA Sustainable Development Scenario pathway (SDS) requires global energy intensity (MWh/t) of overall aluminum production to fall by at least 1.2% annually up to 2030 (IEA, 2019). The European average emission intensity in 2017 was 15.29 MWh/t (EU TEG, 2020)

## Scope 3 emissions (S3)

### Status:

- Upstream scope 3 emissions from mining and refining of bauxite ore are estimated at ~6% between mining and semi-finished end products (Carbon Trust 2011).
- Aluminum is used in a wide range of end products, from vehicle manufacturing to beverage cans.
- Aluminum recycling emits 5% CO2 relative to emissions resulting from production of primary aluminum. Only 32% of aluminum was produced from scraps in 2017 (IEA, 2019).
- Europe is the leading in recycling, both in terms of recycling rates and production. Over half of the aluminum produced in Europe in 2019 was from recycled aluminum. The share of recycled aluminum in European end-use applications was 26 % in 2000 (European Aluminum, 2019).
- Scope 3 emissions are difficult to measure.

### Potential and challenges:

- Increasing the recycling systems to re-use aluminum from buildings and cars in all countries.
- Aluminum would make cars lighter, saving fuel, but this could lead to an increase in the production of high emitting vehicles, typically heavy cars, like SUVs and limousines.

### Targets

- The automotive industry is increasing the share of aluminum in European cars, to meet the European Commission's requirements to limit average CO2 emissions below 130g/km.  From 2021, phased in from 2020, the EU fleet-wide average emission target for new cars will be 95 g CO2/km (EU, 2020).

# Climate risk management

## Current risk management

In order to meet expected future demand, while meeting climate change targets, the industry must deliver significant decarbonisation. Short term options to increase recycle rates exist, and should be given increased focus. Medium term options include new technology to reduce the carbon intensity of primary aluminium production (see Fact box).

The Aluminium Stewardship Initiative (ASI) has developed a certification program for sustainable aluminium .[4] These include smelter-specific emissions thresholds. Smelters starting production after 2020 must keep Scope 1 and 2 GHG emissions below 8 tCO2e /t aluminium produced. Existing aluminium smelters that were in production before 2020 must meet this by 2030 (ASI, 2020). Per July 2020, 59 certifications had been issued to plants in 28 counties[5]. While this represents a step in the right direction, this certification does not by itself mitigate climate risk. For comparison, TPI has estimated that the average carbon intensity of an aluminium producer aligned with a 2-degree scenario is less than 5.5 t CO2eq /t aluminium produced in 2020 (TPI, 2019).

According to projections by PWC on behalf of European Aluminium, a decarbonization of the European power sector, could reduce the carbon intensity of European primary smelters to 1,73t CO2eq /t aluminium in 2050. This study shows the importance of energy sources to the overall emissions of aluminium. (European Aluminium, 2019).

### Key opportunities

- Aluminium is a key input to many technologies needed in the low carbon transition and can assist efficiency improvements in other sectors e.g. by reducing vehicle weight.
- Increasing share of recycling, and especially recycling combined with renewable energy use, can bring down emissions.
- Increasing the share of renewable energy sources in aluminium production would also decrease emissions in the production of virgin aluminium.
- Climate aware customers will demand aluminium produced with reduced CO2-emissions.
- New production technologies could drastically reduce GHG-emissions, see Fact box.
- Carbon Capture and Storage (CCS) could be used to capture emissions from the production process. However, CCS is not currently commercially viable.

### Key pitfalls

- Increasing demand for aluminium can increase emission intensity of the aluminium sector if fossil fuel electricity is used in the production of the additional capacity. Note that the new aluminium production is expected to be in Asia (China and India) and based on coal (European Aluminium, 2019).
- While many of the end-products aluminium is used for could be classified as low carbon, aluminium production itself is an emission intensive activity and could be subject to stringent emissions policies.

