Decarbonization of the aluminium smelting industry

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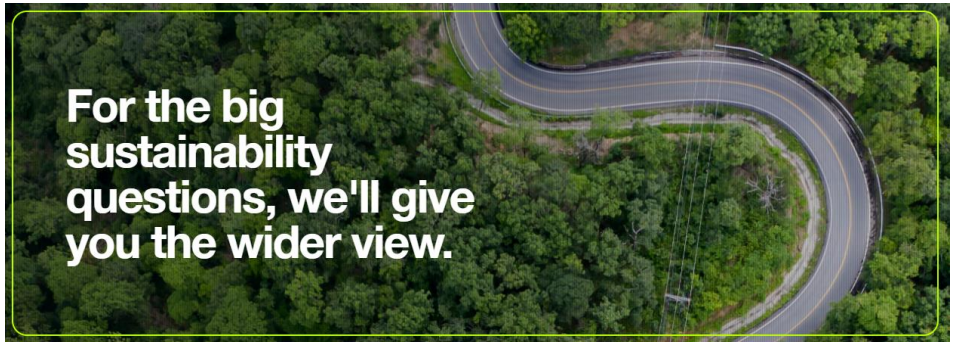
Introduction



CRU has been providing **market analysis and data** for more than 50 years.

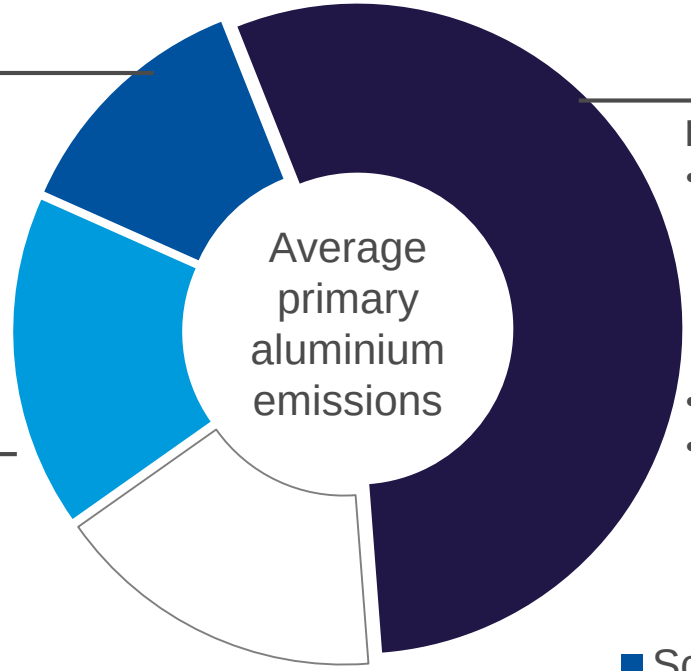
The Aluminium team has provided **carbon emissions data** for more than 10 years.

Overview on emissions across the industry

Emissions in aluminium smelting

Process emissions
- **1.9 t CO_2e/t Al**
- Includes emissions from the casthouse and carbon/paste plant

Upstream emissions
- **2.7 t CO_2e/t Al**
- From alumina refining mainly
- Excludes emissions from waste management and some purchased goods and services



