The Element of **Possibility**™

Renewables and Electrification in Alumina Refining

Net Zero Emission Mining in Western Australia Conference
October 2021

Ray Chatfield

Alcoa

Advancing Sustainably

Operations
Reduce risk exposure: minimise environmental impacts to improve our footprint

Products
Improve value: enhance our products through differentiation

Communities
Obtain the right to grow: create sustainability value for the communities where we operate

SUSTAINABLE DEVELOPMENT GOALS

ICMM International Council on Mining & Metals

asi Aluminium Stewardship Initiative

Net zero greenhouse gas emissions by 2050

- Our ambition is to achieve net-zero greenhouse gas emissions globally by 2050
- Builds on our existing reduction targets of 30 per cent by 2025 and 50 per cent by 2030 from 2015 baselines
- We aim to achieve this by:
  - Increasing the use of renewable energy
  - Growing our low-carbon portfolio
  - Bringing breakthrough innovations to the market

Alumina Refining and GHG Emissions

In 2020, GHG emissions from Australia's alumina refining represented 2.7% of Australia's total emissions.

Alumina refining GHG emissions are:

- **70%** from the low-temperature Bayer process
- **24%** from the high temperature calcination of alumina tri-hydrate and miscellaneous emissions
- **6%** from electricity imports

IMAGE: ALCOA'S PINJARRA ALUMINA REFINERY

Addressing Bayer process emissions

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IMAGE: ALCOA'S PINJARRA ALUMINA REFINERY

Renewable Bayer Process Heat Technology Review

SOLAR THERMAL

- Low penetration (27-50%) at existing refineries[1]

HYDROGEN

- Expensive at forecast prices[2]
- Not proven at commercial scale sizes

BIOMASS GROWN AS A FUEL

- Uneconomic under current conditions

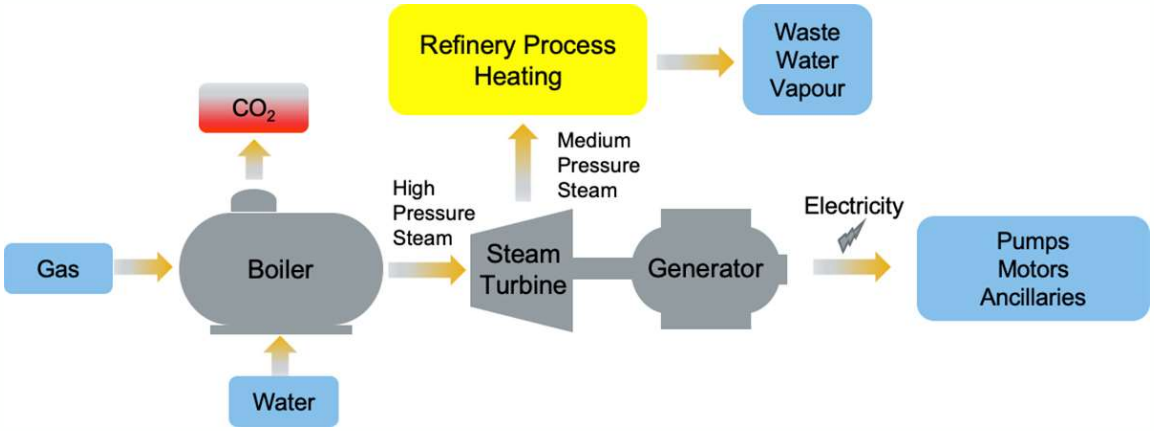
Mechanical Vapour Recompression

- Zero carbon potential with 100% renewable grid power
- Reliable power grid, no need for back up infrastructure
- Economics positive for new facilities, plausible for retrofit cases
- Reduced water use as boiler feed water eliminated

