THE GNCS FACTSHEETS

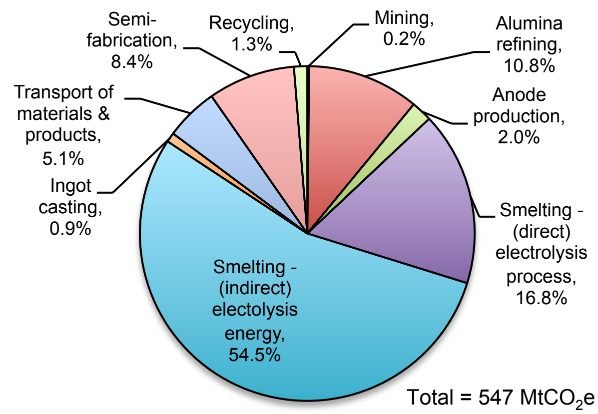
Mitigating Emissions from Aluminum

The production of new aluminum results in around 1% of global annual greenhouse gas (GHG) emissions. Mining, refining, smelting and casting primary aluminum releases about 0.4 billion tons (Gt) of carbon dioxide equivalent (CO_2e) emissions per year.[1] Today as little as 5% of this results from perfluorocarbons (PFCs) released during the production process, down from around 25% in 1990.[2] But total emissions have remained fairly stable since 1990 because output has almost doubled.[3] Aluminum is used widely (*e.g.* in buildings and construction, transportation and packaging) and output will continue to grow. China is the single largest producer and consumer of aluminum, representing 35% of production in 2009.[4] The newest producers employ the lowest GHG emitting technology for production. The aluminum industry has succeeded in coordinating voluntary emissions reductions because there is an economic incentive for producers to eliminate associated inefficiencies. However, significant further emissions reductions will require the decarbonization of electricity inputs and technology breakthroughs.

Emissions from Aluminum Production

Primary aluminum production involves refining alumina from bauxite ore, then smelting it to extract aluminum. Smelting is through the Hall-Héroult electrolysis process, which involves running large inputs of electricity through dissolved alumina via a carbon anode. Emissions result from *direct energy-related emissions* (CO_2 from fuel used in mining, alumina refining, anode production, smelting, casting, transport, semi-fabrication and recycling; about 25% of emissions); *indirect energy-related emissions* (from electricity inputs required for the electrolysis process; about 55% of emissions); and *process-related emissions* (mainly CO_2 released from consumption of the anode and PFCs resulting from inefficiencies in the electrolysis process, and some CO_2 from anode production; about 20% of emissions). The largest source of GHG emissions is electricity: smelters consume around 4% of global electricity output.[5] Half the industry's power is from hydroelectric generation; the rest is mostly from fossil fuel power.

Aluminum GHG emissions, 2008



Source: IAI (2009)

The quantity of CO_2 released during the electrolysis process depends on whether "Söderberg" or "prebaked" anodes are used.[6] The latter reduce energy consumption and emissions and their share in total smelting capacity has risen from 32% in 1990 to 83% in 2009,[7] as Söderberg cells are being phased out.[8] Emissions of high global warming potential PFCs during the smelting process (90% CF_4 and 10% C_2F_6) result from process failures called 'anode effects', during which insufficient amounts of alumina are dissolved in the electrolyte bath, reducing smelter productivity.[9] The industry has thus had an economic incentive to prevent anode effects and PFC emissions per ton of aluminum declined almost 90% between 1990 and 2009.[10] Total PFC emissions fell from 96 to 22 $MtCO_2e$ in that period, a reduction of over 75%,

[1] IEA. (2010). *Energy Technology Perspectives 2010*. Paris: International Energy Agency. p. 194.
[2] Calculated from IAI, (2010). *Results of the 2009 Anode Effect Survey: Report on the Aluminium Industry's Global PFC Gases Emissions Reduction Programme*. International Aluminium Institute. 5 July 2010.
[3] IAI (2010), p. 20.
[4] *Ibid.*, p. 8.
[5] IEA (2010), p. 194. Electricity consumption figure is for 2007.
[6] IPCC. (2006). *Guidelines for National Greenhouse Gas Inventories.* Geneva: Intergovernmental Panel of Climate Change. p. 4.47.
[7] IAI (2010), p. 10.
[8] BCS Inc. (2007). *U.S. Energy Requirements for Aluminium Production: Historical Perspective, Theoretical Limits, and New Opportunities.* Columbia: US Department of Energy. p. 21.
[9] IAI (2010), p. 6.
[10] *Ibid.*, p. 7.