4 For more information see: https://aluminium-stewardship.org/why-aluminium/responsible-aluminium-asi-role/
5 For a map over certified facilities see https://aluminium-stewardship.org/asi-certification/map-of-asi-certifications/

# Disclosure and integration of climate risk

## Disclosure of climate risk and environmental impact

- Emissions disclosure and publicly available emission data is limited. For Norwegian aluminium production, GHG- and production data at the plant level is given on www.norskeutslipp.no
- Companies that do disclose emissions, do so in different ways: some focus on recent and current emission intensities ($CO_2$eq/t aluminium) and set future targets in terms of intensity; some report on their emissions in absolute terms (un-normalised); and other companies set targets in terms of emissions intensity (i.e. total emissions related to overall activities). The latter involves some assumptions on the company's future activity levels.
- The aluminium producers should be prepared to report on alignment with relevant thresholds in the EU taxonomy.

## Integration of climate risk in operations / decisions

- Transition Pathway Initiative (TPI) assesses the world's largest publicly listed companies involved in aluminium production. Out of the 12 companies evaluated by TPI, seven companies integrate climate risk in their operations and decision making through an established process to manage climate-related risks.
- Three companies assessed by TPI incorporate climate change risks and opportunities into their strategy and undertake climate scenario planning.
- Several of the big aluminium producers (e.g. Hydro, Alcoa and Rio Tinto) have started to report on climate risk in accordance with the TCFD-recommendations.

# Regulations and scenario information

## Policies in Norway

Aluminium is included in the European Emissions Trading System (EU ETS)[6]. The Norwegian aluminium sector is also regulated by the Industry Emissions Directive (IED), enforced through permits from The Norwegian Environment Agency. Requirements include cleaning the PCF-gases and to improve energy efficiency. Importers of aluminium to the EU may in the future be required to bear the cost of embedded emissions through a border adjustment tax. (EU, 2020).

Enova SF, a government enterprise, has provided technical and financial support to several R&D projects in the aluminium sector.

## EU Taxonomy

Aluminium manufacturing is covered by the EU Taxonomy (March 2020), and is eligble if it is relying on low carbon energy (e.g. hydropower) and reduced direct emissions. Criteria 1 in combination with either Criteria 2 or 3 must be met (EU-TEG, 2020):

- Criteria 1: Direct emissions for primary production must not exceed the EU-ETS benchmark (1.514t$CO_2$eq/t as of June 2019);
- Criteria 2: Electricity consumption for electrolysis is under the European average emission factor (15.29 MWh/t as of June 2019 (IAI, 2017) but shall be updated annually)
- Criteria 3: Average carbon intensity of electricity used for primary aluminium production must not exceed 100 g$CO_2$eq/kWh (Taxonomy threshold, subject to periodic change).
- Threshold criteria will be subject to periodical updates, e.g. due to tightening of EU-ETS benchmarks for the phase 4.

All aluminium recycling is eligible due to significantly lower emissions. No additional mitigation criteria need to be met.

6 The market price at the close of September 25,15 EUR per ton CO2, https://markets.businessinsider.com/commodities/co2-european-emission-allowances

In addition, the criteria above, the "do no significant harm" objective must be met. The main potential significant harm to other environmental objectives from the manufacture of aluminium is associated with e.g. emissions to air and the toxic, corrosive and reactive nature of waste. See the EU taxonomy excel tools for more details on aspects of this objective for the sector.

### Global scenarios

- Chemicals, iron and steel, and aluminium production together account for around 15% of electricity use worldwide. Aluminium production grew at 6% per year since 2000, leading to a 5% electricity growth in that sector – the fastest rate among end-uses in industry (IEA WEO 2018.)
- The IEA Sustainable Development scenario (SDS) assumes increased policies to support recycling of aluminium, steel, paper and plastic across all regions.