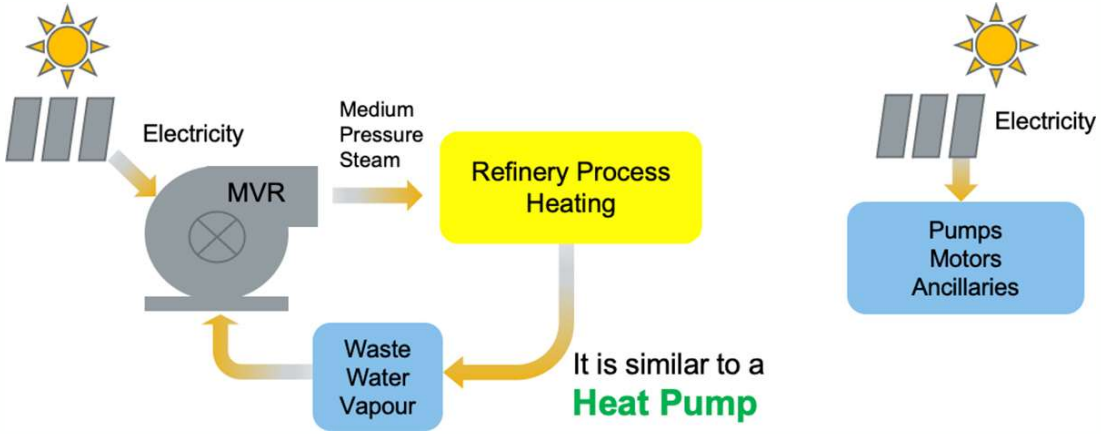
1. Lovegrove, Bader, Bayon and Beath, March 2020 | 2. https://www.csiro.au/-/media/Do-Business/Files/Futures/18-00314_EN_NationalHydrogenRoadmap_WEB_180823.pdf

MVR Eliminates Fossil Fuel Use in Process Steam Production

Current condition
Fossil fuel burned in boilers to make steam for process heat



Future condition
Renewable electricity drives MVR equipment to compress waste vapour to make steam for process heat



ARENA: Concept to Reality

Alcoa

Australian Government
Australian Renewable Energy Agency

ARENA

Three Fundamentals

- Significant
- Replicable
- Demonstration

Funding Process

- **Expression of Interest** - Independent Panel
- **Full application** - Board Approval

ARENA will offer full assistance with your application development

Alcoa uses $11m grant to test its green plan

JOSH ZIMMERMAN

Alcoa will look at using renewable energy to slash carbon emissions at its Wagerup plant after receiving a $11.3 million Federal Government grant.

focus on reducing energy prices to support consumers and energy-intensive businesses like aluminium smelters.

If the feasibility study is successful, Alcoa vice-president for continuous improvement Euge-

This Project received funding from ARENA as part of ARENA's Advancing Renewables Program

SOURCE: THE WEST AUSTRALIAN

Decarbonising the Bayer Process

Alcoa

Australian Government
Australian Renewable Energy Agency

ARENA

MVR Project – Key Aspects

1. Wagerup Demonstration
2. Retrofit and Growth Study

Economics support new facilities and plausible for retrofit installations

Long-term Industry Vision

- Significantly reduce fossil fuels from Bayer process
- Leverage Australia's abundant renewable energy
- Reduce water use by approximately 25 GL per annum

Wagerup Demonstration

Process

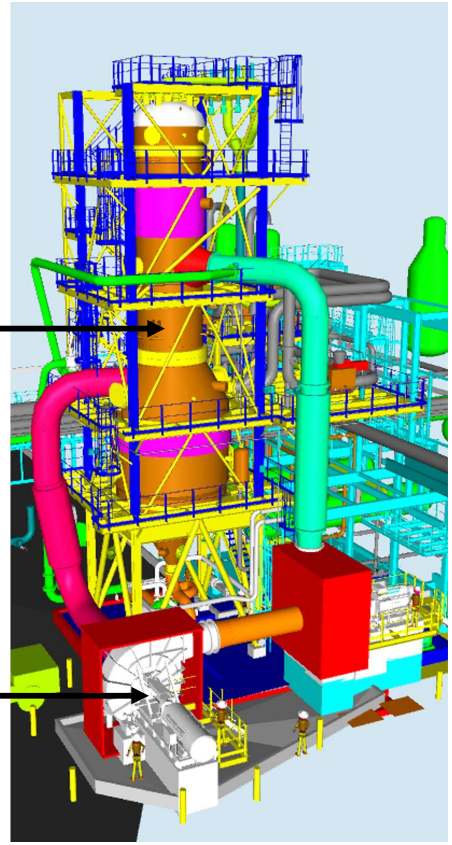
- Vapour exiting the evaporator is compressed, increasing its condensing temperature providing the thermal driving force in the heat exchanger to evaporate more liquid