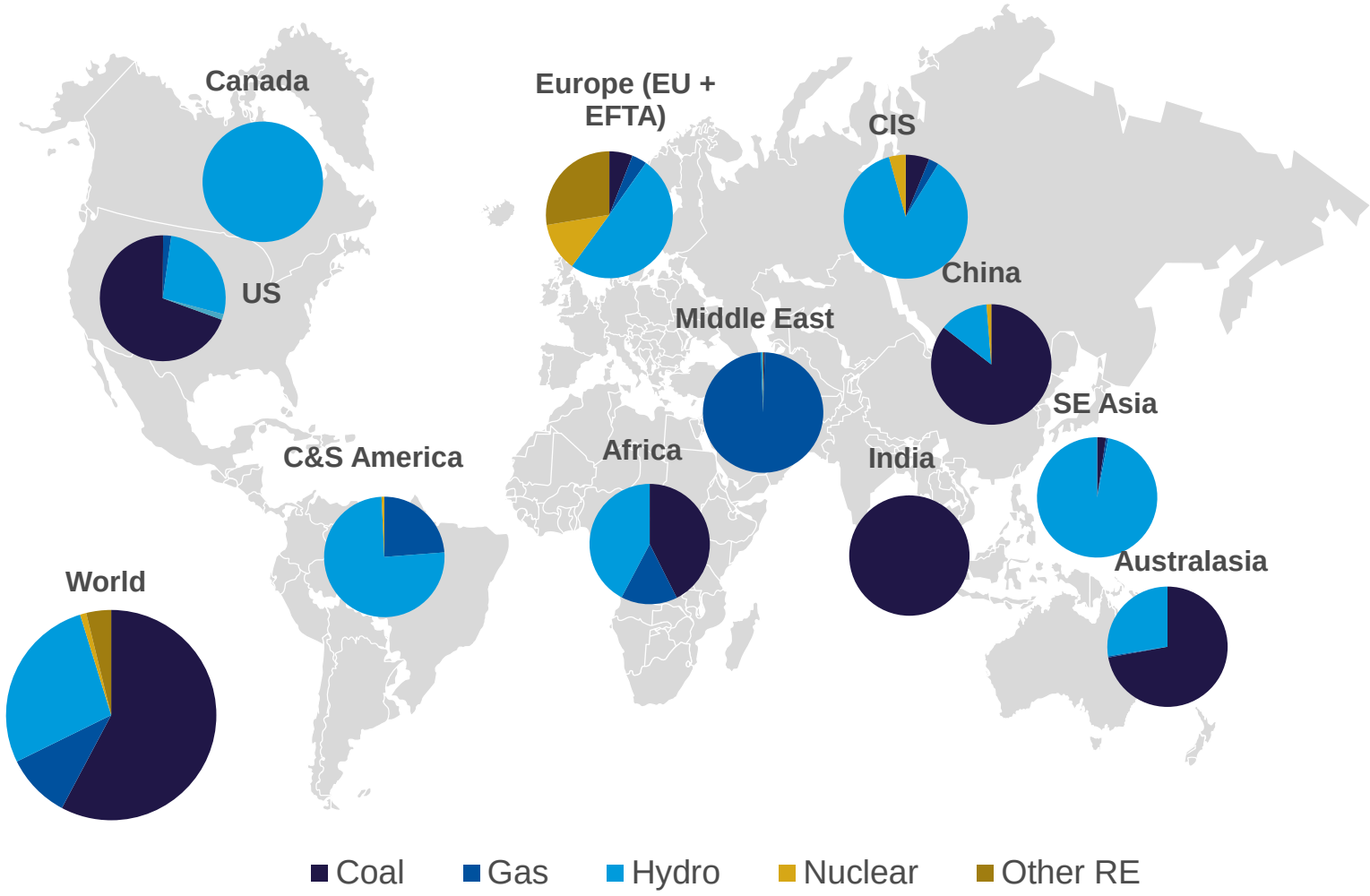
Power supply
- Varies extensively depending on power source(s):
  Hydro/nuclear/RE <0.3 t CO_2e/t Al
  Gas 6 t CO_2e/t Al
  Coal 15 t CO_2e/t Al
- World average: 8.5 t CO_2e/t Al
- Scope 1 or 2 depending on ownership

Downstream emissions
Currently assessed by CRU for rolling – typically **0.5-2.5 t CO_2e/t Al**

