HYDRO'S APPROACH TO SUSTAINABILITY

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About the Presenter

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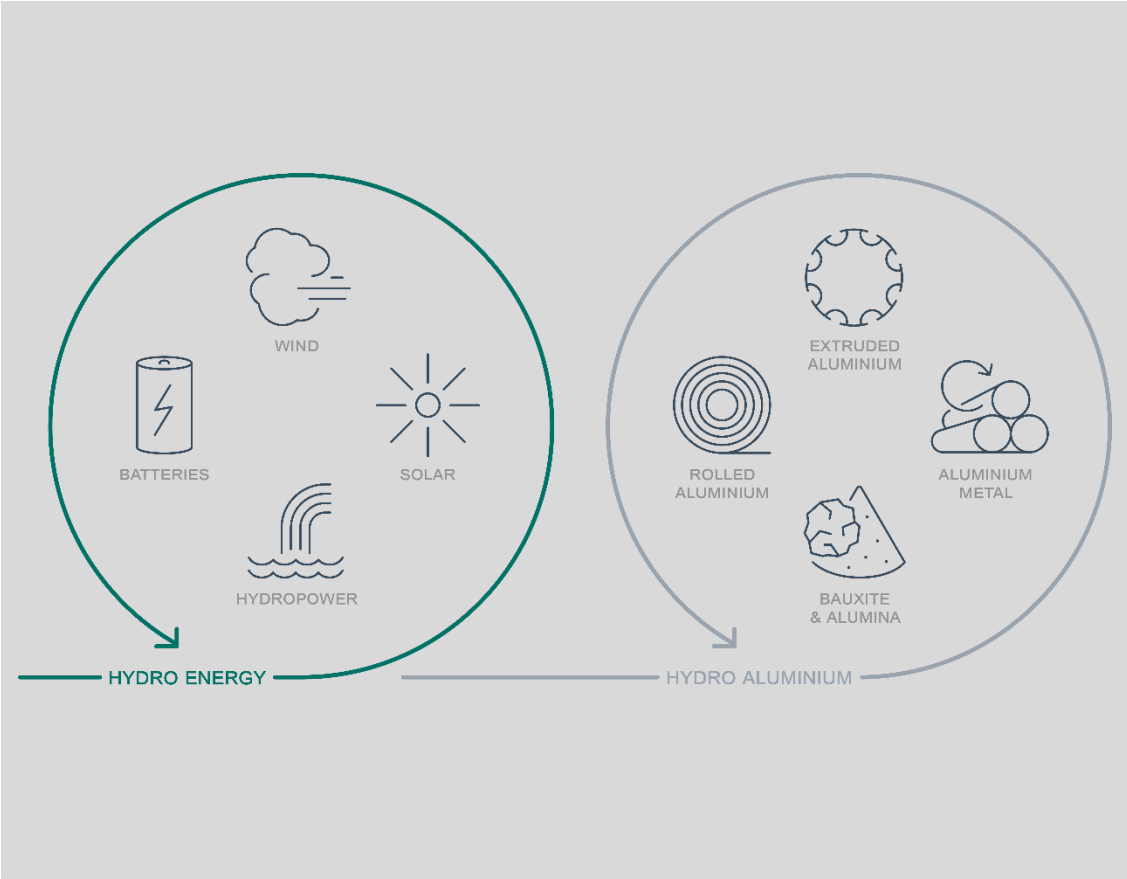
Building industries that matter

A leading industrial company with basis in renewable energy and aluminium



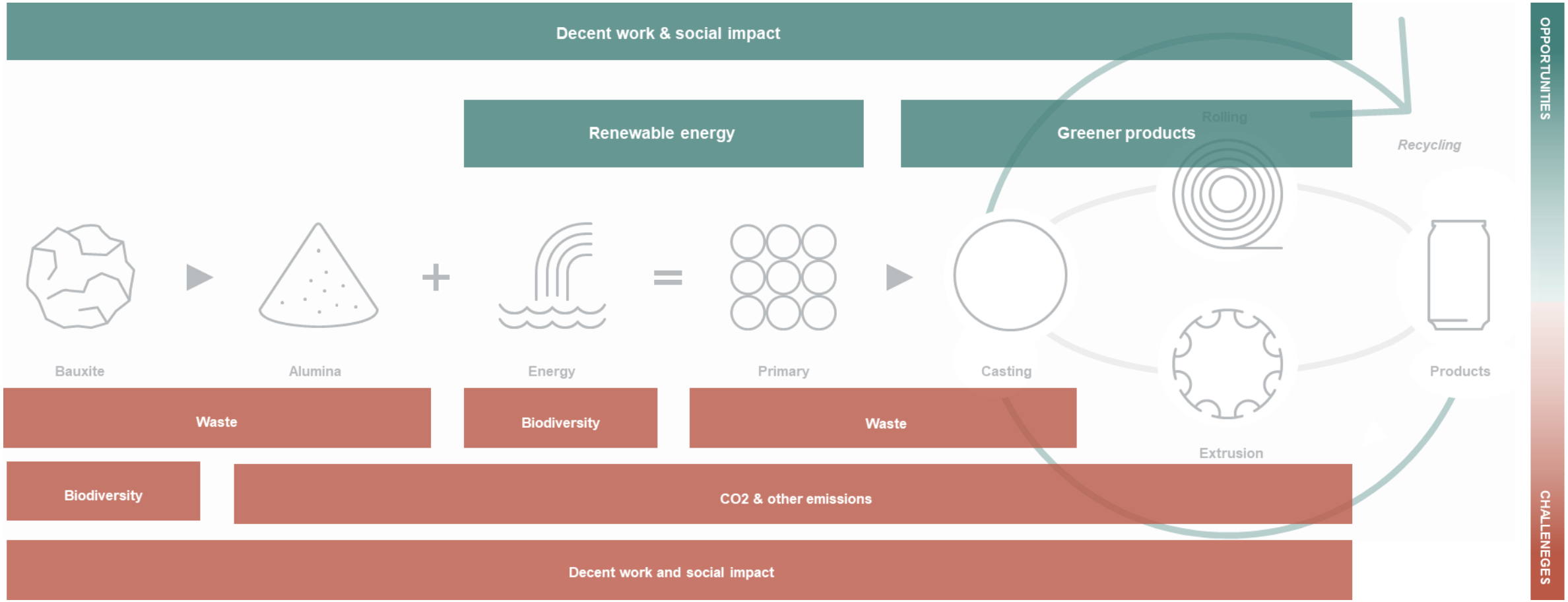
- Global provider of aluminium raw materials, products and solutions and of renewable energy
- First-class operations within renewable energy, raw materials, primary aluminium metal, rolled products, extruded solutions and recycling
- 34,000 employees at 140 locations in 40 countries
- Market cap ~USD 9 billion (as per January ‘21)
- Annual revenues ~USD 15 billion (2020)
- Included in Dow Jones Sustainability Indices, Global Compact 100, FTSE4Good

