# Hydro's Climate Model: Carbon Neutral in a Life-cycle Perspective by 2020

In 2013, Hydro launched a new climate strategy with the ambition to be carbon neutral by 2020 in a life-cycle perspective. The strategy is designed to give Hydro decision-making flexibility while providing different tools to reduce the carbon footprint of our activities, products and solutions.

As basis for this strategy, a calculation model was developed to track progress. The intention of this memo is to describe the concept of this model, including scope and assumptions.

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## Hydro's climate strategy

Hydro's climate strategy was developed as a business strategy to better position Hydro in a carbon-constrained future. While aluminium is energy intensive and emits a significant amount of greenhouse gases in the production phase, the inherent properties of aluminium can contribute to significant reductions in energy consumption, and thus lower greenhouse gas emissions during the use phase. The use-phase benefits of aluminium are most obvious in the transport sector, where light-weighting of vehicles is essential to reduce energy consumption and greenhouse gas emissions per kilometer traveled. The use-phase benefits of aluminium are also evident in the packaging sector, where the barrier properties of aluminium reduce the need for cooling and contribute to longer lifetime for products. Aluminium is also an enabling material for energy-neutral buildings.

We strongly believe that the sustainable materials of the future are the materials that have the lowest carbon footprint over the life cycle. It is therefore important to focus on the life cycle of our aluminium, from bauxite to finished products and solutions, to be able to make the right decisions to reduce the global impact of our activities and products.

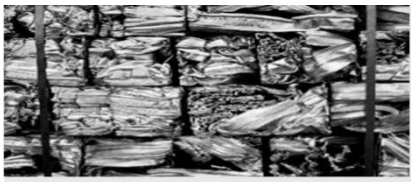
Hydro's strategy to be carbon neutral by 2020 in a life-cycle perspective is based on three pillars. These three pillars give decision-making flexibility and different tools to reduce the carbon footprint of our activities, products and solutions.

- Reduced emissions from own production,
- Increased use-phase benefits, i.e., avoided emissions, of Hydro's products in the use phase,
- Increased recycling of post-consumer metal.

*Reduced emissions from own production*

*Increased use phase benefits*

Avoided emissions of Hydro's products in the use phase



*Increased recycling of post-consumer scrap*

## Concept

Carbon neutrality in a life-cycle perspective can be defined in many ways. In Hydro's climate strategy, carbon neutrality is defined as a balance between emissions from production on one side, and the savings of using aluminium in the use phase on the other side.

Hydro's climate strategy is a strategy for the company as a whole, it is not a product strategy. This means that while some production plants or products might have a higher carbon footprint than others, the overall balance for the company (emissions minus benefits) should be zero or negative by 2020.

## Methodology and scope for carbon-neutral model

Hydro is a fully integrated company, covering all steps of the aluminium value chain, from bauxite mining through alumina refining, aluminium smelting and casting, to recycling. Hydropower production and anode production are also parts of our business. Hydro's model for calculating carbon neutrality includes all of Hydro's production plants. The model does not include production outside of Hydro's ownership.

Hydro's climate model takes a company perspective, covering scope 1 and scope 2 emissions as defined by the WBCSD GHG Protocol. For the calculations, ownership equity is used, as this gives the perspective of Hydro's overall responsibility. Scope 3 emissions are not included in this model, except for deforestation, which is included. Given the extraordinary situation at the Alunorte alumina refinery in Brazil in 2018 and 2019, scope 3 emissions from purchased alumina are also included for 2018 and 2019. The carbon footprint of this alumina is similar to the carbon footprint of Alunorte and thus does not change the overall balance.

The model does not track material flows through the company. This means that metal imported into the Hydro boundaries are not tracked further. More specifically, this means that the carbon footprint of the external cold metal remelted in our casthouses and sent to the market is not included in the calculations. As a consequence, the use-phase benefits of this metal are also not included.

## Emissions from our own production

Our model includes historical scope 1 and 2 emissions from Hydro's ownership equity, which are tracked in our internal reporting system. These data are then used as the basis for historical progress tracking.

For production and emission prognosis, internal business plans for the next five years have been used.

