Aluminium Production: A Pathway to Zero Carbon by 2050

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About the Presenter

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- **Current role – commercializing the EnPot shell heat exchanger technology for flexible aluminium smelter operation**

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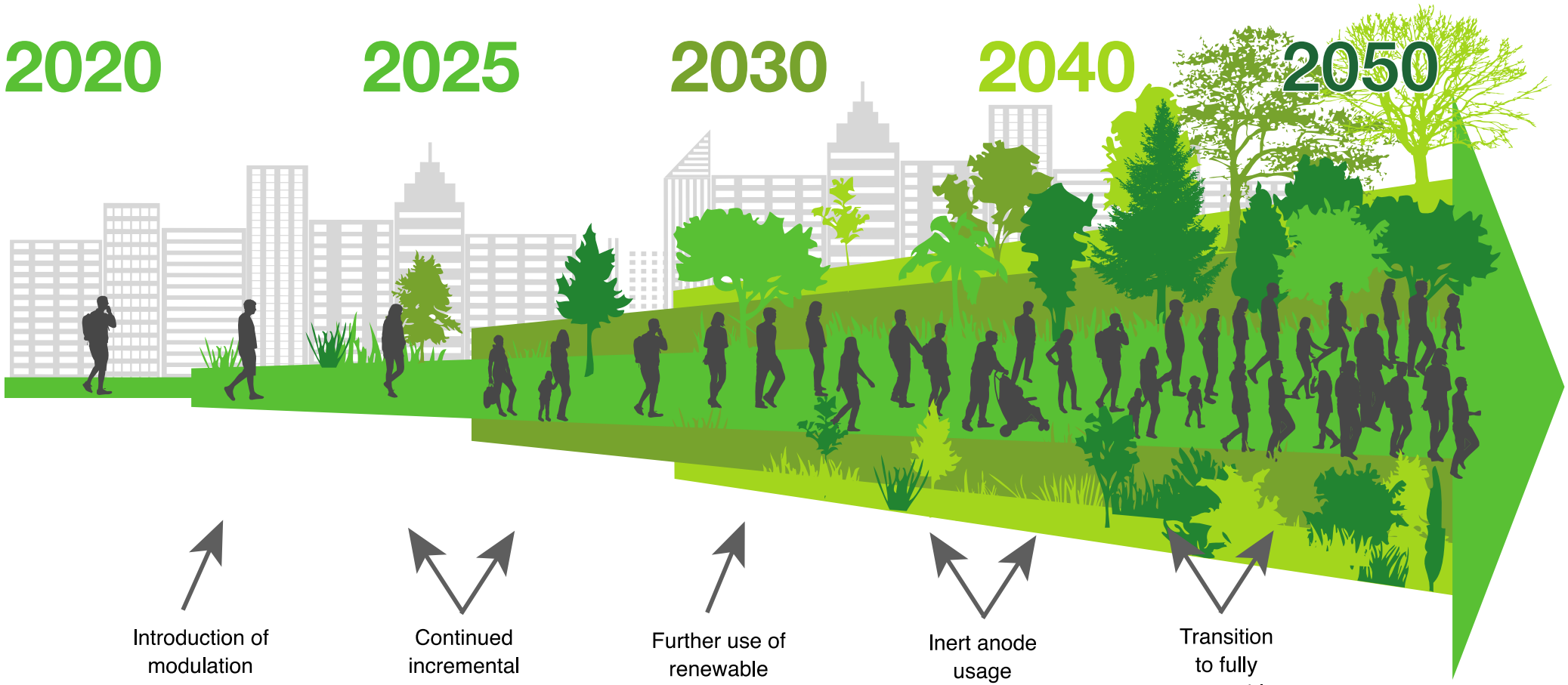
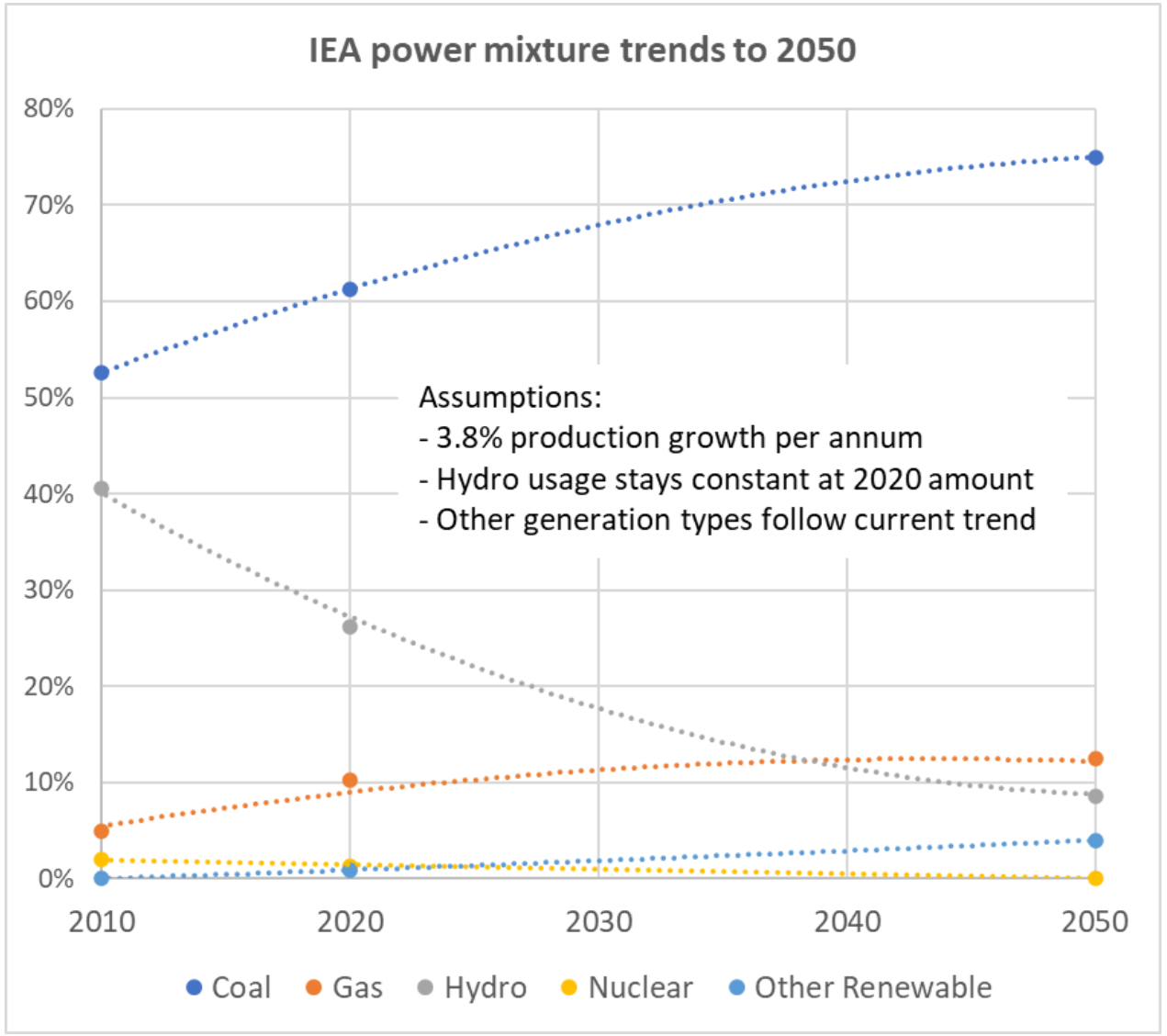
Acknowledgements: Dr Nick Depree, Geoff Matthews, Dr David Wong