Introduction

Strong increase in sustainability, environment and climate awareness

Action and improvement needed on waste, recycling and emissions (CO_2) to defend aluminium's position

Sustainability challenges and opportunities in the aluminium value chain



Hydro’s 2030 sustainability targets

Social responsibility

Strengthening local communities and our business partners

Environment

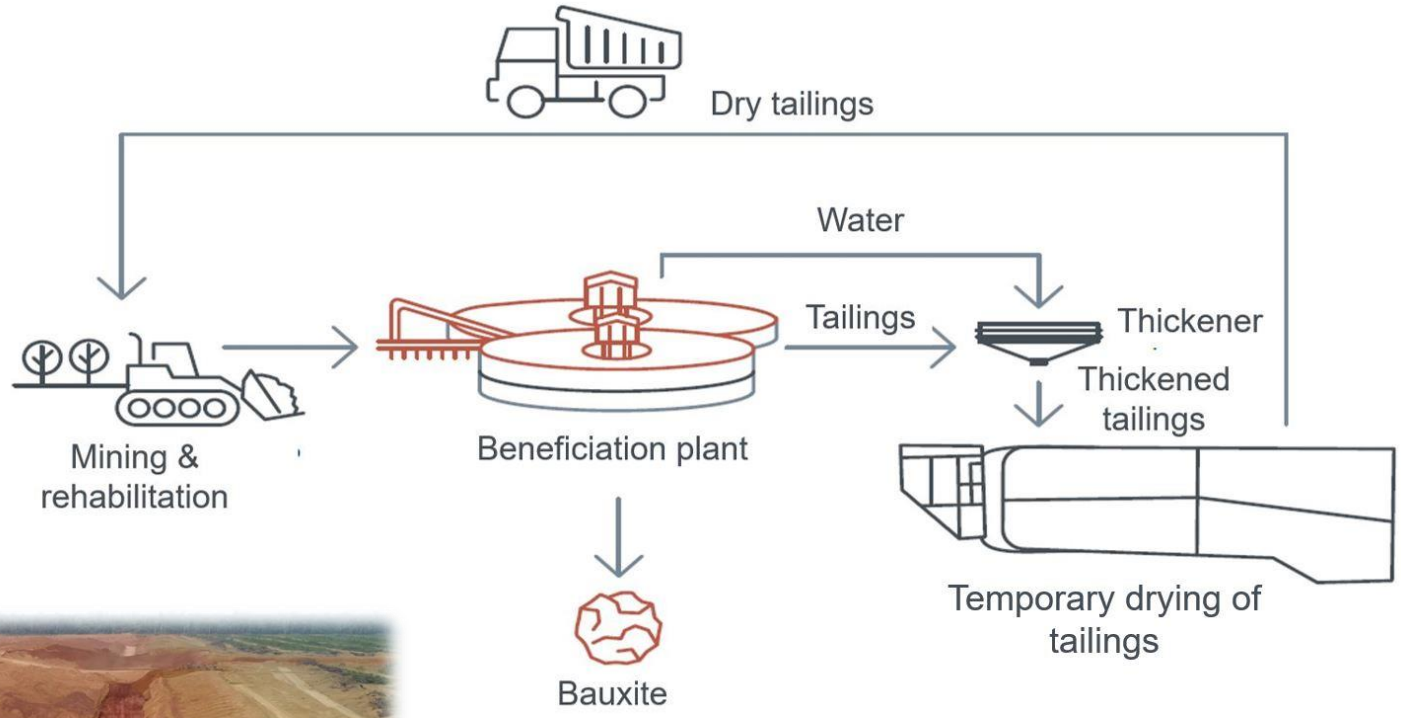
- 1:1 rehabilitation
- Tailings dry backfill
- Utilize 10% of bauxite residue
- 50% reduction in key non-GHG air emissions

Climate

Cut CO_2 emissions by 30%

Sustainability in the marketplace: our greener products portfolio

Tailings dry backfill in operation



Bauxite residue: from waste to products

Steel Industry

- Alternative iron ore
- % Utilization*: 20

Agriculture

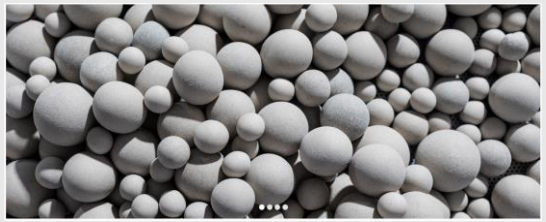
- Soil conditioner
- % Utilization: 10

TMS Light Metals Award (2021)

Civil Construction

- Cement, concrete, aggregates, components, pavers
- % Utilization: 50

Oil and Gas



- Proppant
- % Utilization: 20

% Utilization (potential) = used BR (ton) / total generation (ton)