- Scope 1
- Scope 1 or 2
- Scope 3 Downstream
- Scope 3 Upstream

Data: CRU

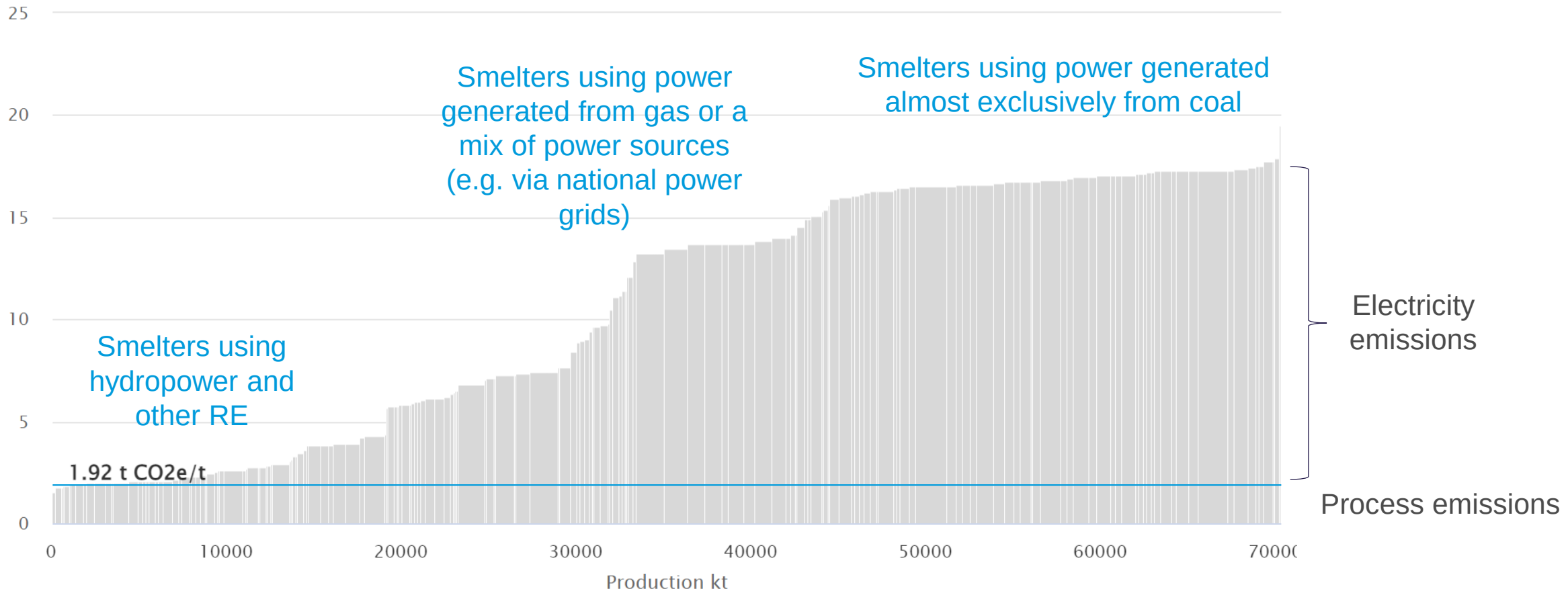
Power sources in the aluminium industry



Data: CRU

Primary aluminium emissions curve

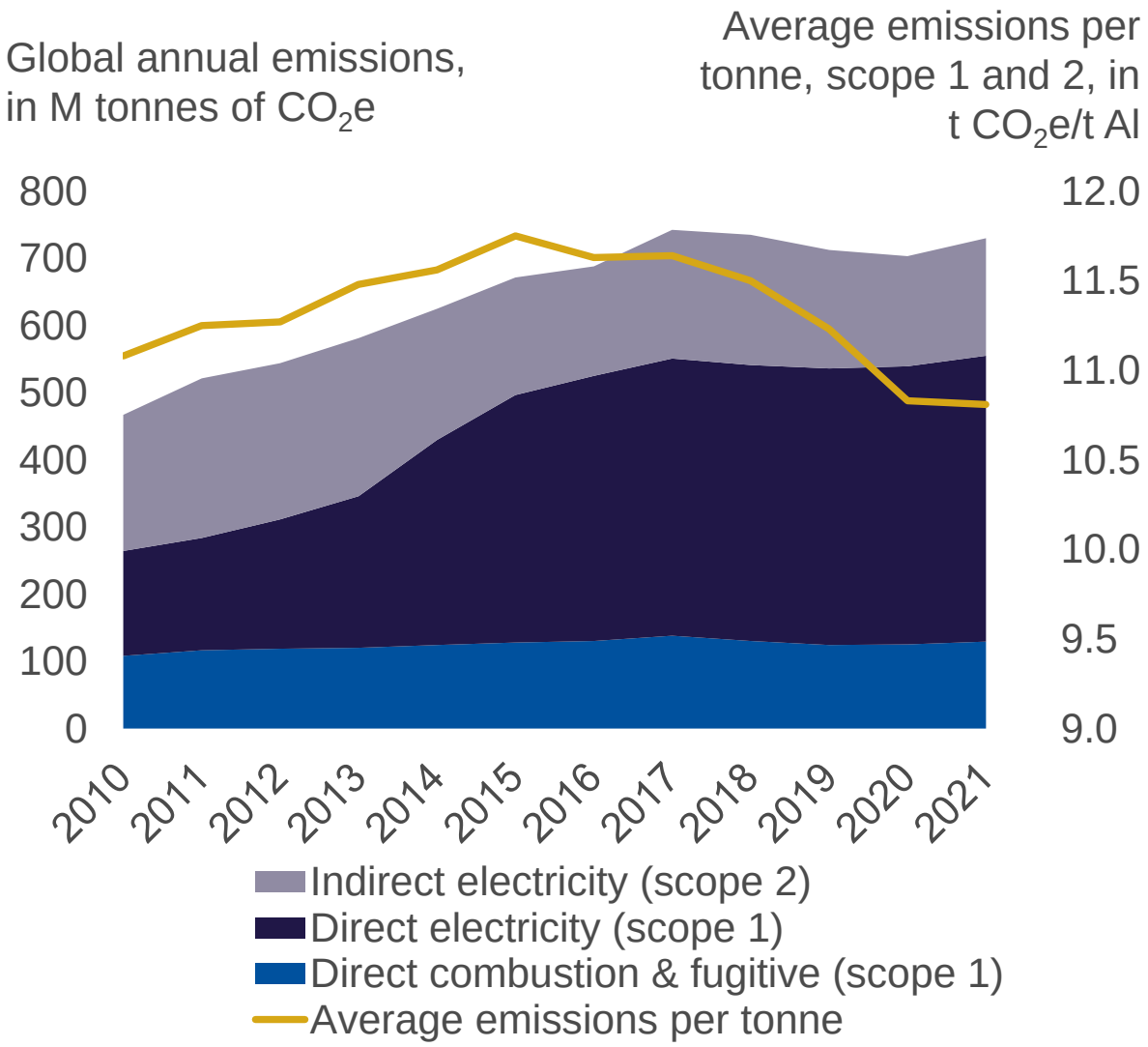
In t CO2e/t Al, 2022, process and electricity-related emissions (scope 1 and 2)