Primary Aluminium Smelting Pathway to Zero Carbon 2050



Primary Aluminium Production

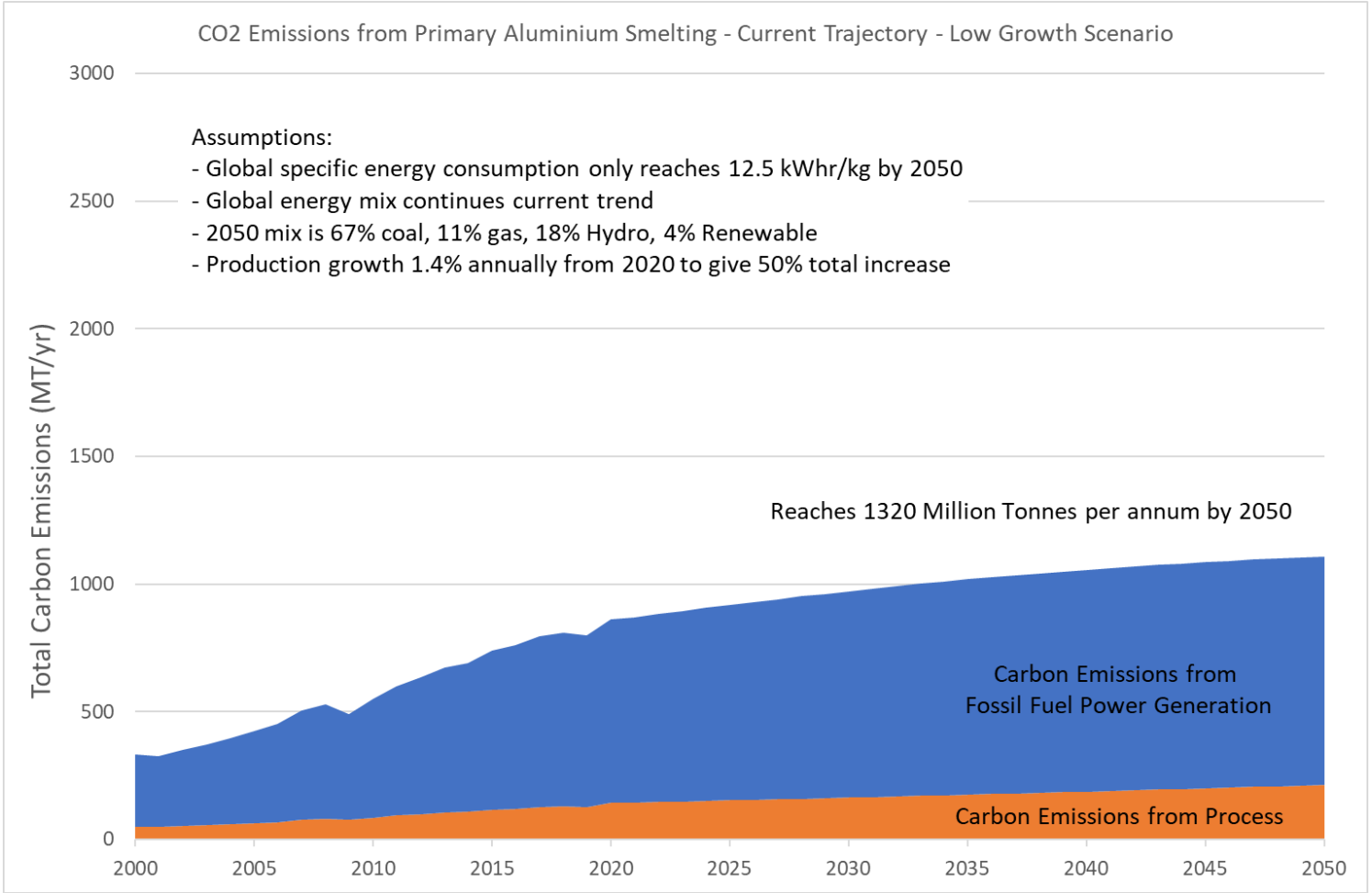
- The current energy mix trajectory shows a continued increase in coal and diminishing percentage of ‘green’ aluminium.