Wagerup Demonstration

- Two low speed compressors in series with a total installed capacity of 4 MW will be retrofitted to an existing falling film evaporator.
- Presently in FEL3 Engineering phase
- Commissioning planned 2023

Key Objectives

- Demonstrate MVR operation in an alumina refinery
- Demonstrate load flexibility



ARENA and Alcoa - Retrofit and Growth

Retrofit capability is extremely important given that refineries can remain viable over 60 years

To retrofit an existing conventional evaporator, we need to take waste vapour at 50°C and 14 kPa absolute, almost a vacuum and compress it to 850 kPa absolute to replace boiler steam

- Requires ~13 proven conventional compressors in series
- Requires very high volume compressors due to the low inlet pressure
- Not aware of any MVR facility that does this

To fully convert Wagerup to MVR, we would need about 70 low speed compressors and 200 MW of import renewable power

Finding space for, and managing maintenance of this many compressors would be a challenge, particularly in older refineries

IMAGE: EIGHT COMPRESSORS IN SERIES COURTESY PILLER

Compressors

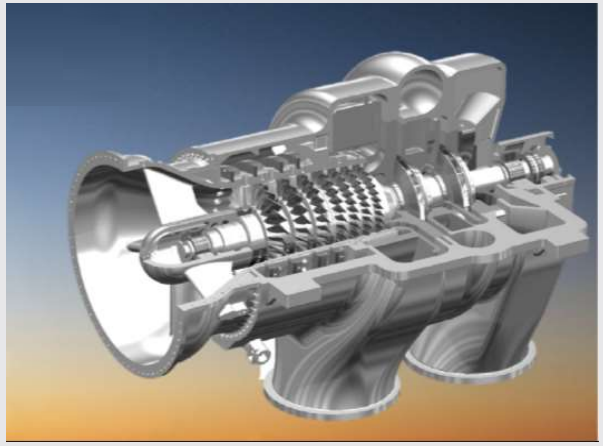
We are working with compressor suppliers

There are 3 styles of compressors available on the market.

1) Low speed centrifugal – ~3000 rpm
   - Proven, robust and make up most of the MVR market .
   - 13 required in series for the previous duty

