WORLD ALUMINIUM

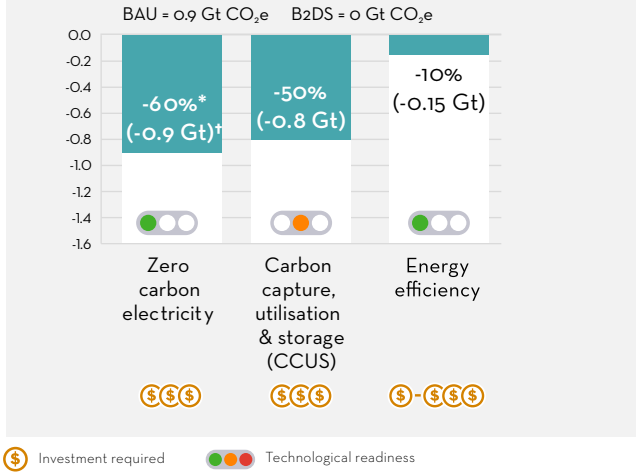
Pathway 1

ELECTRICITY DECARBONISATION

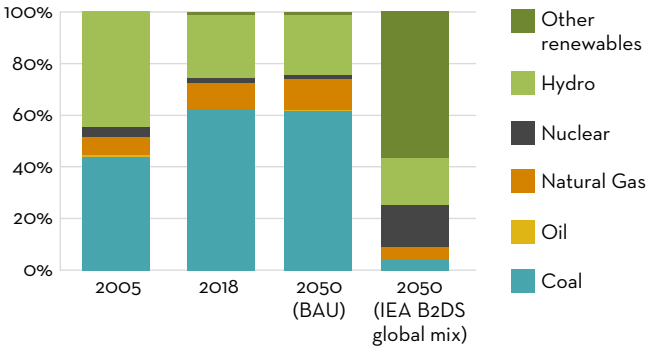
Primary aluminium production is an energy-intensive process, requiring significant amounts of electricity to break the strong oxygen-aluminium bonds of the raw material, alumina.

More than sixty per cent of the aluminium sector's 1.1 billion tonnes of CO_2e emissions (2018) are from the production of electricity consumed during the smelting process. By mid-century, under an International Energy Agency Beyond 2 Degree Scenario (B2DS), such emissions would reduce to near zero, as fossil fuels would be phased out or continued with carbon capture, utilisation and storage (CCUS).

Electricity decarbonisation potential



Electricity decarbonisation

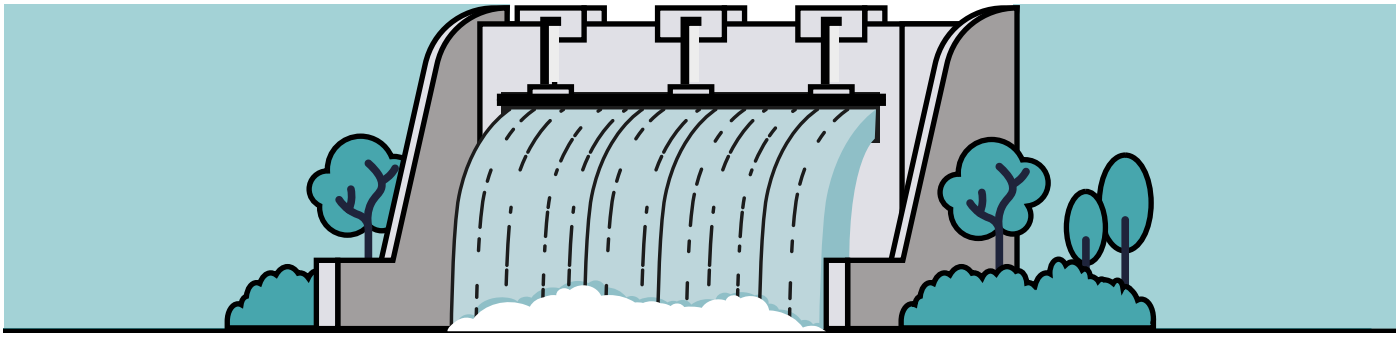


Changing smelting power mix under 2050 Business and Usual (BAU) compared to IEA Beyond 2 Degree Scenario (B2DS). Fossil fuel in B2DS predominantly with Carbon Capture and Storage.

Two-thirds of the sector's electricity needs are met by power stations owned and operated by aluminium producers. Most of these are fossil-based and are among the newest and most efficient of the industry's capacity. Decarbonised power generation and the deployment of CCUS offer the most significant opportunity for emissions reduction for these power producer-consumers.

Smelters that are already grid-connected will need to reduce their electricity emissions via the decarbonisation of existing grids. As power systems transition to (intermittent) renewables, large and consistent electricity consumers, like smelters, will play an essential role in stabilising grids.

In addition to the decarbonisation of the (already electrified) smelting process, electrification and renewable energy could reduce emissions from the sector's major fuel combustion processes (furnaces, alumina refineries and transportation).



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Pathway 2

DIRECT PROCESS EMISSIONS

The major sources of non-electricity related emissions in the aluminium sector are fuel combustion, smelter anode consumption, transport, and the carbon footprints of raw materials.

These sources are common to all producers, with minor variability in performance across the industry.

By mid-century, under an International Energy Agency Beyond 2 Degree Scenario (B2DS)-aligned slope, the 650 million tonnes of Business As Usual greenhouse gases emitted from these sources will need to be reduced to around 250 million tonnes, even as demand for the metal increases by about 80%.