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

Current trajectory – low growth scenario (1.4%)

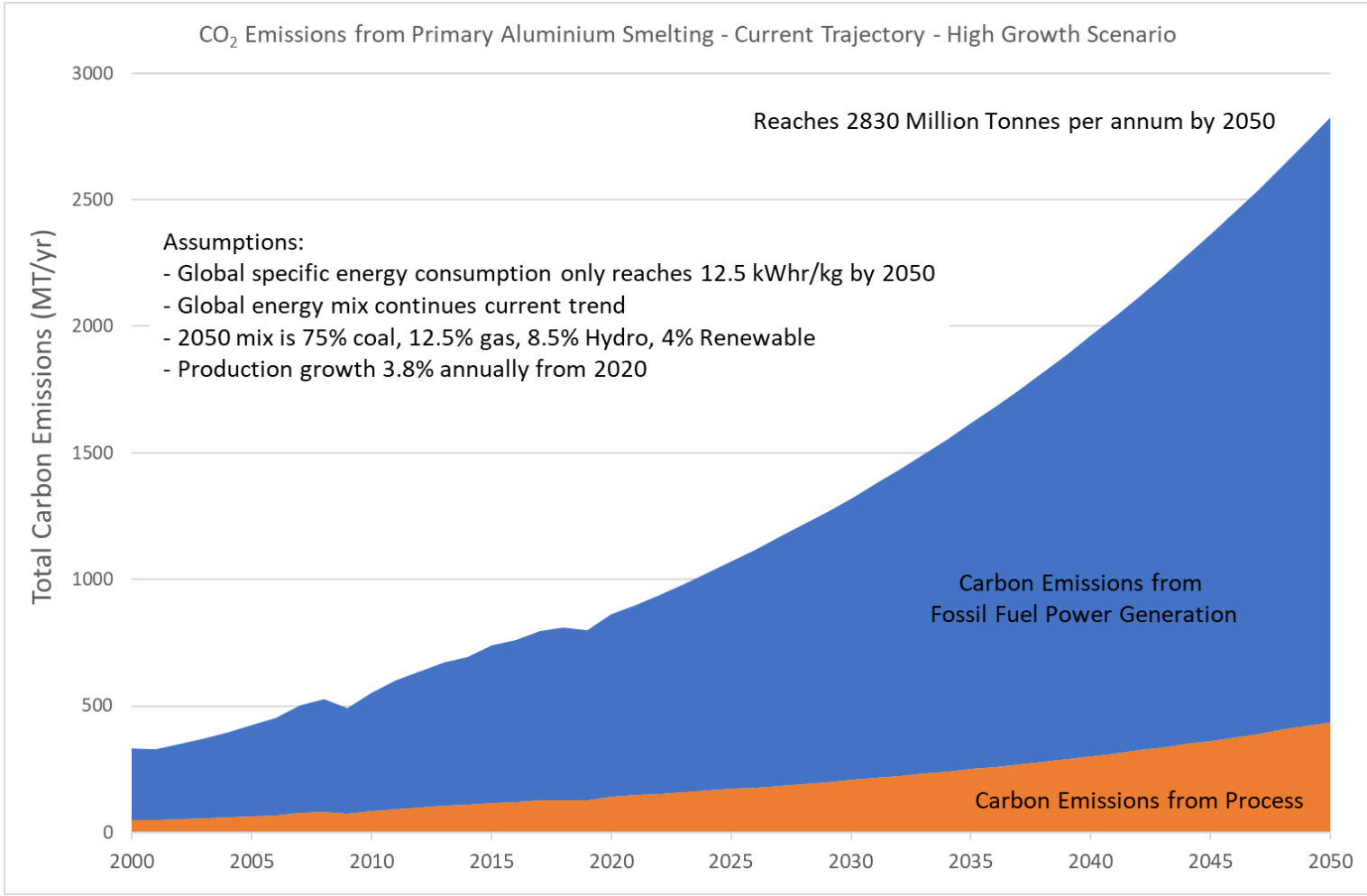
- Reaching 1.32 billion tonnes per annum by 2050
- Low growth scenario @ 1.4% amounts to 34.3 billion tonnes of CO_2 cumulatively from 2020-2050
- The equivalent of 43% of all the passenger vehicles in the world today.
- Will be unsustainable and unacceptable on a global scale
- Aluminium won't remain 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 CO_2 into the atmosphere from 2020 – 2050
- By 2050 Al smelting will be the consumer responsible for 100% of the CO_2 from fossil fuel power generation globally
- This is equivalent to over 90% of the CO_2 emissions from all of the passenger vehicles in the world today
- Will make the decarbonization-effect from light-weighting an urban myth.