# CICERO Shades of Green & analyst perspective[7]

### CICERO Dark Green for the sector

#### Considerations for main activities

- Manufacturing of secondary aluminum (i.e. production of aluminum from recycled aluminum) combined with renewable electricity generation is the lowest emissions option for the sector.
- Relying on renewable energy generation is the only low-carbon alternative for aluminum production.
- Recycling of own scrap is highly encouraged

#### Considerations for upstream and downstream factors

- Upstream solutions include identification of water scarcity risks and appropriate management of water quality and consumption around bauxite mining, including waste disposal and bauxite tailings.
- Downstream solutions involve circular economy thinking and pollution prevention. Appropriate waste management and use of aluminum scrap (incl. old scrap and from own production process).
- Aluminum used in transportation and aviation can decrease emissions by decreasing the weight of a vehicle which leads to lower fuel consumption. Potential rebound effects if e.g. larger vehicles (SUVs) become more popular due to lower costs related to energy efficiency.
- Aluminum is a necessary material for many products that support a low carbon future. Producers should take climate change impact considerations into account when they decide whom to sell extruded products.

7 The Shades of Green methodology assesses alignment with a low-carbon resilient future. CICERO Dark Green is allocated to projects and solutions that correspond to the long-term vision of a low carbon and climate resilient future. For more information see: https://www.cicero.green/our-approach

## Current best practice – activities

- ★ Best practice is a high focus on R&D on new technologies (see Fact box) with concrete plans for zero emissions in 2050, renewable energy sources for electricity generation and implementing the latest energy efficiency technologies.
- ★ Aluminium companies should be involved in R&D developments on new technologies (see Fact box) and energy efficiency..
- ★ Aluminium producers can benefit from sourcing renewable Power Purchase Agreements (PPAs) to lock in renewable energy capacity for their production.
- ★ Norsk Hydro's technology pilot project in Karmøy is testing the most climate and energy-efficient aluminium production technology in the world and is using renewable energy sources.
- ★ Alcoa, Norsk Hydro and Rio Tinto are the three aluminium producers that are currently aligned with the Paris Agreement benchmark (TPI, 2019b)

## Current best practices - governance

- ★ Best practice includes setting long term targets for reducing GHG emissions, undertaking scenario stress-testing, and incorporating climate risks and opportunities in company strategy, e.g. by adopting reporting according to the TCFD-recommendations.
- ★ Alcoa, Rio Tinto and South32 integrate climate risk into their strategic assessment (TPI, 2019b)

# Data and indicators for climate risk disclosure

## Historic data

Figure 1 illustrates that there is a long-term consistent trend of increasing energy consumption associated with aluminium production. This is probably not a trend that is most aligned with a low carbon and zero emission vision of the future.

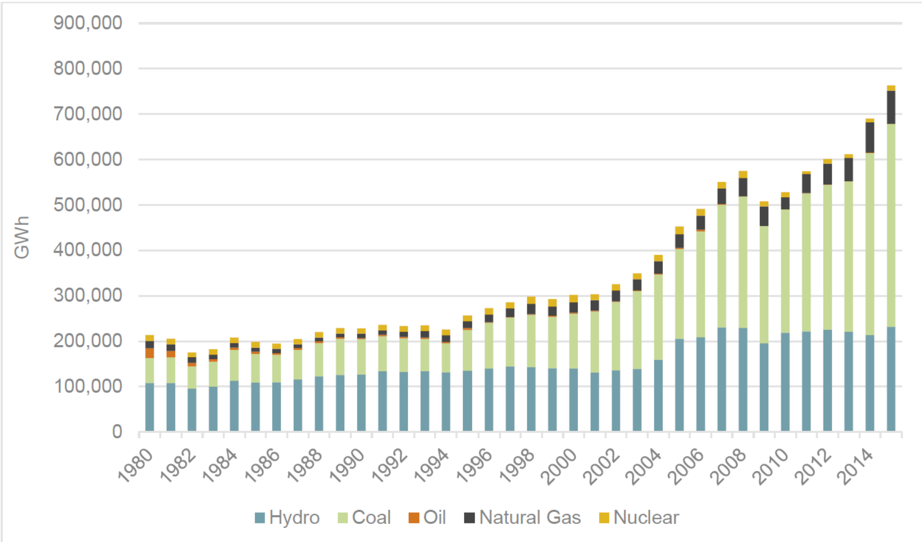



*Figure 1 Global aluminum industry power mix for years 1980 – 2015 (IAI, 2017)*

Figure 2 shows the historical sectorial end-use of aluminium, and projected demand to 2027. The figures show high historical and expected growth in demand from key sectors. Transport and construction are the most important sectors, each representing about a quarter of demand. Other key sectors include packaging, electrical, machinery and consumer durables.