Graph: CRU Emissions Analysis Tool

Data: CRU

Current global trend



- In a decade (from 2010 to 2020), average process emissions per tonne of aluminium decreased by 25%.
- Most of the new capacity that came on stream over the period has been using captive coal-fired power stations, in China.
- China currently produces 72% of all emissions (scope 1 and 2) in the primary aluminium industry. It is followed by India, the second largest emitter, responsible for 9% of all emissions.

Data: CRU

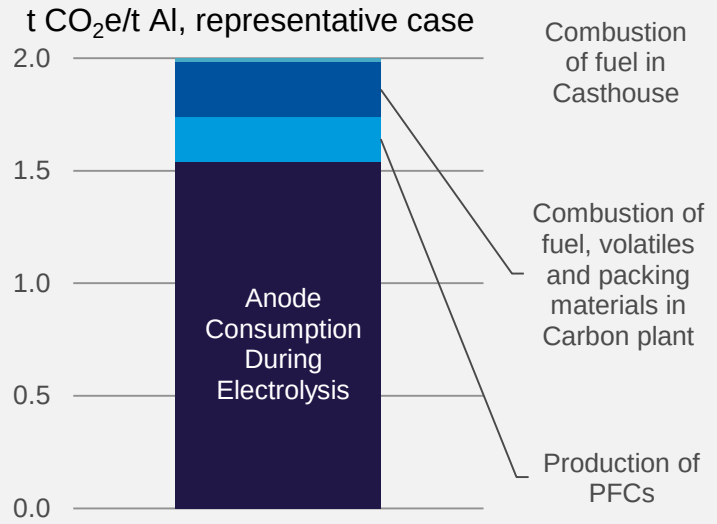
Decarbonization

Decarbonizing the smelting technology

- Most recent smelting technologies emit less and consume less power
  - World best: **Norsk Hydro's HAL4e and HAL4e Ultra** technologies (2018)
    - Power consumption 11.5-11.8 MWh/t Al (world average 13.5 MWh/t Al)
    - Process emissions 1.4-1.5 t CO_2e/t Al (world average 1.9 t CO_2e/t Al)
- Modern power stations emit less GHG emissions
    - EGA's new power station

- **Inert anode** technology
  - Oxygen is emitted instead of CO_2 during main reaction, but power consumption is likely increased due to this reaction
  - Test and pilot scale at present
    - Elysis (2018)
  - Would likely be most suitable for greenfield projects due to design. Currently not commercially available and not yet proven to be cost effective
  - Opportunities for greenfield projects with renewable power are likely limited