Sources: An initial assessment of the impact of the covid-19 pandemic on global aluminium demand, 18 May 2020, CM Group.
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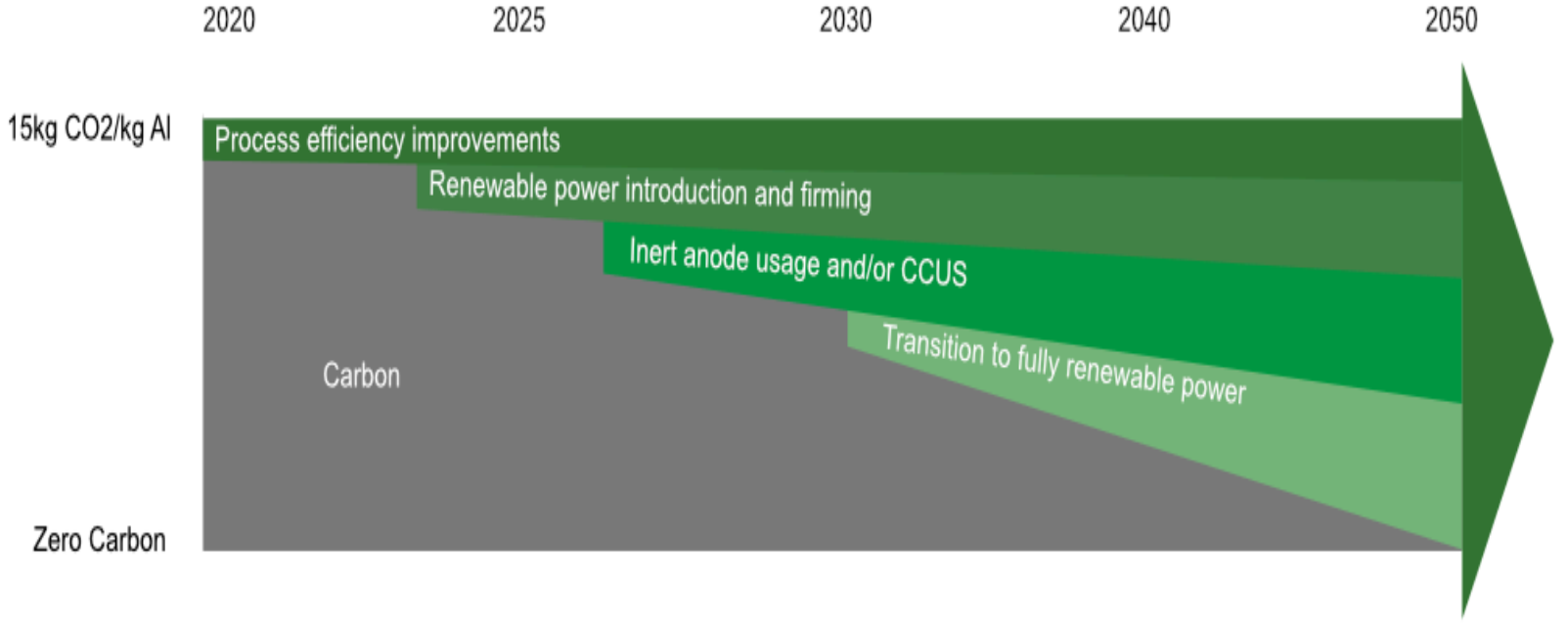
https://www.europarl.europa.eu/news/en/headlines/society/20190313STO31218/co2-emissions-from-cars-facts-and-figures-infographics
https://www.carbonbrief.org/mapped-worlds-coal-power-plants

Five Planks on the Pathway to Achieve Zero Carbon

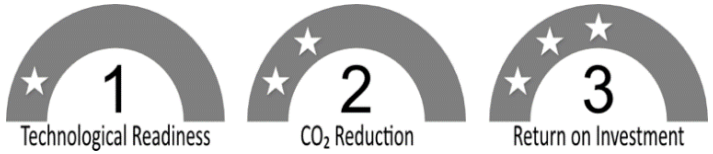
There are only five possible options to significantly reduce carbon emissions by 2050 (only four while maintaining growth):

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.