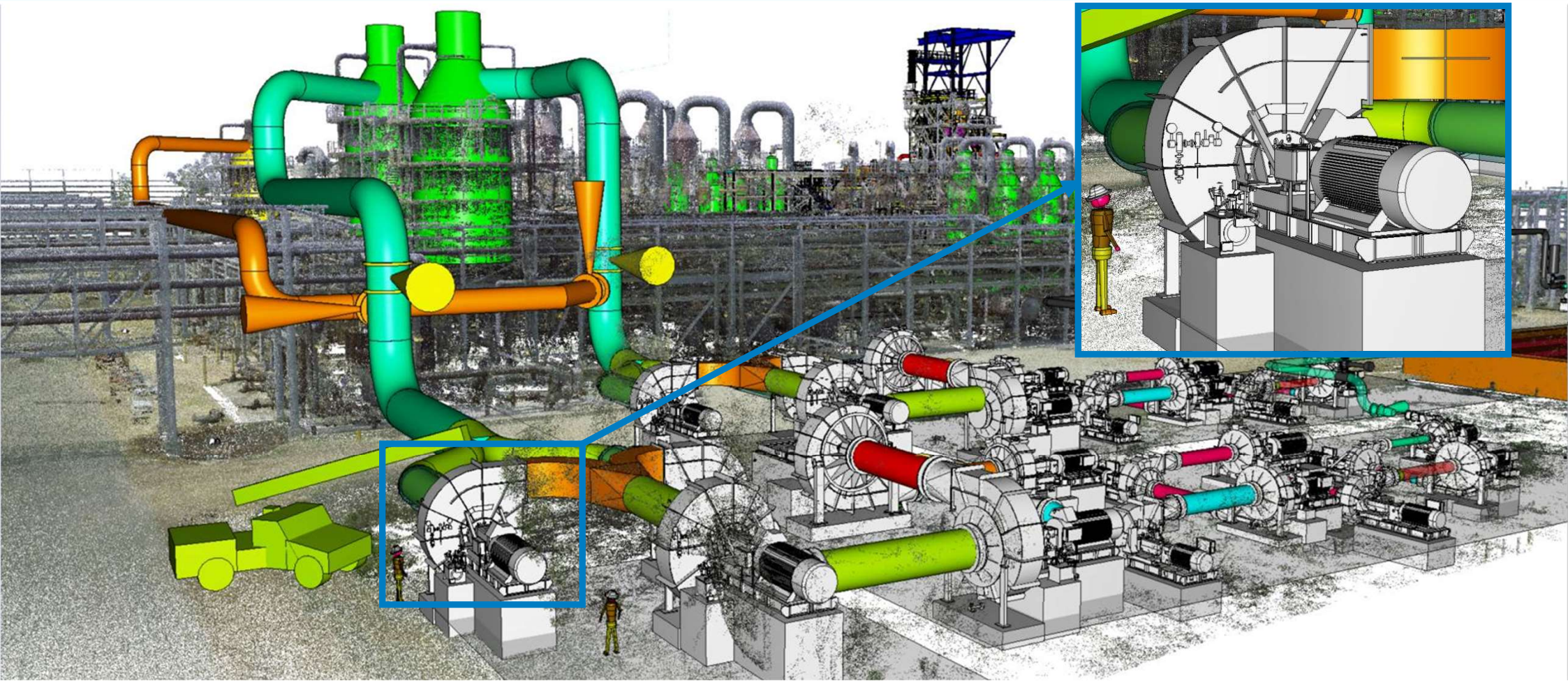
2) High speed centrifugal, gear driven – +7000 rpm
   - Proven in many installations
   - 8 required in series for the previous duty

3) High speed axial flow
   - High capacity and compact
   - Developed for air separation units