Process emissions breakdown, per tonne of primary metal



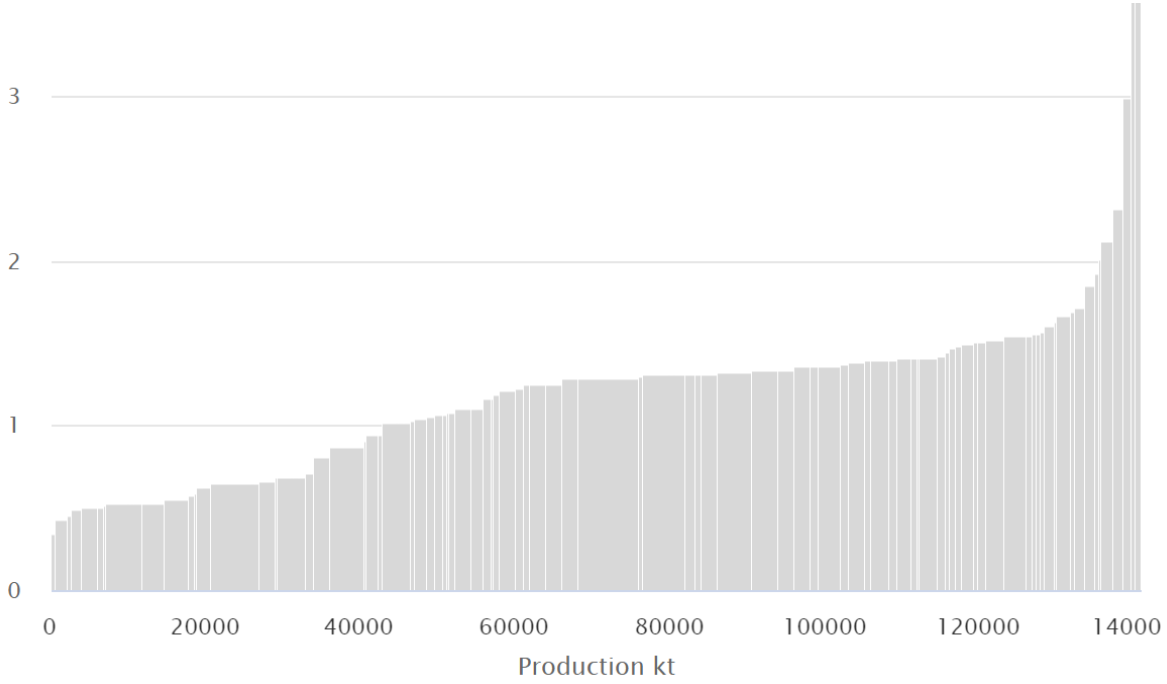
The main reaction during electrolysis is responsible for most of the CO2e emissions

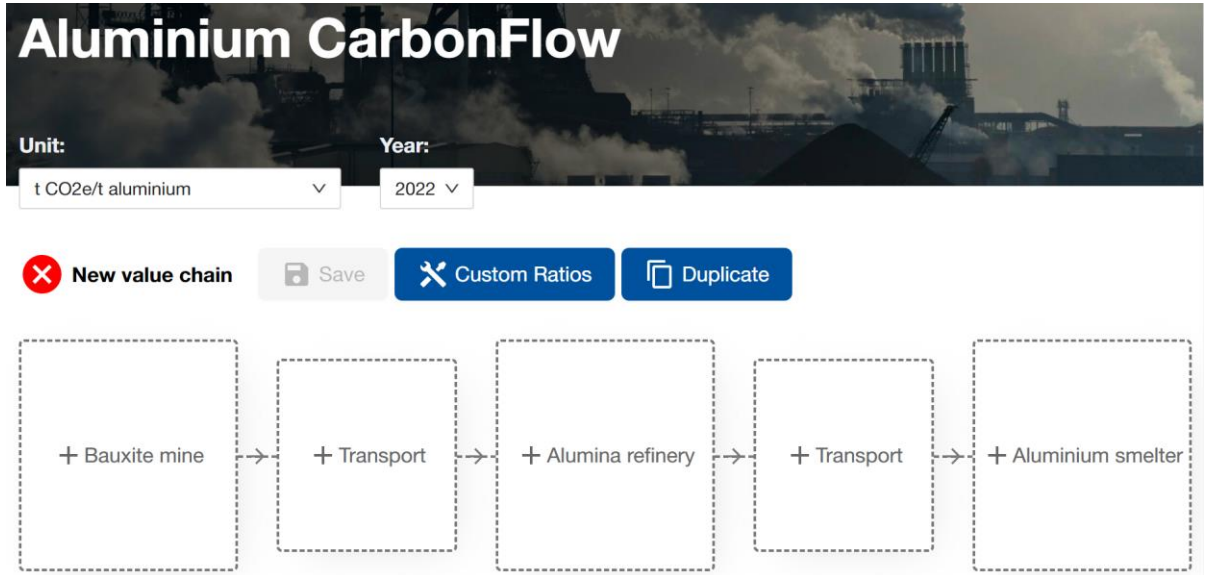
$$2\,Al_2O_3 + 3\,C \rightarrow 4\,Al + 3\,CO_2$$