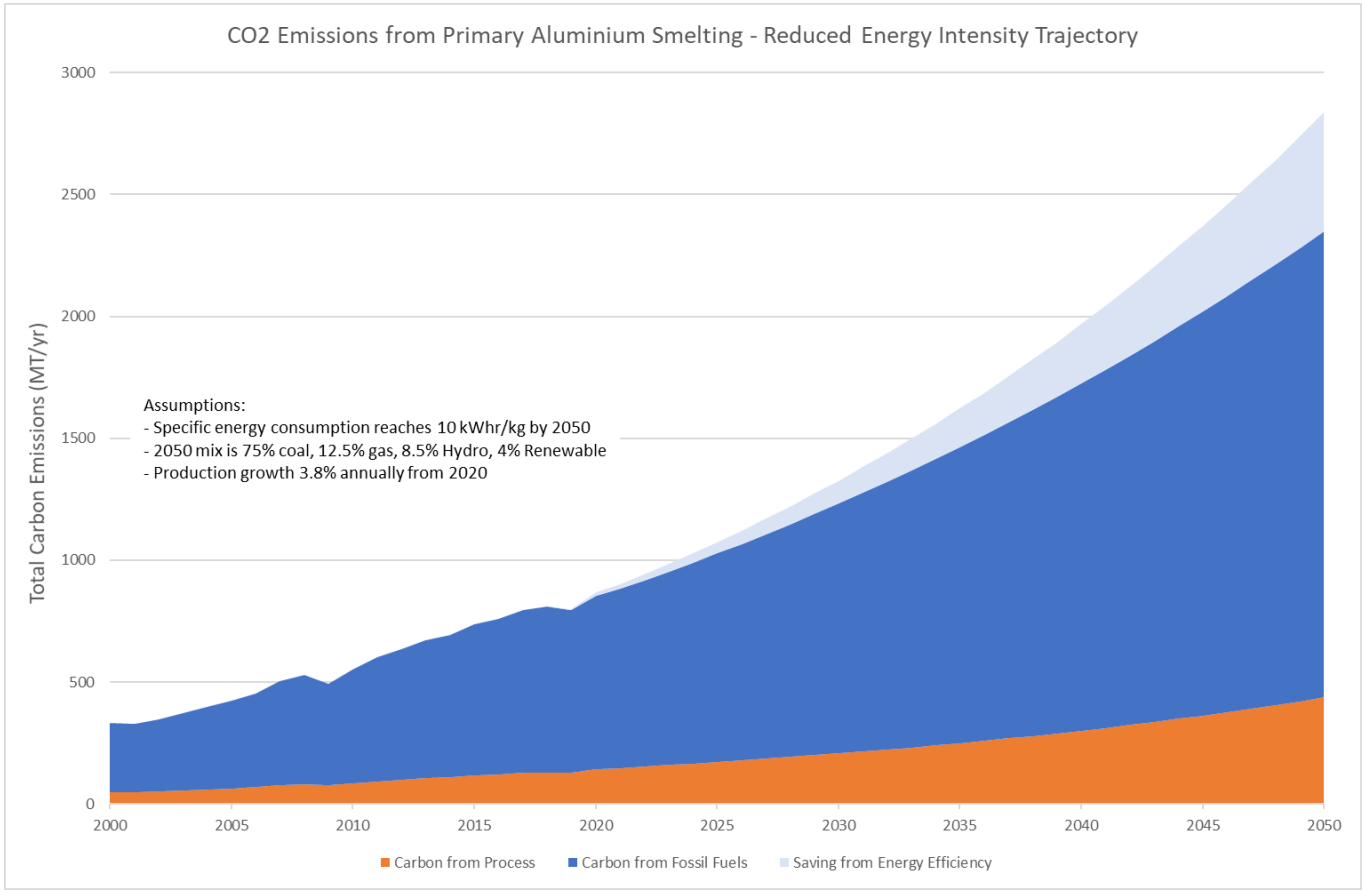


A - Process Efficiency Improvements

Reducing energy intensity of primary aluminium to a present-day vision target of 10kWh/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).