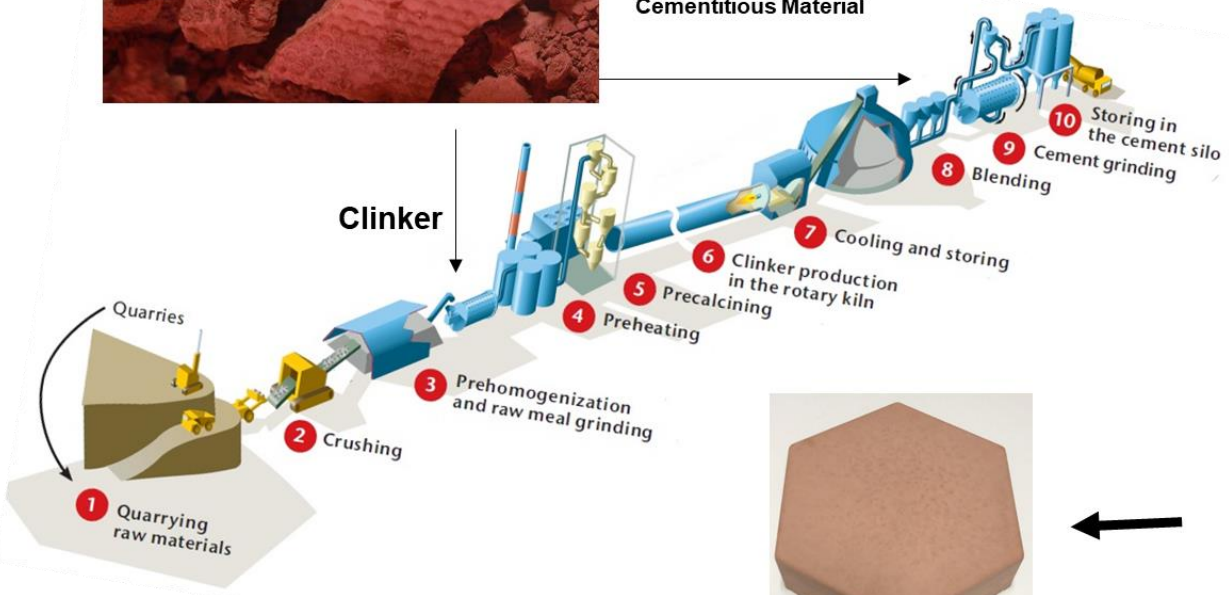
Cement industry with largest potential

Bauxite Residue

Aggregate

Supplementary Cementitious Material

Clinker



Cement

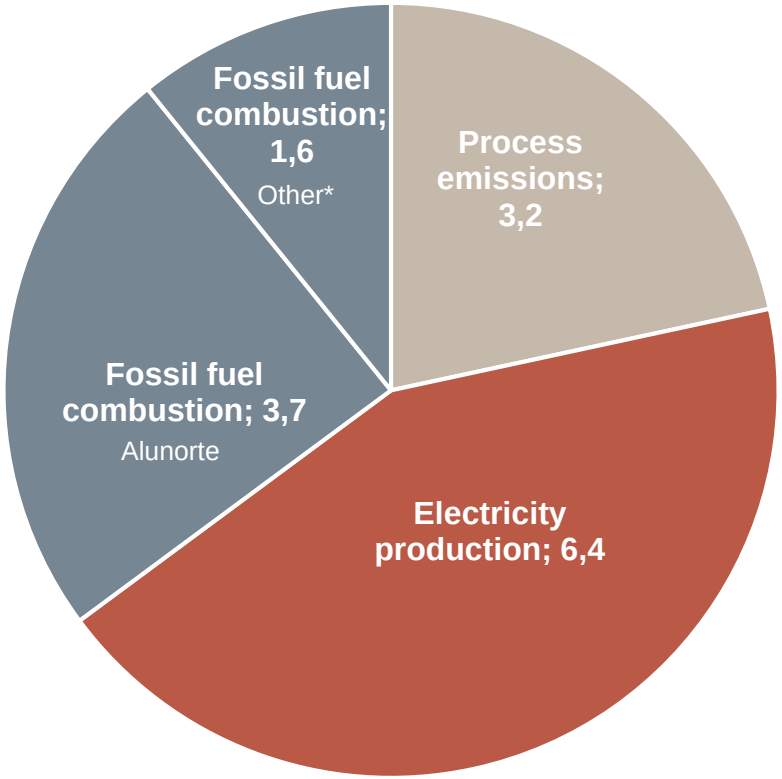
+

Cementitious products (ex. Pavers)

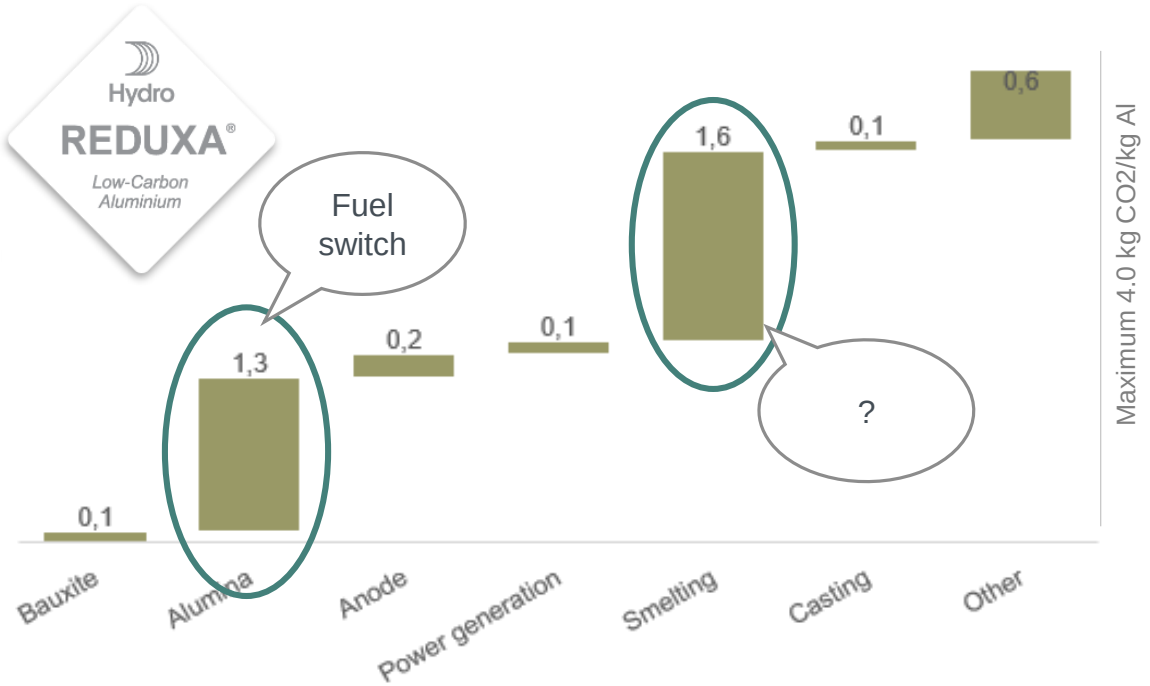
Concrete

Mortar

Sources of Hydro's 15 Mt CO_2-emissions



Hydro's certified 4.0 low-carbon aluminium

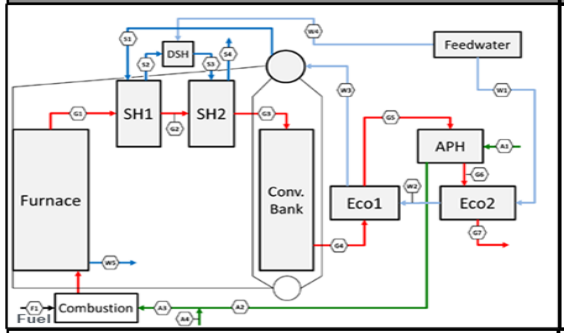


Emission data is as reported in Hydro annual report for 2017 with Extruded Solutions emissions included.
Graphic: Breakdown of emissions of in the total Hydro value chain, including Extruded Solutions
*** Casthouses, re-melting, anode baking, furnaces etc**