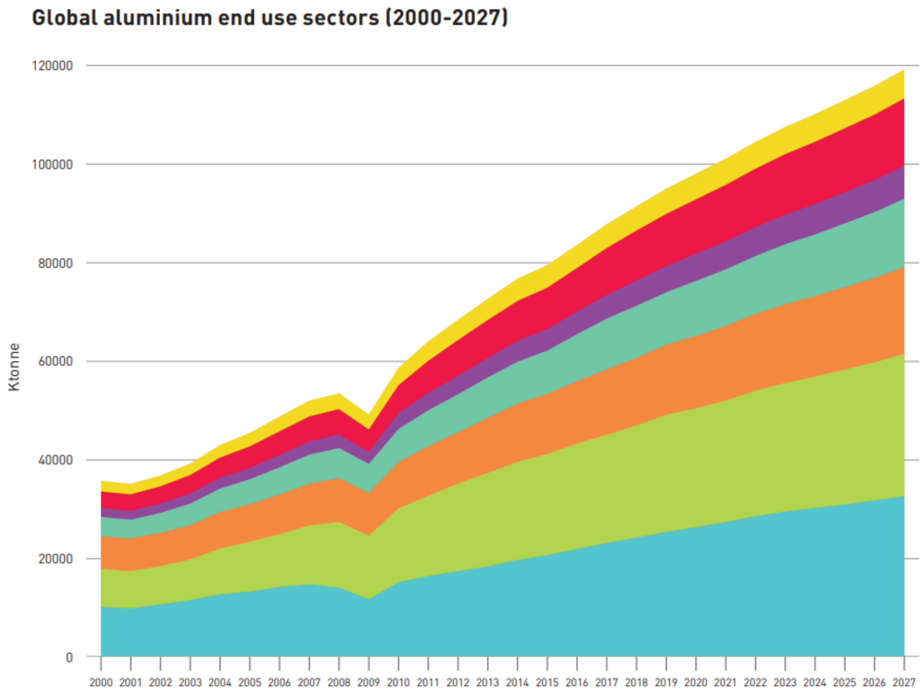



Figure 2 Global aluminium end use sectors (2000 – 2027). Source: European Aluminium (2019), CRU (2018)

Figure 3 shows the emission intensity of aluminium production per ton, and the electricity mix by regions in 2008. Note that since this there have been both efficiencies in the aluminium production process and some changes to the regional grids. However, the link between fossil fuel heavy grids and a high emissions intensity hold.  China is the largest producer of aluminium and produces at the highest emission intensity. At present Europe is the largest market for aluminium. In the context of an anticipated three or four fold increase in global aluminium production and consumption over the next 40 years, there is a strong possibility that EU aluminium production will not grow above current levels, while aluminium consumption continues to rise.