despite a 90% increase in primary aluminum production (from 19.5 to 37 Mt).[11] Aluminum can be infinitely recycled. More than a third of aluminum produced each year originates from recycled scrap metal, and around 75% of aluminum ever produced is still in use today.[12] The recycling process requires 5% of the energy used in primary production, and emits 5% of the GHGs.[13]

Mitigation Options

The industry achieved reductions in the GHG intensity of production of around 22% from 1990 to 2008 but total emissions remained constant as output grew.[14] Additional abatement opportunities in the aluminum industry are:

1. *Further reducing PFC emissions*. Having achieved an 86% reduction on 1990 levels by 2006, the industry has pledged to reduce PFC emissions per ton of aluminum by a further 50% of 2006 levels by 2020.[15] This reduction has been associated with the dissemination of point fed prebake technology, which is in operation in all new plants (including all those in China), as well as retrofitting computer control and point-feeding systems in older facilities. Many retrofits are inexpensive (<\$7/tCO_2e).[16] Best available technology and procedures can almost entirely eliminate anode effects and thus PFC emissions.

2. *Further improving efficiency*. With the cost of electricity comprising about a third of primary production costs, the industry has a strong economic incentive to continue to improve energy efficiency. The industry has set a target of using electricity inputs of 11 megawatt hours (MWh) to produce one ton of aluminum by 2020, down from 15.7 MWh today and 21 MWh in the 1950s.[17] Since energy consumption in US smelters (15 MWh/t average) is more than twice the theoretical minimum requirement, the US Department of Energy estimates that current R&D efforts could reduce smelting energy needs by up to 30%.[18]

3. *Decarbonizing electricity inputs*, *e.g.* through hydro, nuclear or CCS power plants, would eliminate the majority of emissions from aluminum production.

4. *Increasing recycling*. Global average recycling rates for aluminum transport and construction applications are as high as 90%, while 70% of all aluminum beverage cans are recycled. Public policy can increase recycling rates. Brazil, Japan and Sweden have strong recycling policies and recycle over 90% of their beverage cans. By contrast, Greece and Portugal recycle less than 40%.[19]

5. *Breakthrough technologies*. An inert (non-carbon) anode, in conjunction with wetted cathode technology, would eliminate PFC emissions, as well as CO_2 emissions from anode consumption, and reduce energy consumption by 25%, resulting in a reduction of over 40% of the industry's GHG emissions.[20] The US Department of Energy has funded inert anode research that is now in advanced trial stages, as has the world's largest steel producer, Rusal.[21] The costs associated with inert anode technology are unknown but the associated energy savings, and cost savings on producing and replacing carbon anodes, increase its potential viability.

International Coordination

Industry associations at the national and international levels have established voluntary goals to improve performance standards. The International Aluminium Institute (IAI), a voluntary organization embodying 80% of the world's primary aluminum production, coordinates, monitors and promotes performance standards (including PFC reduction and energy efficiency targets) through its *Aluminium for Future Generations* program.[22] In the US, the Voluntary Aluminum Industry Partnership between industry and government has identified a number of "near-term, cost effective" technical actions and operational procedures to reduce emissions. In Europe, the aluminum sector was not included in the first phases of the EU emissions trading system but will be from 2013.

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Further resources are available at **www.theGNCS.org**

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[11] IAI (2010), p. 7.
[12] IAI. (2009a). *Aluminium for Future Generations: Contribution to UNFCCC COP-15 Copenhagen Climate Change Negotiations.* p. 2.
[13] *Ibid.* Aluminum recycling saves an estimated 80 MtCO_2e per year.
[14] *Ibid.*, p. 2.
[15] IAI (2010).
[16] EPA. (2006). *Global Mitigation of Non-CO_2 Greenhouse Gases.* Washington D.C.: US Environmental Protection Agency. p. IV-144–52.
[17] IAI (2009a).
[18] BCS Inc. (2007), p. iv.
[19] IAI. (2009b). *Global Aluminium Recycling: A Cornerstone of Sustainable Development*. International Aluminium Institute. p. 23.
[20] Argonne. (2009). *Ultra-High Efficiency Aluminum Production Cell*. Argonne National Laboratory, USA. p. 2.
[21] *Ibid.* and see: http://www.rusal.ru/en/in_anod.aspx.
[22] Reporting of PFC emissions to the IAI account for over 90% of production (outside China). IAI (2010), p. 14.