Alunorte fuel switch project

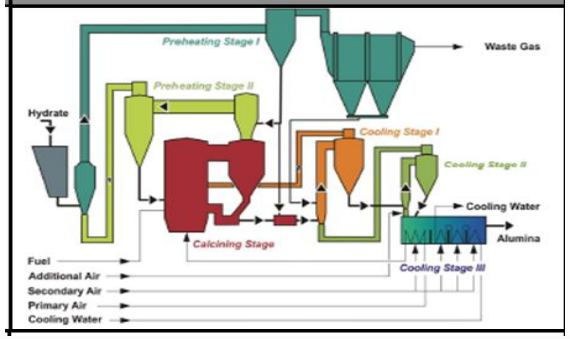
Converting boilers and calciners to natural gas, LNG

Boilers



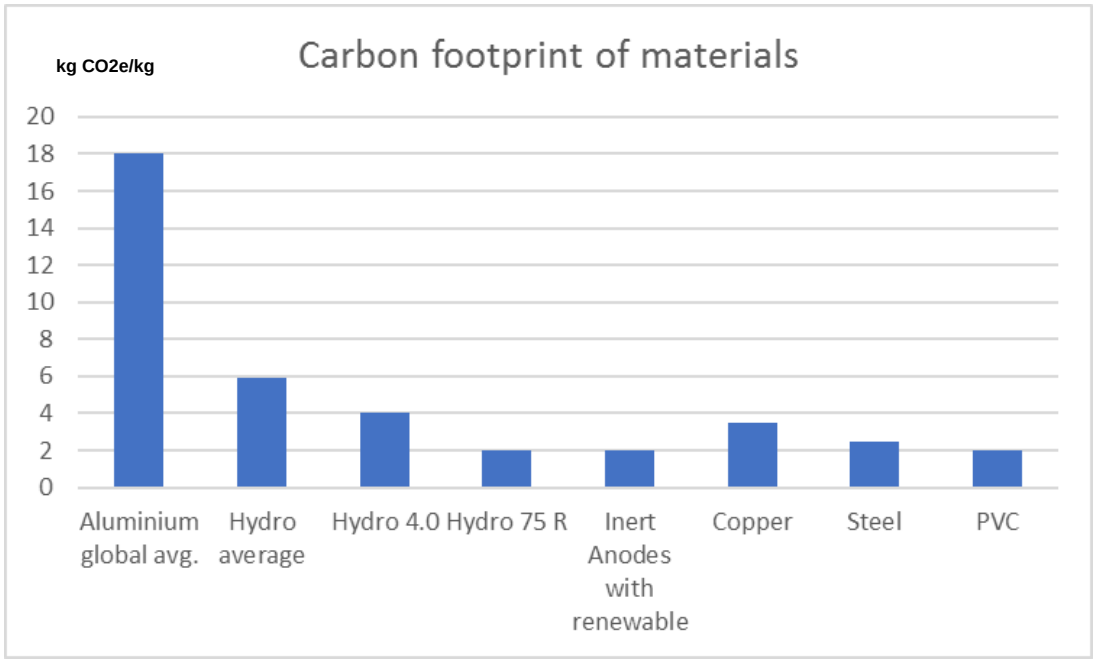
- Gas as single Fuel
- According to NFPA 85
- Emissions limits shall comply with European standards
- NOx emissions control using steam injection

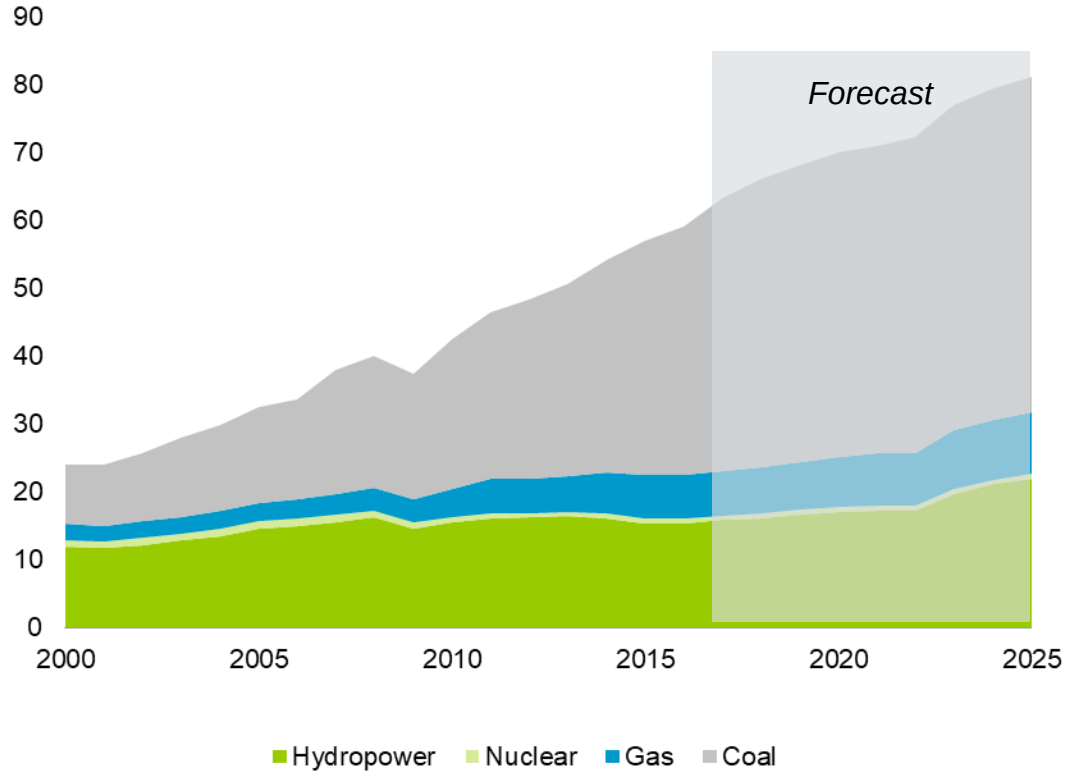
Calciners



Primary aluminium production can come under pressure

All energy sources need to be based on renewable energy





Electrolysis climate technology roadmap

Build on the Hall-Heroult process and existing plants:

- Convert to renewable power
- Optimise operations
- Energy consumption
- Industry 4.0
- Broad portfolio R&D incl. bio carbon

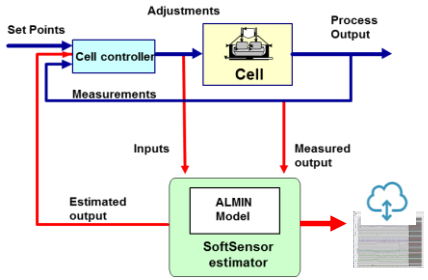
Intermediate phase:

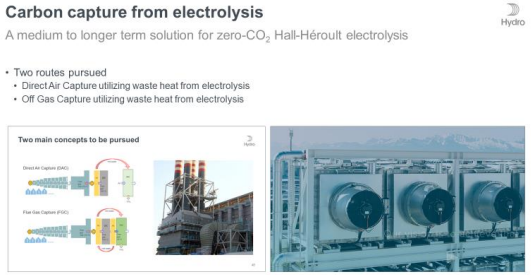
- Conclude on viability of R&D work
- Continue power conversion
- Further optimising operations
- CO_2 capture and storage or utilization, CCUS
- DAC solutions

New technology in «new» plants:

- Inert anodes
- Chloride/other innovative processes
- CCUS and DAC solutions

2020 → 2035 → Towards Zero → 2050

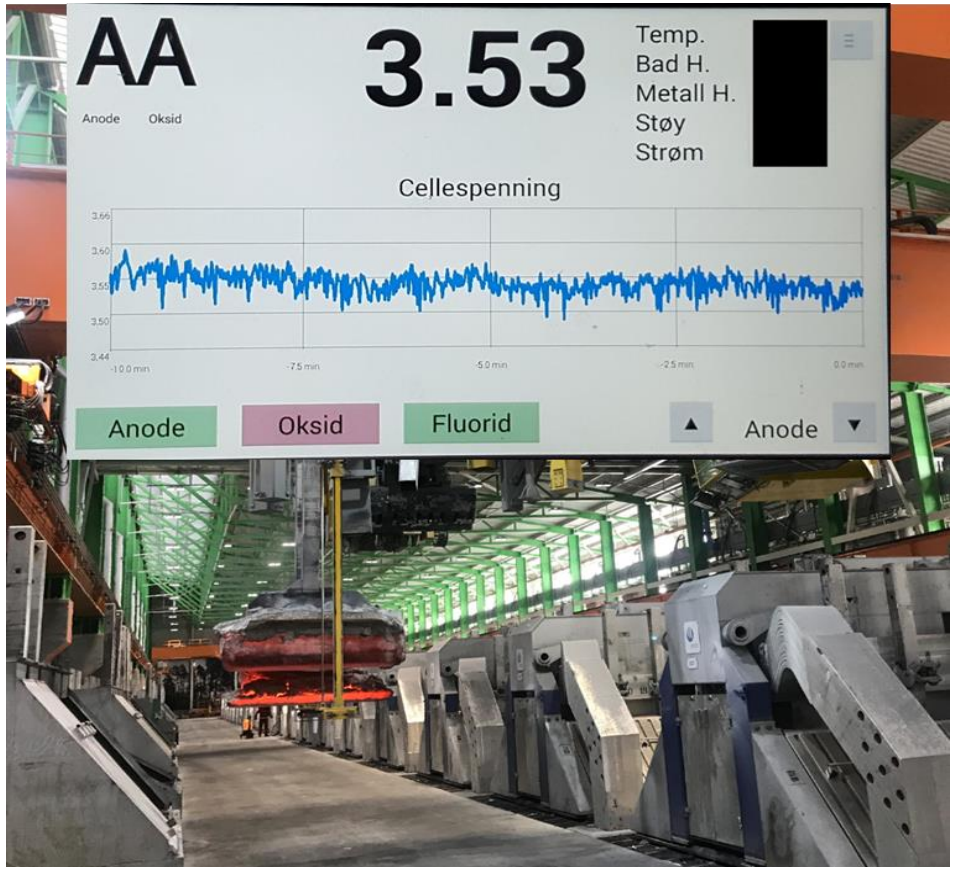




Andrée Laforest, Quebec's minister of municipal affairs and housing and Jean Region, speaks at the event at the planned R&D facility on August

The planned facility is located within Rio Tinto's Complexe Jonqu smelter, Vaudreuil refinery and Arvida research and development (US$37.7 million) construction project is expected to be fully ope 2020, employing 25 technical experts.

Energy consumption – Karmøy tech pilot

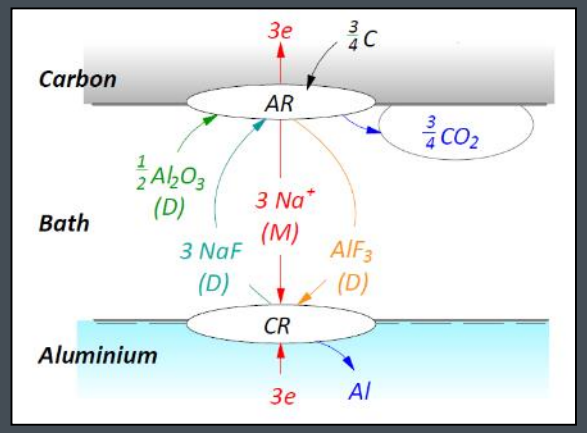


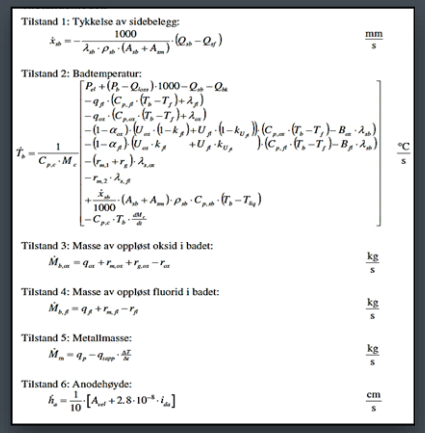
Successful validation test: EC < 12.4 / 11.8 kWh, CO_2 < 1.4 kg – technology element deployment

Towards autonomy
Digital twins

Process data

Domain competence





Tilstand 1: Tykkelse av sidebelegg:

$$\dot{x}_{sb} = -\frac{1000}{\lambda_{sb} \cdot \rho_{sb} \cdot (A_{sb} + A_{ss})} \cdot (Q_{sb} - Q_{sf}) \quad \frac{mm}{s}$$

Tilstand 2: Badtemperatur:

$$\dot{T}_b = \frac{1}{C_{p,c} \cdot M_c} \begin{bmatrix} P_{el} + (P_s - Q_{conv}) \cdot 1000 - Q_{sb} - Q_{ss} \\ -q_{gf} \cdot (C_{p,gf} \cdot (T_b - T_f) + \lambda_{gf}) \\ -q_{ae} \cdot (C_{p,ae} \cdot (T_b - T_f) + \lambda_{ae}) \\ -(1-\alpha_{ae}) \cdot \left(U_{ae} \cdot (1-k_{gf}) + U_{gf} \cdot (1-k_{U_{gf}})\right) \cdot (C_{p,ae} \cdot (T_b - T_f) - B_{ae} \cdot \lambda_{ae}) \\ -(1-\alpha_{gf}) \cdot \left(U_{ae} \cdot k_{gf} + U_{gf} \cdot k_{U_{gf}}\right) \cdot (C_{p,gf} \cdot (T_b - T_f) - B_{gf} \cdot \lambda_{ae}) \\ -(r_{ae,1} + r_{gf}) \cdot \lambda_{c,ae} \\ -r_{ae,2} \cdot \lambda_{c,gf} \\ +\frac{\dot{x}_{sb}}{1000} \cdot (A_{sb} + A_{ss}) \cdot \rho_{sb} \cdot C_{p,sb} \cdot (T_b - T_{liq}) \\ -C_{p,c} \cdot T_b \cdot \frac{dM_c}{dt} \end{bmatrix} \quad \frac{^{\circ}C}{s}$$