Data: CRU

Finding raw materials with lower carbon footprints?

Alumina emissions curve, in t CO_2e/t Ala, 2022 (scope 1 and 2)





Graph: CRU Emissions Analysis Tool

Data: CRU

Producers shift to greener power sources

- Wind & solar power become competitive
  - Norsk Hydro & Alcoa wind sourcing in Norway
  - Alcoa's San Ciprian smelter to restart with wind PPA
  - Aluar's wind farm
  - European grid mix becomes greener

- EGA uses solar power

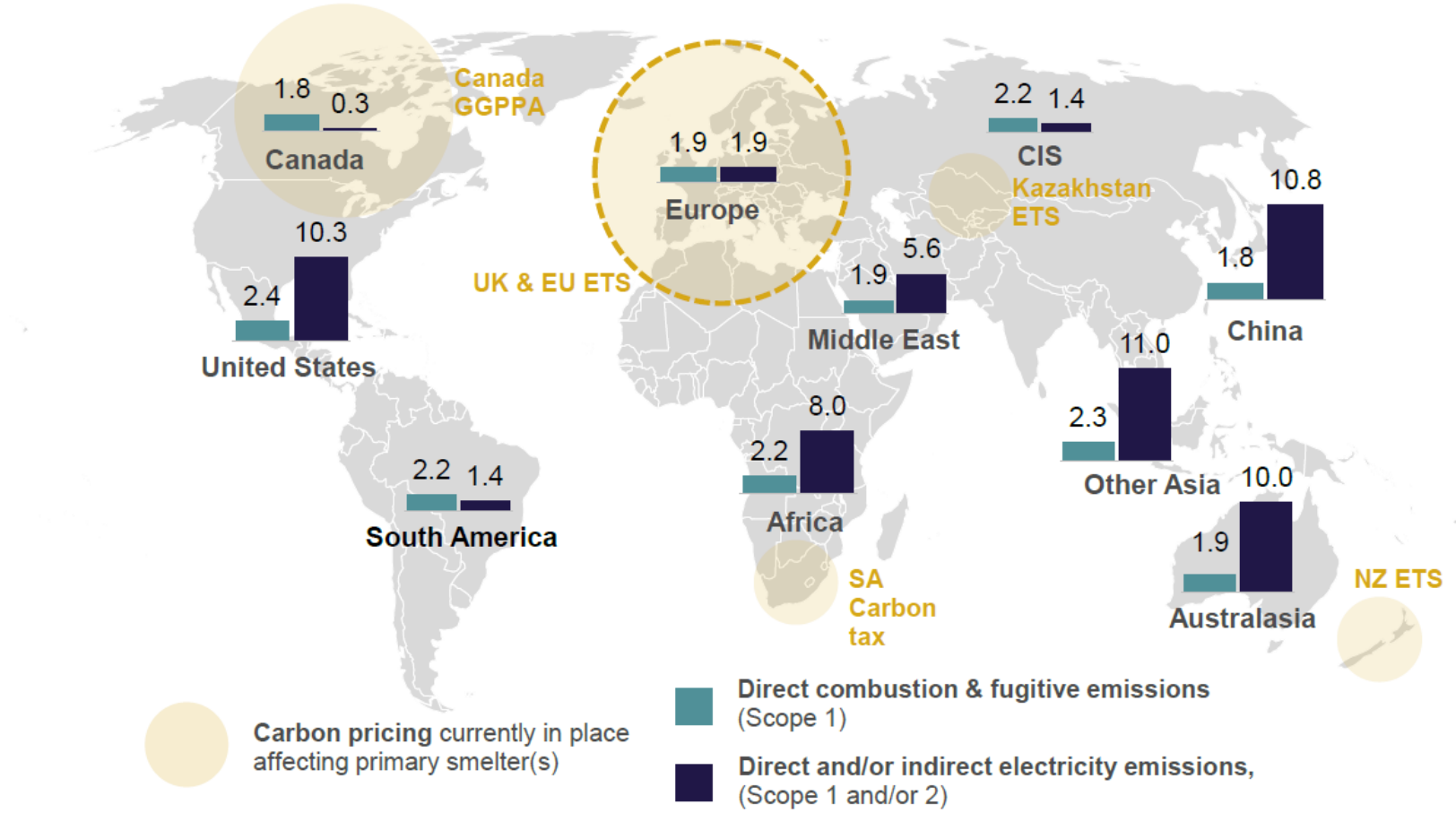
- More than half of the production growth in China in 2022 is expected to be made using hydro or wind power (+1.4 M tonnes in 2022)

