Aluminium Production:
A Pathway to Zero Carbon by 2050

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About the Presenter

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Primary Aluminium Smelting Pathway to Zero Carbon 2050

- **2020**: Introduction of modulation technology for downwards flex 20%
- **2025**: Continued incremental efficiency improvements
- **2030**: Further use of renewable energy and firming, adding upwards flex of 20%
- **2040**: Inert anode usage
- **2050**: Transition to fully renewable power
Primary Aluminium Production

- The current energy mix trajectory shows a continued increase in coal and diminishing percentage of ‘green’ aluminium.

Sources: https://www.iea.org/reports/aluminium
Current trajectory – low growth scenario (1.4%)

- Reaching 1.32 billion tonnes per annum by 2050
- Low growth scenario @ 1.4% amounts to 34.3 billion tonnes of CO₂ cumulatively from 2020-2050
- The equivalent of 43% of all the passenger vehicles in the world today.
- Will be unsustainable and unacceptable on a global scale
- Aluminium won’t remain a relevant material

Sources: https://www.iea.org/reports/aluminium
Our current trajectory - high growth scenario (3.8%)

- Reaching 2.83 billion tonnes per annum by 2050
- Contributes 52.7 billion tonnes of CO₂ into the atmosphere from 2020 – 2050
- By 2050 Al smelting will be the consumer responsible for 100% of the CO₂ from fossil fuel power generation globally
- This is equivalent to over 90% of the CO₂ emissions from all of the passenger vehicles in the world today
- Will make the decarbonization-effect from light-weighting an urban myth.

Five Planks on the Pathway to Achieve Zero Carbon

There are only five possible options to significantly reduce carbon emissions by 2050 (only four while maintaining growth):

A. Continued process efficiency improvements
B. The adoption of inert (non-consumable) anodes
C. The transition to 100% renewable power
D. The use of carbon capture, utilisation and storage (CCUS) for direct process emissions
E. Decrease production to hydro powered only.
A - Process Efficiency Improvements

Reducing energy intensity of primary aluminium to a present-day vision target of 10 kWh/kg without renewable energy doesn’t meaningfully change the trajectory

• Reducing energy intensity of primary aluminium to a present-day ‘vision’ target of 10 DC kWh/kg presents major technological challenges

• Potential to saves 487 million tonnes CO$_2$ p.a. from power generation emissions by 2050

• Could be assumed that it would require replacement of 50% of today’s existing smelting capacity, with the remaining 50% upgraded.

• Reducing specific energy consumption does present a return on investment however

• ROI 15 years (est).

Sources: http://www.world-aluminium.org/statistics/primary-aluminium-smelting-energy-intensity/
B - Inert Anodes

Relative to the emissions from power source, inert anodes don’t really change the trajectory much either

- Technical challenges are undoubtedly significant
- However, if an inert anode process requires more power, the overall emissions may still be worse
- These emissions will be the hardest to abate from aluminium smelting
- May require replacement and upgrading of smelters
- If inert anodes cannot be deployed across the entire smelting fleet, then CCUS will become necessary
- ROI ???

Sources: https://www.iea.org/reports/aluminium

436 million tonnes p.a. savings by 2050 (if deployed across the entire smelting fleet)
C - 100% Renewable Electricity Generation

By 2050 = $CO_2$ savings of 1.9 billion tonnes p.a.

- Variable Renewable Energy (VRE) is the lowest cost option of new electricity generation globally
- Cost of building new VRE now cheaper than operating existing coal-fired generators
- The cost of replacing all of today’s coal-fired electricity used by Al smelters using the lowest cost 2019 figures = US$142 billion
- The operational savings over coal-fired generation = US$5-9 billion p.a.
- ROI 16-28 years.

Sources: https://www.iea.org/reports/aluminium
C₁ - Self-firming VRE with Modulation

The elephant in the room is the cost of firming VRE

• All Al smelters have the latent potential to become large-scale Virtual Power Plants (VPPs)
• Capable of self-firming up to 40% of their electricity usage
• The first 20% is relatively straightforward with cost-effective retrofitting of technology for downwards modulation
• A further 20% is gained through upwards modulation, which most likely requires additional smelter infrastructure upgrades
• The bonus is that much of this upwards modulation will be from low priced over-generation in the power system
• ROI 4.5 years (est)

Sources: https://www.iea.org/reports/aluminium

764 million tonnes CO₂ annual savings by 2050
C₂ – Firming the last 60% of VRE

Abating the last 1 billion tonnes is more difficult, as Al smelting requires at least 60% constant power supply.

• To shift last 60% to VRE sources will require:
  - collaboration with other users in the electricity grid
  - new purchasing arrangements
  - technological innovation in the power system to bridge the gap in supply and demand.

• This is likely to include:
  - demand side response services.
  - More consistent renewable generation being developed (geothermal, tidal, wave, biomass etc)
  - New not-yet-seen energy storage options developed
  - Increased participation in demand side response services by all users in the power system

Even though there are unknowns ahead, it doesn’t mean we should start on the pathway now

Sources: https://www.iea.org/reports/aluminium
D – Carbon Capture, Utilisation and Storage

- CCUS for direct process emissions – only required if non-consumable anodes are not rolled out across the entire smelting fleet
- Technology readiness (for Al smelting process emissions) - ????

E – Decrease Al production to only use hydro-power electricity

- Likelihood of enough new hydro-power capacity coming online by 2050 is extremely low
- Climate change making hydro-power not as guaranteed/reliable in the future

- Global CO₂ profiles of aluminium smelters illustrate the divide between smelters with hydro-electric power vs coal-fired power.

Source: IAI
Metals of the future will be greener than they are today

We cannot be left isolated from our consumer base

- Even though there are unknowns ahead, it doesn’t mean we shouldn’t start on the pathway today
- Technology enables the solutions, but only people solve the problems.