## Credit for electricity production

Hydro is the third-largest hydropower producer in Norway, with normal annual production of 10 TWh. Hydro is continuously seeking to improve the efficiency of its hydropower production. Planned improvements have resulted in increased hydropower production between 2013 and 2018. In the model, it is assumed that the increased electricity production is made available to increase aluminium production. This aluminium will then replace aluminium on the world market, where we assume that the emission intensity is equal to the global average. The global average is higher, due to large shares of electricity produced with fossil fuels like gas or coal. The difference between the new hydropower based aluminium and the global average is then credited to Hydro's total emissions, using the following formula:

$$CO2 - savings = \frac{Increased\ hydropower\ production}{14.9} \times 5.2$$

Where 14.9 equals a world average electricity consumption for production of aluminium of 14.9 kWh/kg aluminium[1]; 5.2 equals the difference in emissions between aluminium based on hydropower and the emissions for "world average" aluminium, excluding China[2].

## Inclusion of deforestation

Hydro's bauxite mining at the Paragominas mine in Brazil involves removing vegetation and a layer of topsoil and overburden to extract bauxite deposits underground. Deforestation leads to reduced CO2 uptake in the Amazon basin. After deforestation and subsequent mining, the area is replanted with the aim to restore the area's natural state. In 2014, Hydro initiated a cooperation with environmental consultants ERM in Brazil to calculate these effects, based on Hydro's prognosis for deforestation and reforestation. As a worst-case scenario,

[1] International Aluminium Institute, Primary Aluminium Smelting Energy Intensity, December 2018
[2] International Aluminium Institute, Environmental Metrics Report, November 2014

it has been assumed that all biological material is being burned after deforestation. It is assumed that the resulting CO2 emissions equals the reduced uptake of CO2. The emissions are added to Hydro's total emissions, and equal to about 150,000 tonnes in 2014, reduced to about 16,000 tonnes in 2020, because of a better balance between deforested and reforested areas. In 2019, the net effect of deforestation and reforestation was reduced CO2 uptake of about 35,000 tonnes CO2.

## Use-phase benefits

Aluminium has significant carbon footprint benefits in its use phase, especially due to its lightweight properties. However, as Hydro has no production of end consumer goods, the calculation of use-phase benefits can only be based on product specific data to a limited degree.

In order to calculate the use-phase benefits, acknowledged, independent LCA (Life-Cycle Assessment) studies have been used. Combined with product sales data, these studies give a good picture of the use-phase benefits of Hydro's metal going into end products.

As our Rolled Products and Extruded Solutions business areas purchase aluminium from non-Hydro sources, and as these non-Hydro sources are not included in our calculations, the material used as basis for calculating use-phase benefits equals the amount of metal produced by our primary aluminium production plants and remelters. This amounts to approximately 2.3 million tonnes annually. By taking this metal as the starting point, use-phase benefits can be calculated independently of whether the customer is internal or external. By internal customers, we mean the downstream parts of Hydro like Rolled Products and Extruded Solutions.

In order to calculate use-phase benefits, sales to different product categories need to be analyzed. We base the data on historical sales figures and the prognosis is based on Hydro's business plans, which are updated on an annual basis.

As soon as the sale of the different products are calculated, benefits from the use phase can be estimated. However, as product sales do not relate directly to the final product, the accuracy of such estimates can be questioned. In order to mitigate uncertainties, only acknowledged, independent LCA studies are used to calculate the benefits. To find good studies that show the direct benefits of aluminium compared to other materials have proved challenging, however.

### Automotive and transport sector

In the automotive sector, several peer-reviewed LCA studies exist. The reports assumed that 1 kg of aluminium replaces approximately 2 kg of steel. This results in savings of between 13 and 23 kg CO2e/kg aluminium in the vehicle's lifetime, depending on the product[3]. If aluminium is used in trucks, ships or airplanes, the savings are significantly higher. Hydro's climate model assumed a saving of 15 kg CO2e/kg aluminium in 2012, reduced by 5% toward 2027 to take account of assumed technical improvements in the automotive industry. This factor is very conservative, as new studies have confirmed savings of at least 20 kg CO2 per kg aluminium used in the transport sector.[4] While this saving takes place over the lifetime of the car (typically 10-15 years), the savings are accounted for at the moment the material is delivered to this sector. This is done to immediately visualize the life-cycle effect of the production in the given year.