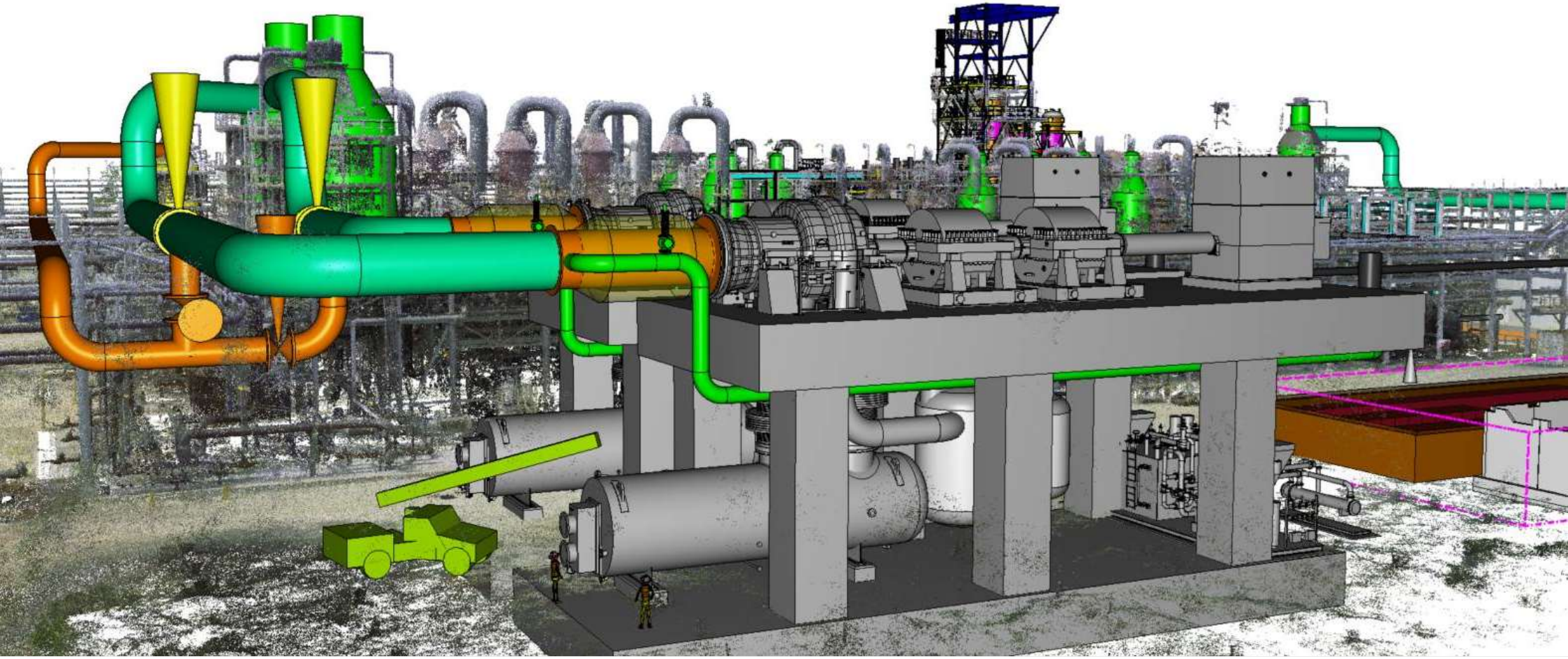


IMAGES COURTESY HOWDEN AND MAN

Retrofit Study Status - Layouts - 13 Stages



Retrofit Study Status - Layouts - Axial 1st Stage, Single Drive



Addressing Calcination emissions

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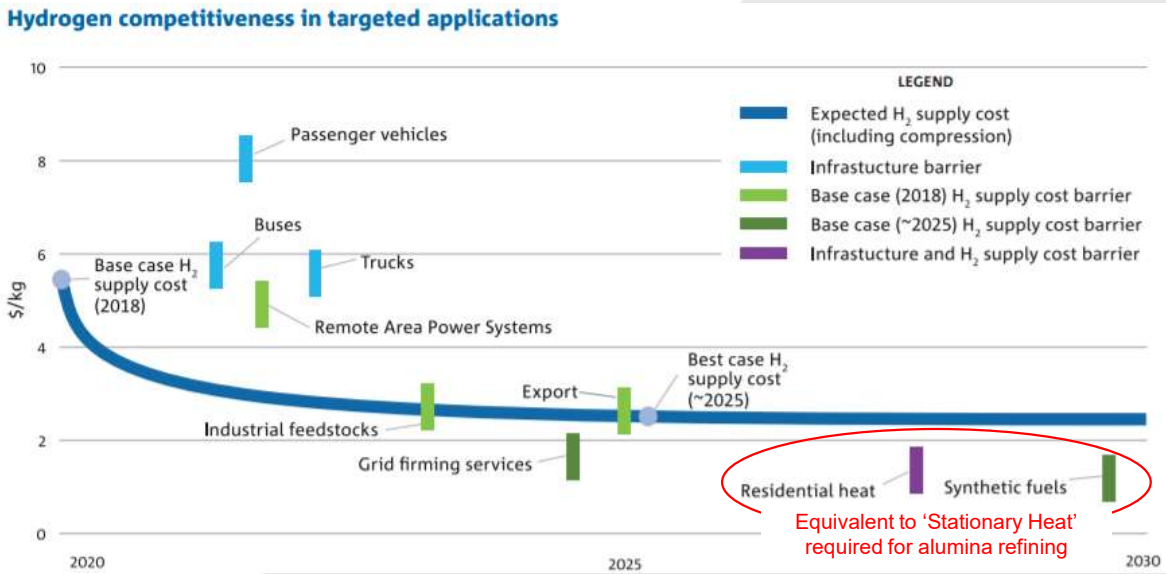
IMAGE: ALCOA'S PINJARRA ALUMINA REFINERY