Tilstand 3: Masse av oppløst oksid i badet:

$$\dot{M}_{b,ae} = q_{ae} + r_{ae,ae} + r_{gf,ae} - r_{ae} \quad \frac{kg}{s}$$

Tilstand 4: Masse av oppløst fluorid i badet:

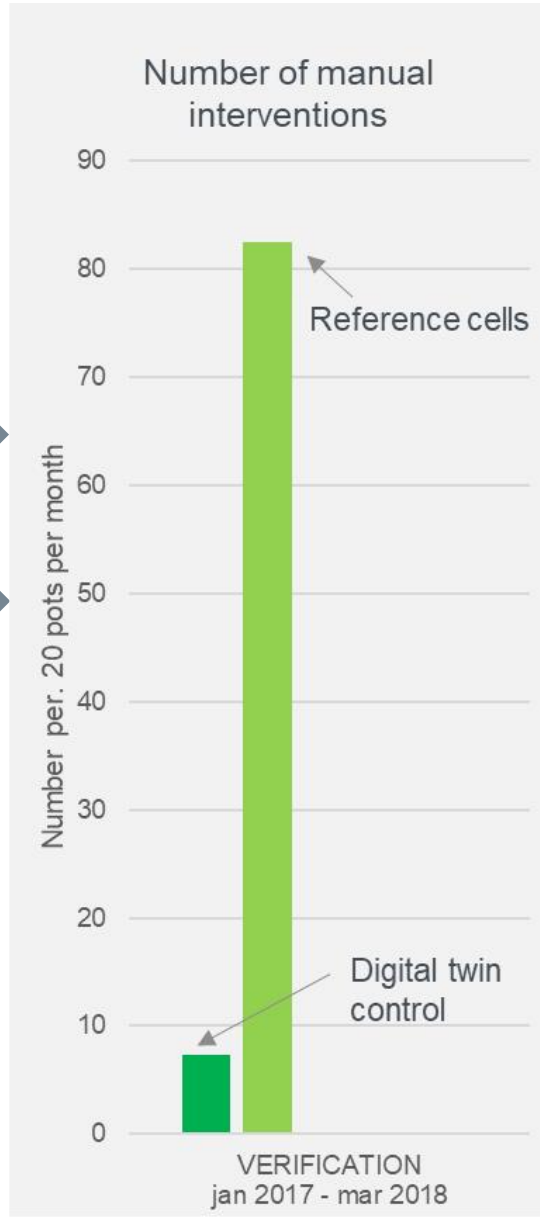
$$\dot{M}_{b,gf} = q_{gf} + r_{ae,gf} - r_{gf} \quad \frac{kg}{s}$$

Tilstand 5: Metallmasse:

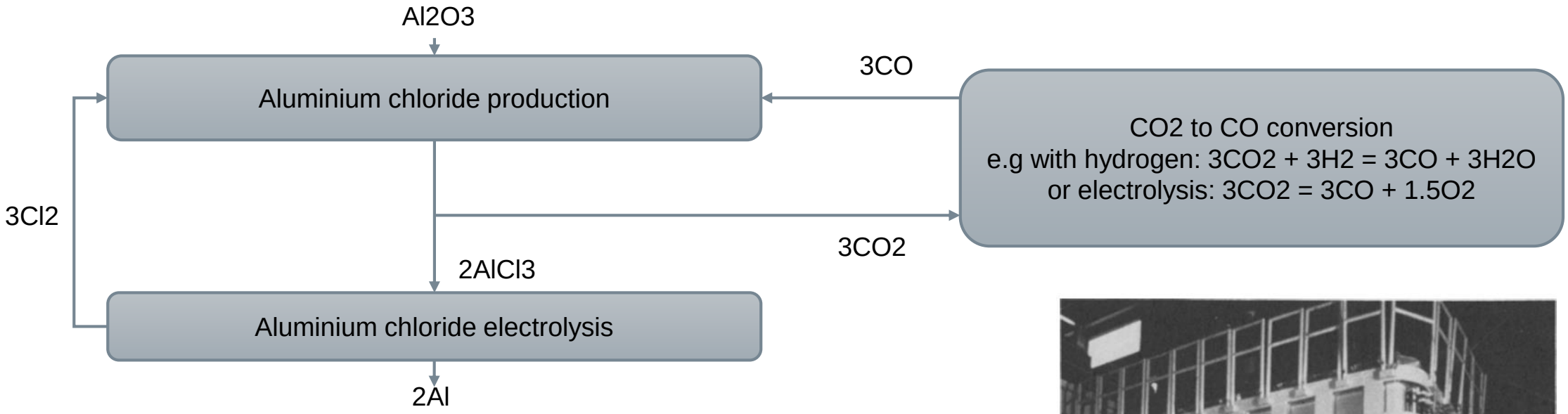
$$\dot{M}_{Al} = q_p - q_{upp} \cdot \frac{\Delta T}{\Delta t} \quad \frac{kg}{s}$$

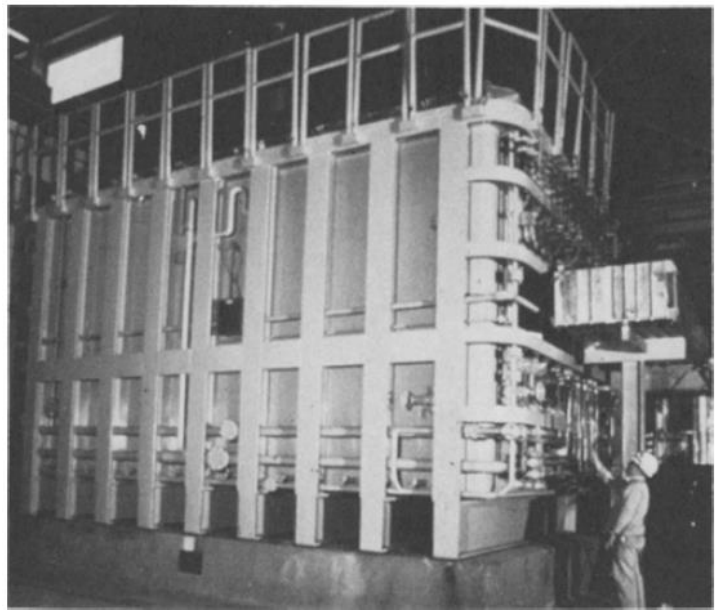
Tilstand 6: Anodehøyde:

$$\dot{h}_a = \frac{1}{10} \left[A_{ref} + 2.8 \cdot 10^{-5} \cdot i_{ln} \right] \quad \frac{cm}{s}$$