### Building and construction sector

In the building and construction sector, aluminium is an enabler of advanced building solutions, including electricity production, efficient ventilation systems, solar shading, etc. This is due to the metal properties of aluminium, like design flexibility, corrosion resistance and formability. However, no LCA studies have been able

[3] International Aluminium Institute, June 2004
[4] International Aluminium Institute, December 2016

to take a holistic system approach and to assign the benefits to the materials being used. The only studies that exist take a product perspective, focusing on specific products like windows, shades, etc. As a result, no benefits have been calculated for Hydro's sales to the building and construction sector.

### Packaging sector

In the packaging sector, aluminium is essential in protecting foods and drinks. As an example, aluminium foil in beverage cartons constitutes 5% of the weight, but 85% of the protection. Many LCA studies have been performed with regards to foil, but relevant studies that compare aluminium foil to alternatives are limited. This is a result of the big variance between products containing foil. The only benefits that are calculated are for when the foil being used for milk cartons. The LCA study that evaluates the milk cartons calculates a benefit of approximately 79 kg CO2e/kg aluminium[5]. The use-phase benefit of aluminium in milk cartons is reduced by 20% towards 2027, to take into account potential alternatives. At present, no such alternatives exist.

With regards to aluminium beverage cans, several studies with varying results exist. The main reason for the variation relates to transport distances. With local distribution, aluminium cans shows a higher carbon footprint than glass bottles, while with regional and international distribution, aluminium cans prove to be the best alternative. As aluminum cans are used both locally and regionally, it is assumed that no benefits result from aluminium going to aluminium cans. Any potential benefits resulting from aluminium cans are thus excluded.

### Use-phase benefits – summary

In conclusion, based on the evaluation of existing LCA studies, all aluminium going to the transport sector is regarded as having benefits in the use phase. For packaging, only foil going to milk cartons is regarded as having benefits, while the benefits of using aluminium cans are regarded as zero. In the building sector, there are several benefits of using aluminium, but existing LCA studies have failed to properly evaluate the benefits of using different materials. In total, the evaluation has revealed that studies exist for between 35 and 40% of Hydro's product portfolio. The remaining amount has no documented use-phase benefits attached to it, seen from a carbon-footprint perspective. Ongoing studies are assumed to reduce this share in the future.

[5] Internal LCA study, peer reviewed by Denkstatt

# Appendix

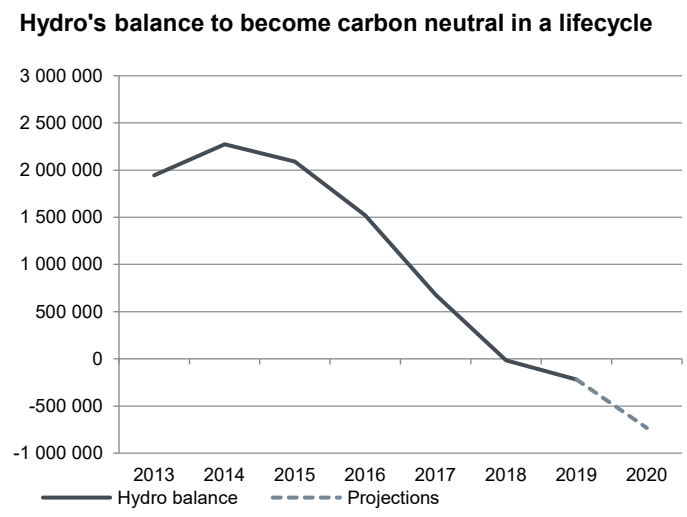
## 2019 results[6]

### 2019 results

For 2019, the calculations show that in 2019, Hydro was 219,000 tonnes below the defined carbon-neutrality level.

**Emissions in $CO_2$ equivalents**
1,000 tonnes

| | |
|---|---|
| Direct emissions | 8,434 |
| Indirect emissions | 4,969 |
| Deforestation (reforestation balance) | 35 |
| Use phase benefits of Hydro's products | -13,657 |
| **Total** | **-219** |




[6] Based on 2019 emissions and production data, and 2019 sales