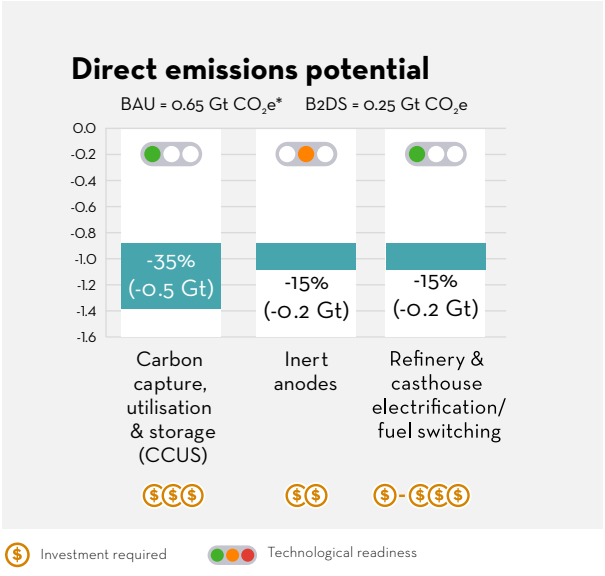
Direct emissions from the combustion of fuels to produce heat and steam make up 15% of the sector's emissions (2018) – from alumina refining, anode production, casting, remelting and recycling processes. For these thermal processes, electrification with low carbon sources offer a potential pathway to decarbonisation. Where electrification is not feasible, green hydrogen, concentrated solar thermal energy, and carbon capture utilisation and storage (CCUS) are the best options.

Another 15% of the sector's emissions come directly from the refining and smelting processes.

Removal of direct emissions from the smelting process is a challenge common to all producers and will require a step-change in technology to realise.

Novel cell technologies such as inert anodes, which emit oxygen instead of CO_2 will play an important role in emissions reduction, even though their deployment is currently very limited.

Ancillary materials and transport emissions (representing around 8% of the sector-wide total) will be reduced at a similar rate as direct emissions, through changes in other sectors and purchasing choices by aluminium producers. Unprecedented investment will be required to deliver an additional 20 million tonnes of low carbon primary aluminium, decarbonise the existing 65 million tonnes, and build a 60 to 70 million tonne low-emitting post-consumer scrap recycling industry by 2050.



*includes 0.15 Gt CO_2e from indirect emission sources (predominantly input materials & transport)

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Pathway 3

RECYCLING & RESOURCE EFFICIENCY

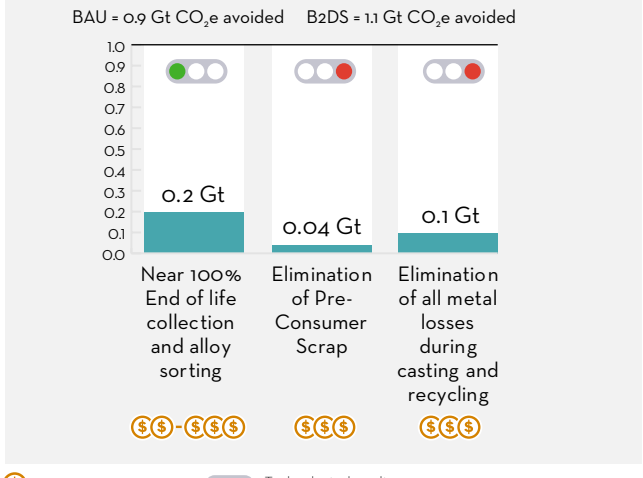
Infinite recyclability without loss of properties is one of aluminium's unique benefits.

Three-quarters (75%) of the more than **1.4 billion tonnes** of aluminium ever produced is still in productive use today, providing services and available for recycling and reuse in the future.

The recycling of post-consumer scrap today avoids the need for almost 20 million tonnes of primary aluminium, thus avoiding around 300 million tonnes of CO_2e every year. Post-consumer scrap recycling is expected to rise to 60 million tonnes by 2050 under a Business As Usual (BAU) scenario. Under a maximised collection scenario, this type of recycled aluminium could increase to more than 70 million tonnes.

There are high scrap collection rates (above 90%) in the building & construction and automotive segments. However, products like cars tend to have long lifetimes, so scrap availability is constrained significantly by product life. Aluminium in packaging applications has a much shorter lifetime and a range of recycling rates, depending on the application, local market, consumer behaviour and political conditions.

Recycling and resource efficiency potential



The global collection rate across all segments is over 70%, with some applications in some regions at near 100%. Production of recycled aluminium from post-consumer scrap has increased by 70% since 2009, while remelting losses have, however, only increased by 4%. This is testament to the recycling industry's huge technological advances over the last ten years.

Once collected, aluminium is recycled back into new products. Producers and consumers (and waste management actors) should ensure that aluminium is brought back into the system at the end of its life. Designers can also help by creating products that make it easy for aluminium components to be efficiently separated, collected and sorted with no loss to value.

Today, around 7 million tonnes of aluminium is lost during the recycling process. This could rise to 17 million tonnes per annum by 2050 if there is no change in current practices. When recycled metal is not retained in the economy, it is replaced by primary aluminium. Primary production today has a greenhouse gas emissions profile on average twenty-five times higher than the recovery of recycled metal.

Near 100% collection rates, improved scrap sorting, elimination of pre-consumer scrap and metal losses could reduce the need for primary aluminium by 20% by 2050. This would deliver an additional reduction of 300 million tonnes of absolute CO_2e emissions in 2050, an impact at the same magnitude as direct emissions reduction under Pathway 2.

This transformation in aluminium supply requires action from all in the value chain. It would also require policy frameworks that enable circularity and encourage investment in product design and innovations that ensure the efficient recycling of aluminium.