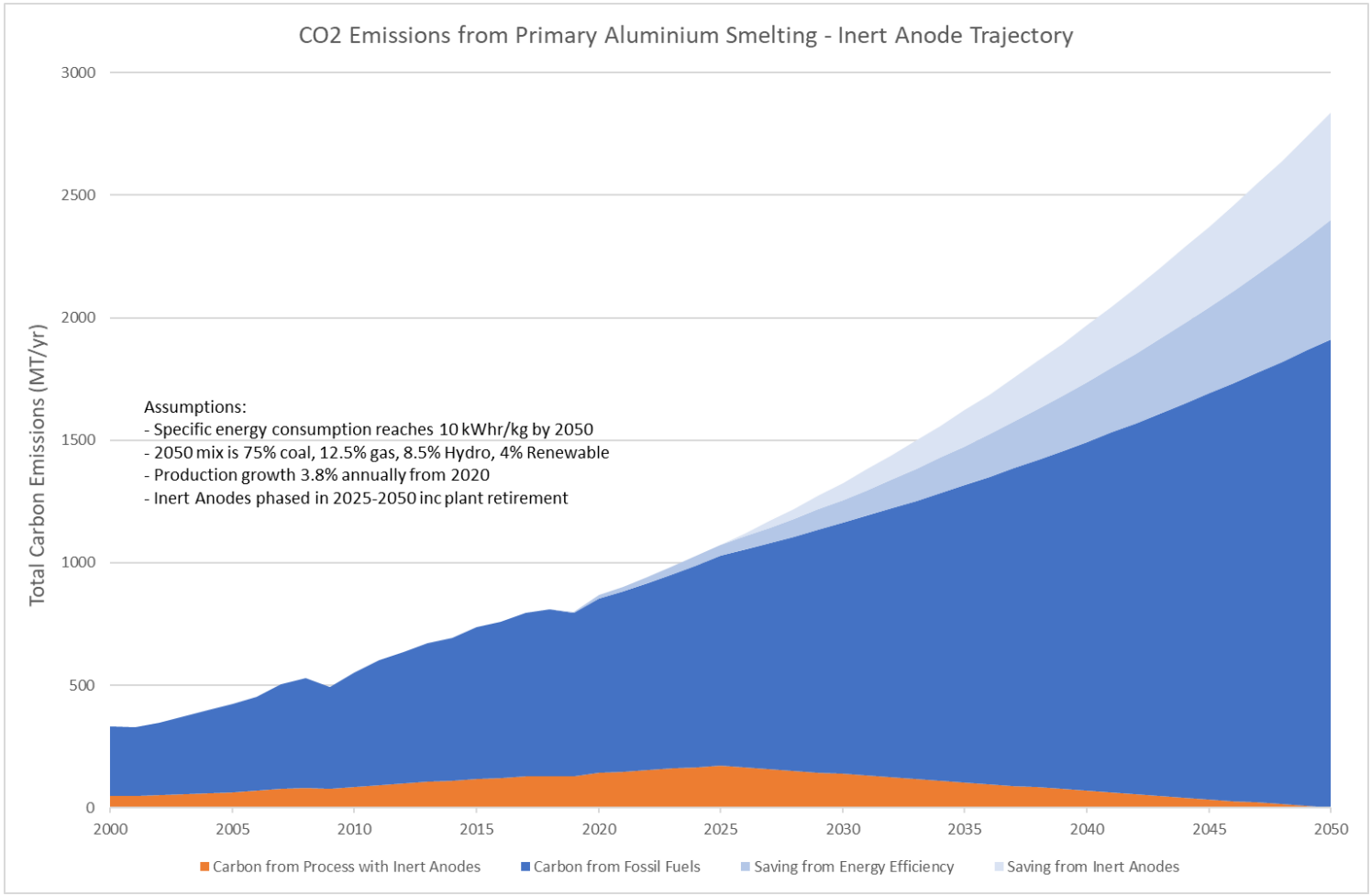


Sources: http://www.world-aluminium.org/statistics/primary-aluminium-smelting-energy-intensity/
https://www.lightmetalage.com/news/industry-news/smelting/karmoy-technology-pilot-world-leader-primary-aluminum-energy-efficiency/

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 ???



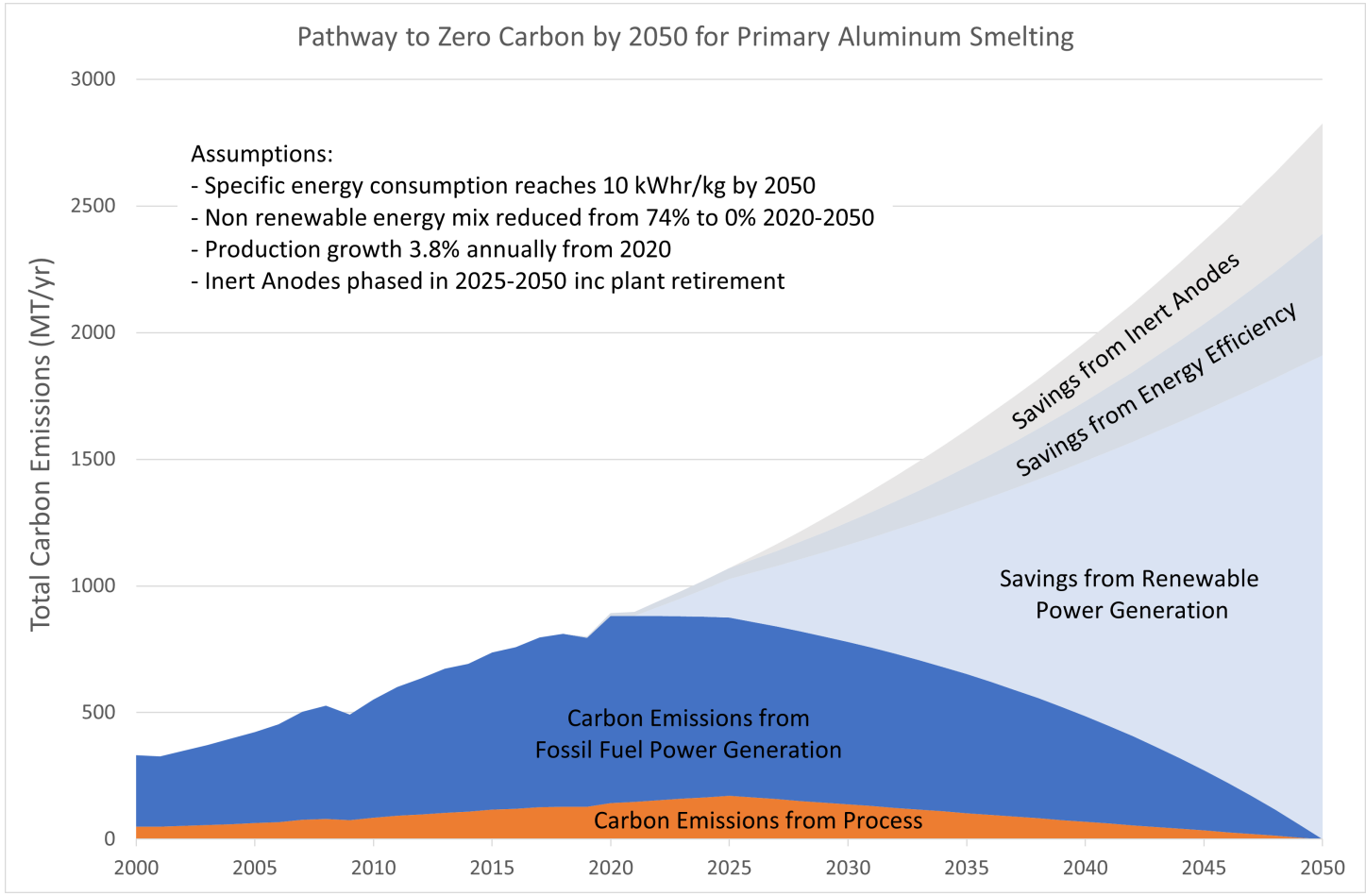
436 million tonnes p.a. savings by 2050 (if deployed across the entire smelting fleet)

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

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.