Calcination: 24% of emissions

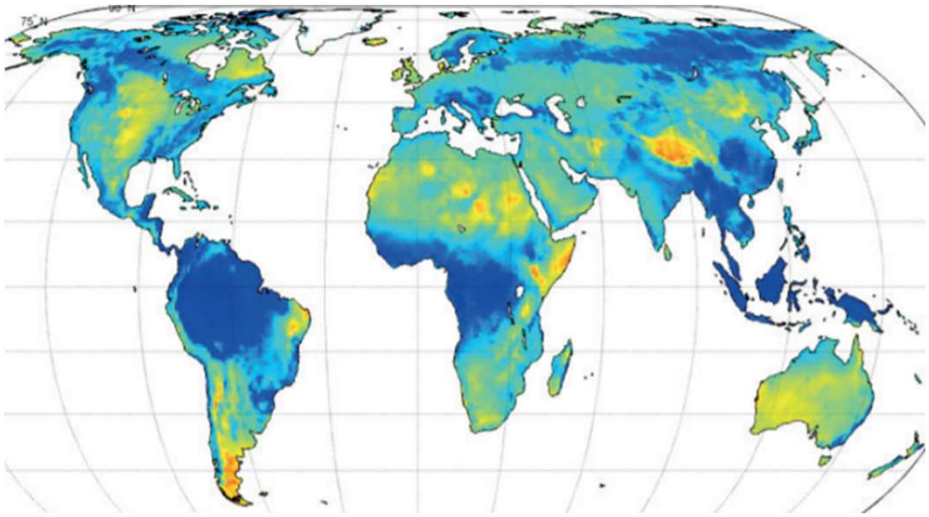
- Calcination of alumina trihydrate to alumina is a high temperature process
- Crystals are heated to ~1000°C to drive off chemically combined water
- Electric power consumption is very high through routes of H_2 production then combustion, or direct electric heating
- H_2 is not forecast to be competitive in the near future
- Power consumption for electrification of calcination in WA at today's production rates will be in the order of 1,500 MW



https://www.csiro.au/-/media/Do-Business/Files/Futures/18-00314_EN_NationalHydrogenRoadmap_WEB_180823.pdf

Renewable Power

- To be effective in decarbonising the industry we must use low carbon power
- Australia has abundant renewable energy resources, in particular Western Australia, providing a strategic advantage
- SWIS grid Whole of System Plan indicates the lowest cost form of new power is renewable
- New load is ~95% served by new renewables[1]
- Total electrification load for WA refineries would be in the order of 2000 MW at today's production rates



Hybrid solar and wind full load hours adjusted by critical overlap in 2005. Philibert 2017.

Source: Adapted and based on Fasihi, Bogdanov and Breyer (2016), "Techo-Economic Assessment of Power-to-Liquids (PtL) Fuels Production and Global Trading Based on Hybrid PV-Wind Power Plants".

1. By comparing high and low load scenarios in the SWIS WOSPumption

Summary

- MVR presents a step-change opportunity for the alumina industry to use renewable energy to displace fossil fuel energy
- Reduce up to 70% of CO2-e which equates to 10 Mt CO2-e per annum in Australia's six alumina refineries
- Reduce water use by approximately 25 GL per annum
- In a carbon constrained world, MVR has potential to leverage Australia's renewable energy advantage and grow the alumina industry
- Development is required to prove the MVR building blocks before they can be implemented at this scale

Thank you

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