A new approach to the chloride process

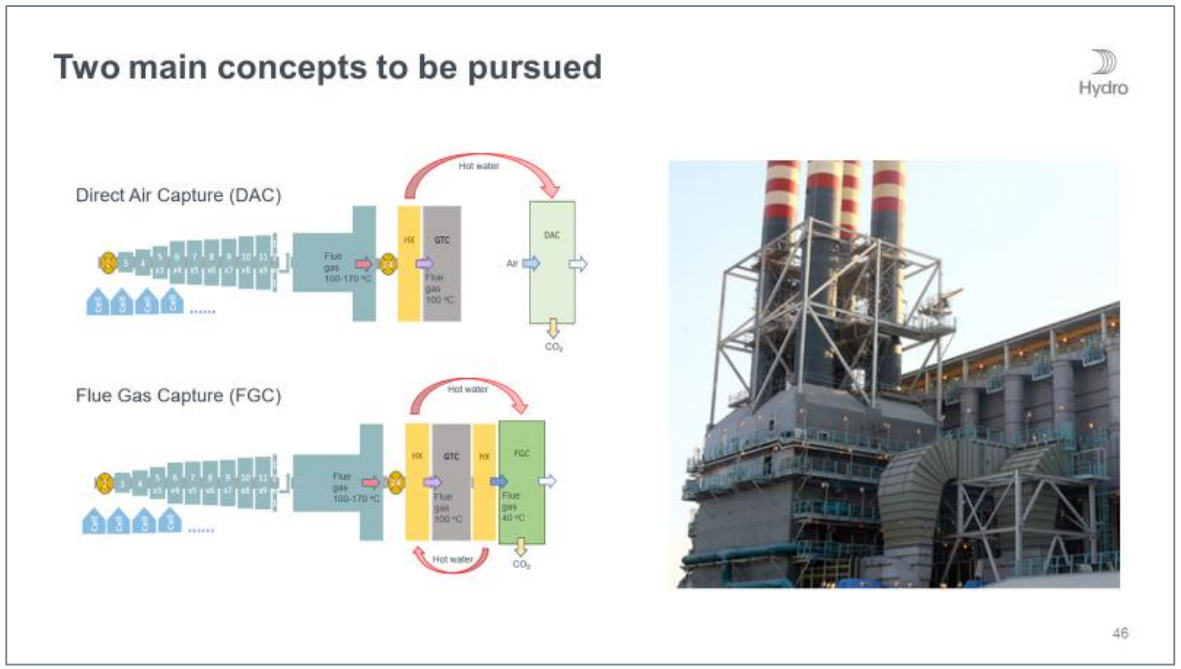




Carbon capture from electrolysis

A medium to longer term solution towards zero-CO2 Hall-Héroult electrolysis

- **Direct Air Capture (potentially utilizing waste heat from electrolysis or off-site)**
- **Off Gas Capture utilizing waste heat from electrolysis**



Recycling - a part of the solution

Aluminium's recyclability is a fantastic competitive advantage

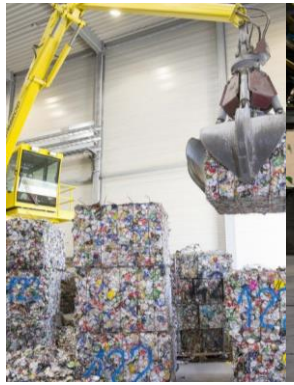
5% to recycle

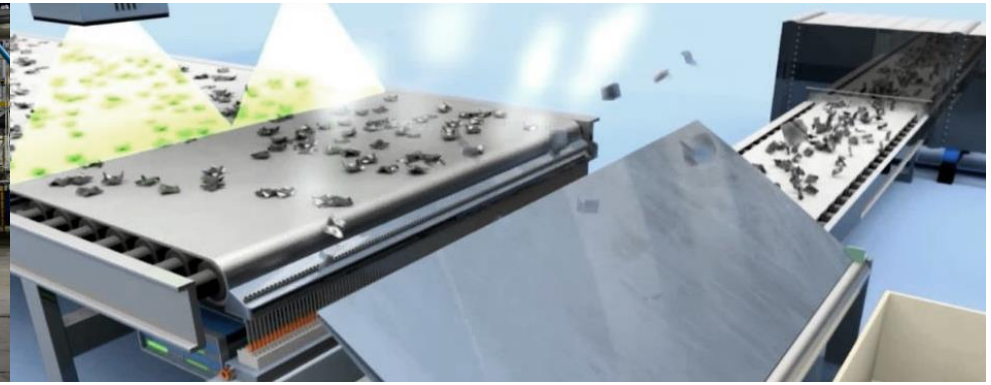
75% **still in use**

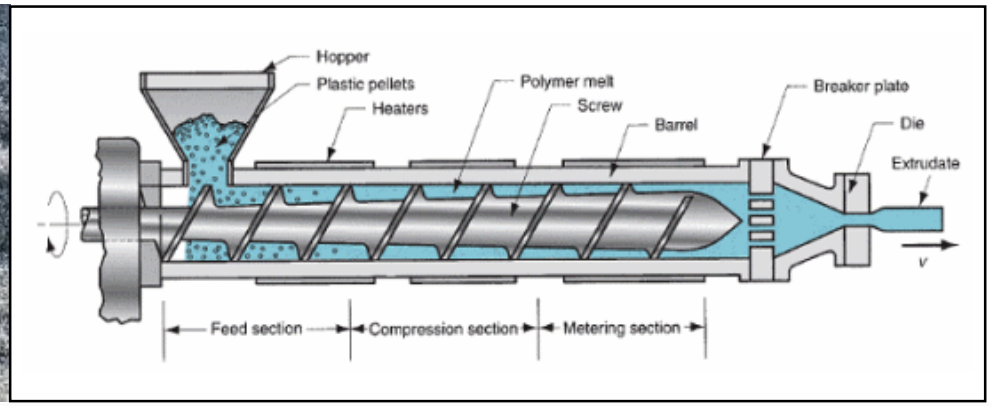
100% equal quality

Challenge:

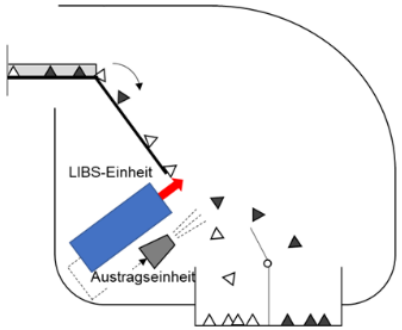
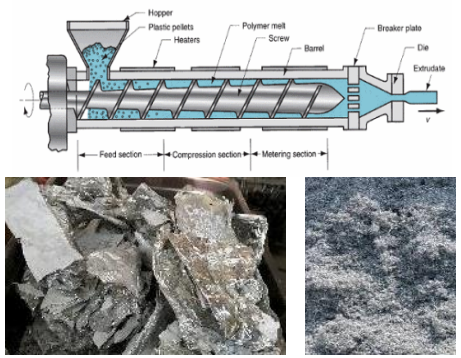
Our approach:







Encouraging recycling project portfolio

Remelt & recycling ambition	LIBS pilot	Thin-gauge scrap	Battery recycling	Packaging
				
• Double EBITDA • Use additional 500 kt post-consumer scrap per year	Pilot for faster learning of industrial alloy sorting	Screw-extruder under development for compacting thin and difficult scrap	Possible future source of scrap and profit	Recycling-friendly aluminium food packaging

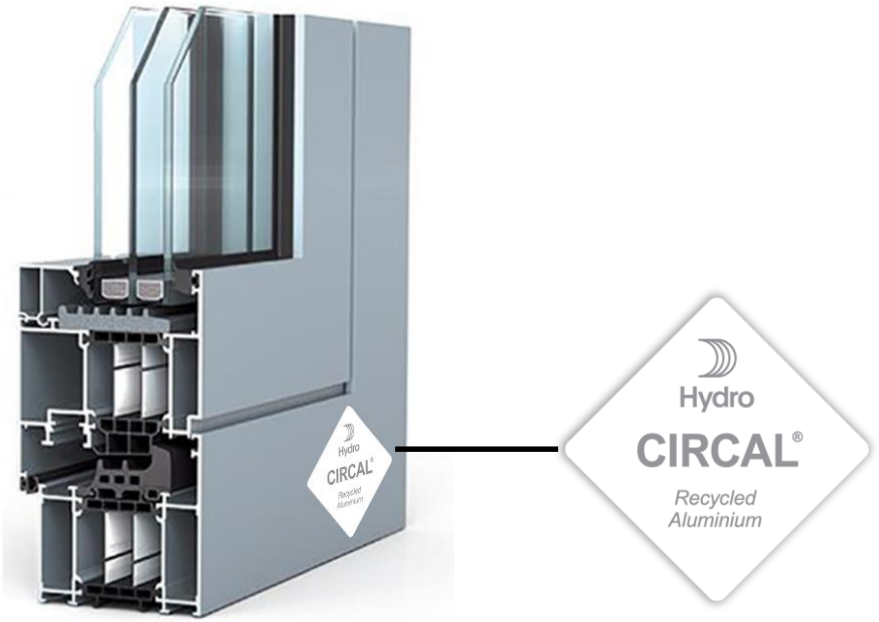
Our premium low-carbon products

REDUXA
Certified, low-carbon aluminium with a maximum carbon footprint of 4.0 kg CO2 per kg aluminium

CIRCAL
Range of prime quality aluminium made with a minimum of 75% recycled, post-consumer scrap

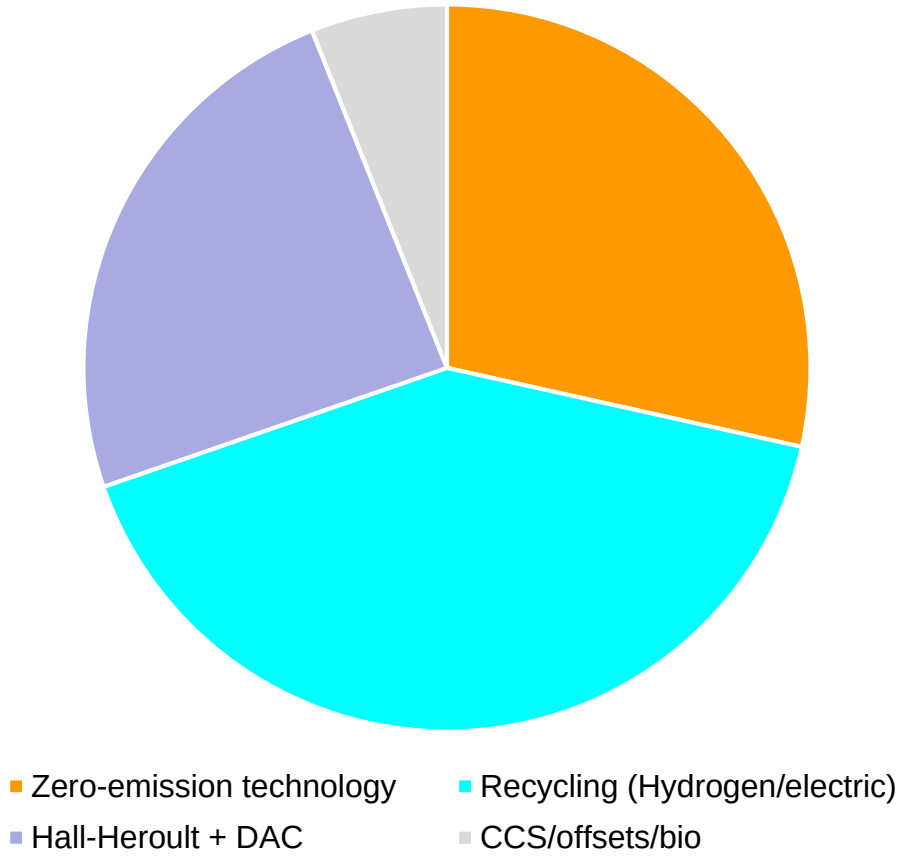
Strong interest in greener aluminium

House of Choice, Sweden, Scandinavia's first zero-energy hotel, Photo: White Arkitekter



Summing up

Increased sustainability awereness is about to change our industry



Directional 2050 Outlook

- IAI: around 165 Mtpy Al demand
  - 65 Mtpy recycled (40%)
  - 100 Mtpy primary
- A net-zero industry
- Clean energy sources
- New-builds with zero-emission technology
- Al-industry will receive few offsets and struggle competing for bio resources
- Existing and modern HH-smelters with on-site CCUS or off-site DAC


Hydro
We are aluminium