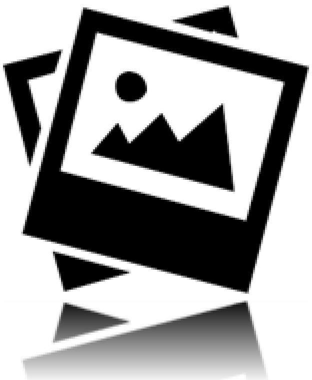
MECLA

Steel Snapshot



Hydrogen and Steel Manufacturing

WHY

There is no single solution to low-emissions steelmaking, and consideration of a broad portfolio of technological options is required. Hydrogen is one potential solution.

WHAT

Hydrogen (H2) can be extracted from hydrogen-bearing fuels, such as natural gas and biogas, and water using electrolysis. The primary source of hydrogen production is currently natural gas, accounting for around three-quarters of the annual global dedicated hydrogen production of around 70 million tonnes. Currently, less than 0.1% of global dedicated hydrogen production comes from water electrolysis[1], but investments are being made to increase this significantly[2].

The energy source for creating hydrogen determines its carbon factor. The Clean Energy Regulator is taking steps through the Guarantee of Origin to track and verify the emissions associated with hydrogen.

Green Hydrogen

When the electricity used for electrolysis comes from renewable sources, the hydrogen produced is called ‘green hydrogen’.

Grey Hydrogen

Hydrogen from natural gas steam re-forming is called 'grey’.

Blue Hydrogen

Hydrogen from natural gas steam re-forming where carbon emissions are captured and stored is called 'blue'.

Hydrogen in the Steel Industry

Approximately 70% of global steel production is produced via the Blast Furnace-Basic Oxygen Furnace (BF-BOF) steelmaking method. The process utilises carbon (most commonly from metallurgical coal) as the key element in the chemical reaction to extract iron from iron ore. Emissions of carbon dioxide are a byproduct of this chemical reaction. Approx 1.85 tonnes of CO_2 emitted per 1 tonne of steel produced[3].

Steel companies are currently looking at hydrogen use in two key ways:

Hydrogen Reduction Technology

Developing and deploying breakthrough hydrogen reduction technology, virtually eliminating direct greenhouse gas (GHG) emissions from the ironmaking process. The International Energy Agency (IEA) views hydrogen reduction as very important for net-zero emission and at technology readiness level (TRL) 5, likely to be available from 2030[4].

Blended Reduction Technology

Transitional use of hydrogen by blending it with fossil-based reductants, using it in conventional steelmaking processes (Blast Furnace and Direct Reduced Iron (DRI)) to improve greenhouse gas efficiency. The approach is rated by IEA at TRL 7, ready for deployment in 2025[4].

Direct Reduced Iron (DRI) is the term given to a group of processes for making iron from ore. In order to be converted into steel, DRI needs to be further processed in an Electric Arc Furnace (EAF) or Basic Oxygen Furnace (BOF).

Hydrogen DRI-EAF

- Replaces natural gas in DRI production stage with hydrogen.
- Not yet commercially viable at scale, however, is a technically feasible low-carbon iron production method.
- Requires specific iron ore grades for DRI (less than 15% of Australian seaborne ores).
- Relies on the supply of appropriate volumes of green hydrogen at affordable rates[6].

Hydrogen DRI-Melter-BOF

- Enables existing BOF-Caster configuration to continue to be utilised.
- Could potentially use lower-grade ores, that is hematite ores predominant in the Pilbara.
- The Melter removes the unwanted material (gangue) from the hematite ore.
- Relies on the supply of appropriate volumes of green hydrogen at affordable rates[6].

Challenges

SCALE UP

Less than 0.1% of global dedicated hydrogen production today comes from water electrolysis. If all current dedicated hydrogen production were produced through water electrolysis, this would result in an annual electricity demand of 3,600 TWh – more than the annual electricity generation of the European Union. Under IEA's Sustainable Development Scenario, global demand for hydrogen increases to 287Mt by 2050, which represents an increase of over 400% from 2020. This presents a massive scale up challenge[1].

SAFETY

Like other energy carriers, hydrogen presents certain health and safety risks when used on a large scale. It requires special equipment and procedures to handle it. Hydrogen is so small it can diffuse into some materials, including some types of iron and steel pipes, and increase their chance of failure. It also escapes more easily through seals and connectors than larger molecules, such as natural gas.[1]

INFRASTRUCTURE

Hydrogen can be difficult to contain and specialised infrastructure may need to be developed to enable distribution at scale. Existing natural gas transmission pipes could be converted to deliver pure hydrogen in the future if they are no longer used for natural gas, but their suitability must be assessed on a case-by-case basis. A further challenge is that three times more volume is needed to supply the same amount of energy as natural gas. Additional transmission and storage capacity across the network might therefore be required.

Electrolysis requires water as well as electricity. Around 9 litres of water are needed to produce 1 kg H_2, producing 8 kg of oxygen as a co-product. This could be a challenge in water stressed areas.[1]

COSTS

The IEA found that innovative process routes can be expected to cost 10-50% more than commercially available counterparts within a given regional context, noting this cost increase significantly exceeds profit margins from steelmaking today.[5]

The IEA analysis found that the cost of producing hydrogen from renewable electricity could fall 30% by 2030 as a result of declining costs of renewables and the scaling up of hydrogen production.[4]

Australian Challenges

COMMERCIAL AVAILABILITY OF GREEN HYDROGEN

DRI-Melter-BOF provides a potentially capital efficient pathway to decarbonisation as it potentially utilises existing BOF and Caster assets. However, until green hydrogen is commercially available at scale, current / proposed DRI pilot projects of scale will continue to use natural gas.

Significant investment in an Australian hydrogen industry and supporting infrastructure is required to deliver economic hydrogen supply. This will likely take a number of investment cycles as well as continued supportive policy from Governments[6]. The South Australian Government is investing in Green Hydrogen to drive change with impacts yet to be reported.

REPLACING NATURAL GAS

Natural gas is inexpensive, and hydrogen is not yet a feasible replacement for natural gas:

There is currently no at-scale production of green hydrogen. The development of green hydrogen production on a commercial scale is currently in its infancy.

As a replacement for natural gas, even if green hydrogen can be produced at the Federal Government's stretch target of $2/kg ($16/GJ), the cost would still be materially above the current cost of natural gas.

To be a partial economic substitute for coal in the blast furnace, hydrogen would need to be below $1/kg.

CSIRO

An overview of hydrogen projects in Australia can be found on the CSIRO website https://www.csiro.au/en/maps/Hydrogen-projects

References

INTERNATIONAL EXAMPLES

HYBRIT (Sweden) https://www.hybritdevelopment.se/en/

H2 Green Steel (Sweden) https://www.h2greensteel.com/

END NOTES

1 https://worldsteel.org/wp-content/uploads/Fact-sheet-Hydrogen-H2-based-ironmaking.pdf

2 https://www.csiro.au/en/maps/Hydrogen-pr

3 https://www.mckinsey.com/industries/metals-and-mining/our-insights/decarbonization-challenge-for-steel

4 https://www.iea.org/reports/the-future-of-hydrogen

5. https://www.iea.org/reports/iron-and-steel-technology-roadmap

6. https://s3-ap-southeast-2.amazonaws.com/bluescope-corporate-umbraco-media/media/3314/bluescope-investor-day-presentation-day-1.pdf