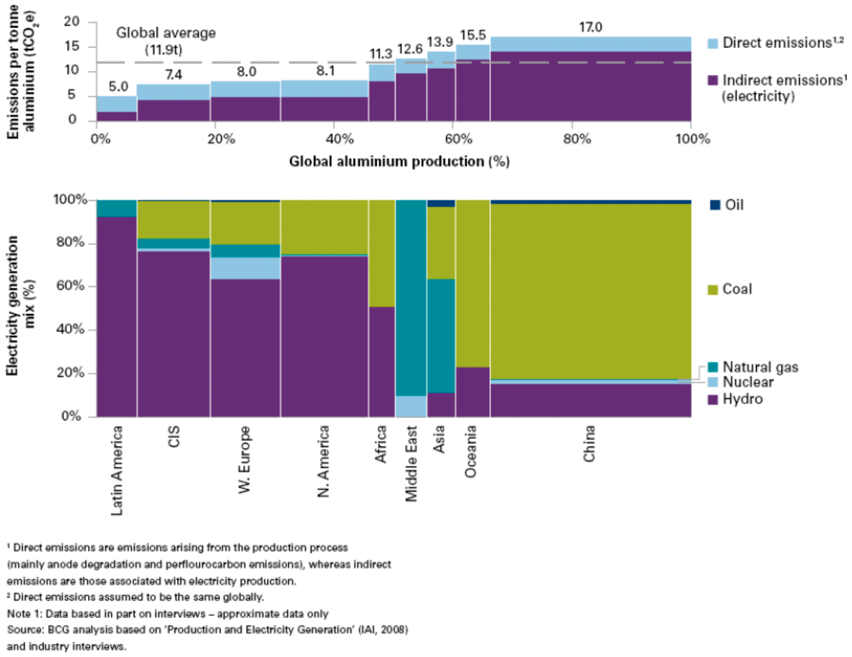



Figure 3: Emissions per ton by region. source: Carbon Tracker (2011)

## Climate-relevant data sources

- Emission intensity (CO2eq/t aluminum produced) and electricity consumption (kWh/t aluminum produced) data is available from some companies
- Intensity of electricity consumption for electrolysis (kWh/t aluminum produced)
- Average carbon intensity of the electricity used for primary aluminum production
- Electricity grid factors

## Potential difficulties in attaining / using existing data

- Data is available from a limited number of aluminum producers.
- Emissions data is reported differently across aluminum producers. Some companies disclose emission intensity, others disclose total emissions.
- In most cases, emission intensity can be calculated, provided data for total emissions and total production is available.
- Carbon intensity of the electricity used can be calculated from the grid factors.

## Indicators which would improve climate risk disclosure[8]

| Preliminary indicators and metrics |
|---|
| Share of production from renewable energy sources for electricity generation in the electrolysis process |
| Renewable energy assets or power perchance agreements (PPA) for renewable energy |
| Measures implemented to enhance climate risk resilience (ex. reinforced structures) |
| Absorption and implementation of most recent commercially available technologies |
| Participation in R&D efforts towards zero or low emission technologies |
| Disclosure of carbon footprint from aluminium production across the life cycle |

Indicators providing information on the scale of climate hazard (e.g. heavy precipitation) could be relevant for the individual plants. Some indicators of physical climate risk are being developed by the CICERO lead CimINVEST project and will be presented in an open access data portal. The project has also developed factsheets on climate risks that provide guidance on physical risk assessment.

8 Please note that these are preliminary indicators and metrics that will be further developed.  As the methodology and data availability evolves, we expect adjustments to the list. Also note that within the sector there are many different busines models and different indicators and metrics may be more relevant depending on the company under assessment.

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**Key analyst questions for all companies in this sector**

1. What is the source of electricity generation in your production plants?

2. What is the company's view on inert anodes and future low emissions technology? Is the company's R&D budget committed to low carbon solutions/ zero emission scenario? Is the company currently testing any low carbon solutions (see Fact box)?

3. What are planned investments into new production facilities? How will the company mitigate lock-in risks for these operations?

4. How does the company report emissions: emissions intensity or total emissions?

5. Do the company have targets related to specific energy consumption? How are they working to achieve the targets?

6. What are the company's climate change targets? Does the company only have targets for emission intensity or are total emissions included? In case of total emissions reporting, what does that mean for the future activity levels of the company? Are these targets better than what you would expect from historic EE improvements?

7. What are the considerations for environmental impacts (incl. environmental contamination risks) throughout the value chain? What does the company do to assess and manage these risks?

8. What is the share of production based on post-consumer scrap recycling?

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