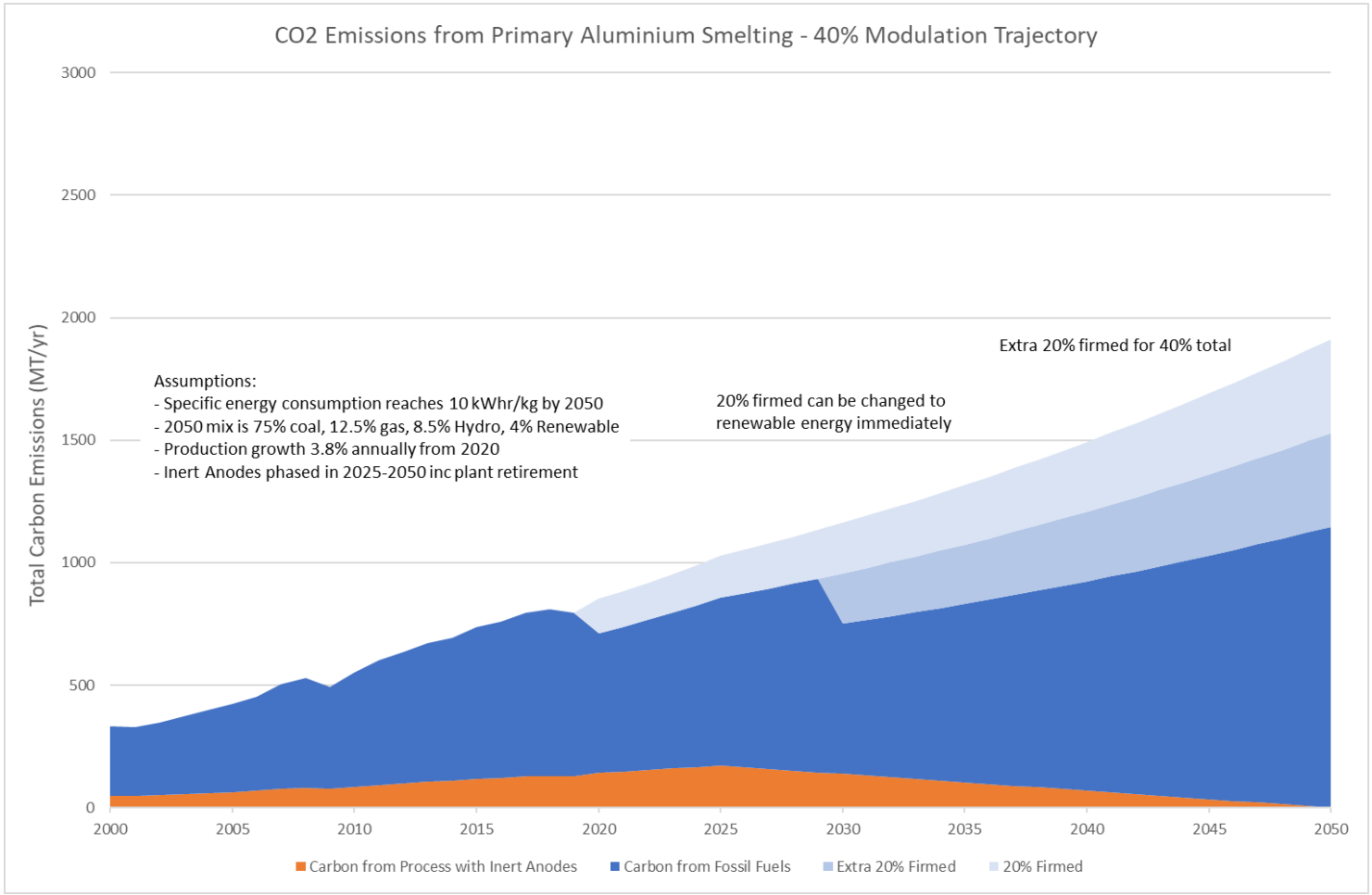


Sources: https://www.iea.org/reports/aluminium

C_1 - 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 straight forward 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)