Data: CRU

Government incentives to reduce emissions

Regional average emissions and carbon pricing areas

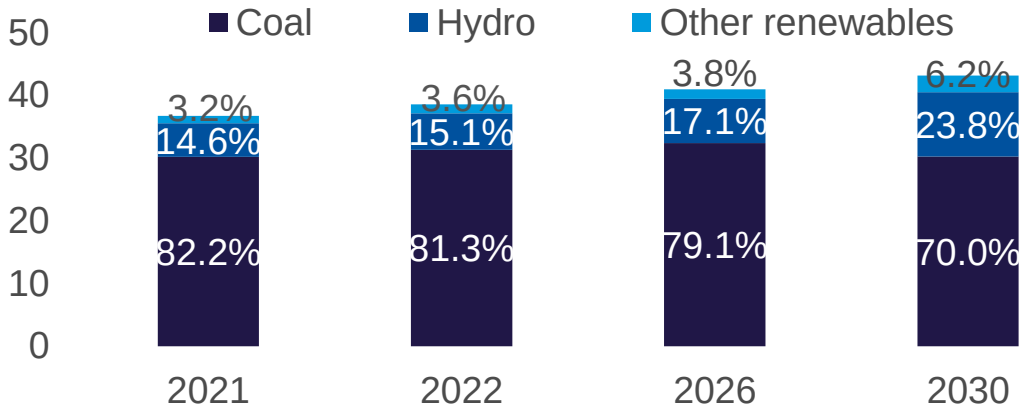
In tonne of carbon dioxide equivalent per tonne of aluminium produced (t CO_2e/t Al), year 2021. Includes all Scope 1 and 2 emissions.



Data: CRU

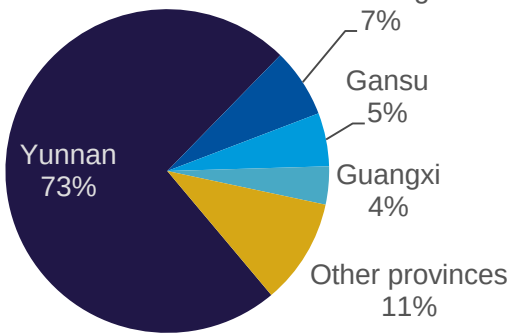
China's 2030 objectives

China aluminium production forecast by energy source, Mt



The increase in production based on hydropower and other renewable energies will be coming from the Yunnan province mainly

Breakdown of production increase between 2021 and 2030



- China's central government has set a target for **aluminium production based on renewable energy to account for 30% of total production by 2030**.
- CRU expects that the relocation of China Hongqiao's capacity in Shandong to the Yunnan province will contribute to accomplish the above target.
- Some smelters in Inner Mongolia have started to invest in solar power capacity.

Data: CRU

Decarbonization pathway

Process emissions	Progress in technology has been slow and implemented across the industry very progressively, either through retrofitting or greenfield projects.
Electricity generation emissions	This is where most of the progress can be made overall in the industry: shifting from coal or gas based power to renewable or nuclear based power. **Wind and solar become competitive in some places** and **government incentives** are driving the shift away from fossil fuels for all industries. **Green premiums** will incentivise shifts to greener power sourcing.
Upstream emissions	There is room for emission reductions for aluminium producers when looking at their raw materials carbon footprint (mainly through alumina sourcing).
Recycling aluminium	Increasing the amount of scrap usage will help reduce the industry's reliance on primary metal; but increasing scrap shares will be challenging due to limitations in collection and sorting technologies of post-consumer scrap. Progress is likely to be incremental but slow.

Decarbonization is progressive and driven by demand as well as governments policies and technology advancements.