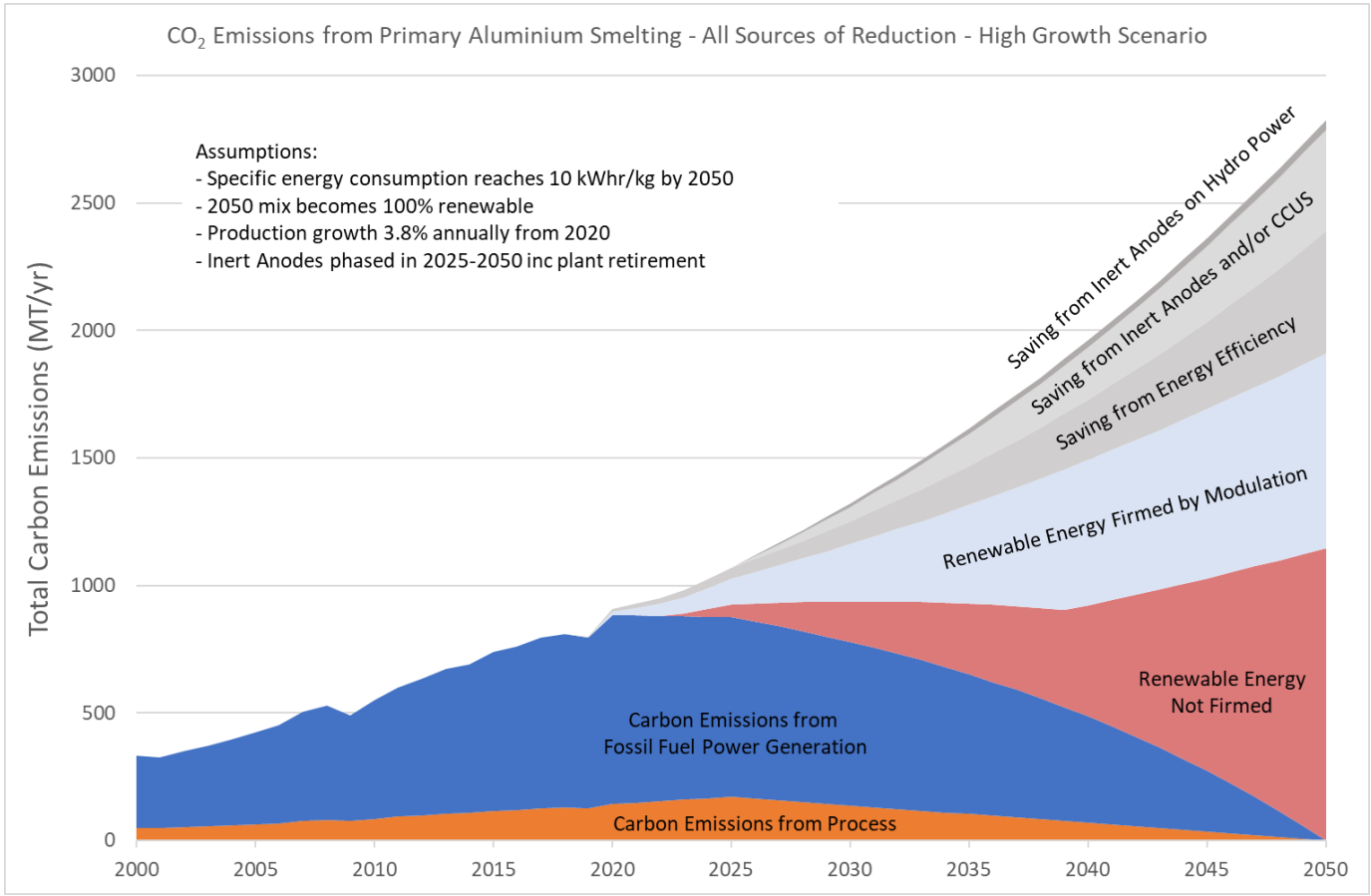
Sources: https://www.iea.org/reports/aluminium

764 million tonnes CO_2 annual savings by 2050

C_2 – 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 et al)
  - 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

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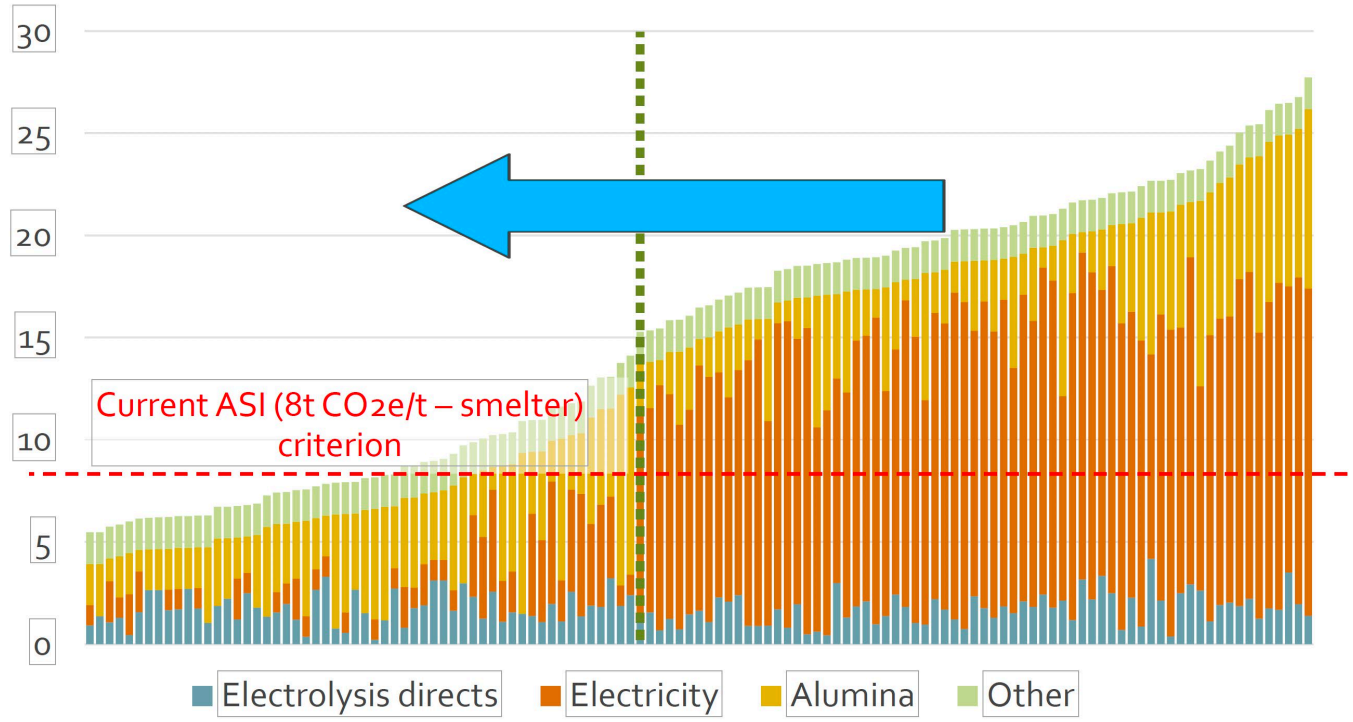
D – Carbon Capture, Utilisation and Storage

- *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 CO_2 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.