SUSTAINABLE FERTILISERS FOR AUSTRALIAN GROWERS

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

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Introduction

In 2022, GRDC commissioned Spiegare Consulting[1] to review the status of sustainable fertiliser production (particularly green hydrogen, green ammonia and green urea) and identify the potential for GRDC to influence or support upstream technology development in this space.

The Spiegare report reviewed costs, current investments, energy requirements, greenhouse gas emissions, and roadblocks to commercialisation. From these insights, GRDC is establishing its position on research, development and extension (RD&E) investments in this space. Overall, involvement in large-scale commercial ventures is beyond GRDC's remit, although support for innovative projects may benefit from RD&E engagement.

Current market insights

Fertiliser is an essential input for modern cropping systems. Achieving yield potential and replacing harvested nutrients requires substantial seasonal inputs. Nitrogen requirements dominate growers' fertiliser budgets, with potassium and phosphates also significant. As a result, most fertilisers are nitrogen compounds including urea, monoammonium phosphate, diammonium phosphate, ammonium sulphate and other nitrogen-phosphorus-potassium (NPK) mixtures.

The global demand for fertiliser is approximately 200 million tonnes per annum (MTPA), with urea accounting for about 55 per cent or 110 MTPA.[2]

Photo: ©GRDC.

Fertiliser is an essential input for modern cropping systems. However, ammonia production, essential for nitrogen fertilisers, currently accounts for three per cent of global carbon emissions.

In recent years, Australia has imported about 2.4MTPA of urea,[3] generally from producers in the Middle East and China. This urea (and most other fertiliser) is produced from ammonia made by combining atmospheric nitrogen with hydrogen from natural gas or coal feedstock, using the well-established Haber-Bosch chemical synthesis process.

Including hydrogen and nitrogen production, ammonia production accounts for one to two per cent of global energy consumption, three to five per cent of global natural gas consumption, and three per cent of global carbon emissions.[4]

The Australian agriculture industry is facing significant greenhouse gas reduction targets and fertiliser production offers a notable opportunity to reduce the industry's carbon footprint.

Australian fertiliser security and sustainability

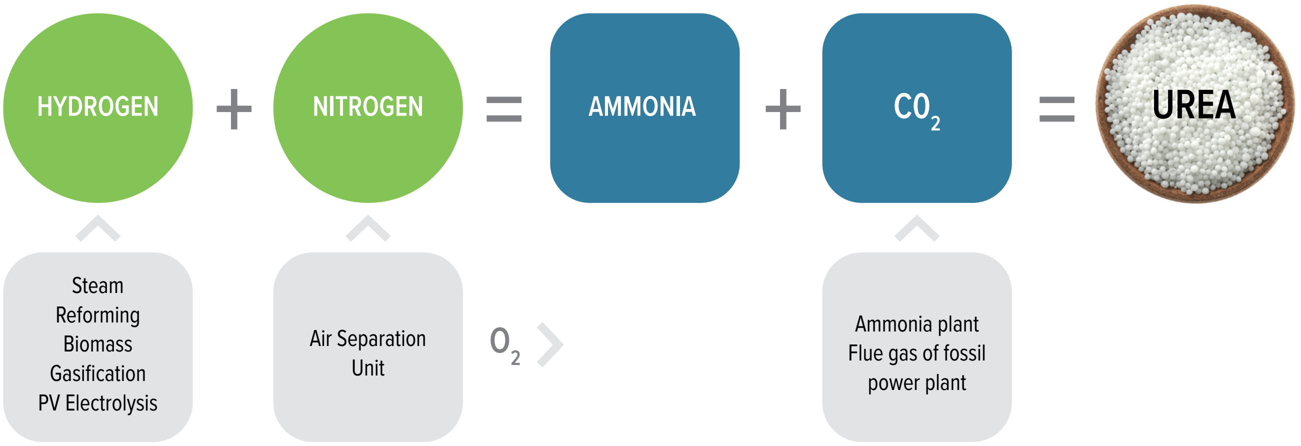
In modern cropping systems, food security and fertiliser security go hand in hand. Recent global events have highlighted the vulnerability of Australia's fertiliser supply to fuel feedstock prices, transport costs and geopolitical events.

Ammonia is the main intermediary for nitrogen in all nitrogen-based fertilisers and about 80 per cent of the ammonia produced globally is used as agricultural fertiliser.[5]

While Australia has considerable coal and gas supplies for ammonia production, it also has abundant sustainable energy potential that could be used to de-carbonise hydrogen, ammonia and fertiliser production for both domestic and export supply.

This would have the added benefit of decoupling domestic ammonia production from global fossil fuel prices.

FIGURE 1. Urea production.



$H_2 + 3N_2 = 2NH_3$

$2NH_3 + CO_2 = NHSCOONH_4 \rightleftharpoons NH2CONH_2$ (UREA) $+ H_2O$

Source: Alfian, M. & Purwanto, W. W., 'Multi-objective optimization of green urea production', *Energy Sci Eng*., 2019; vol. 7, pp. 292–304. doi: 10.1002/ese3.281

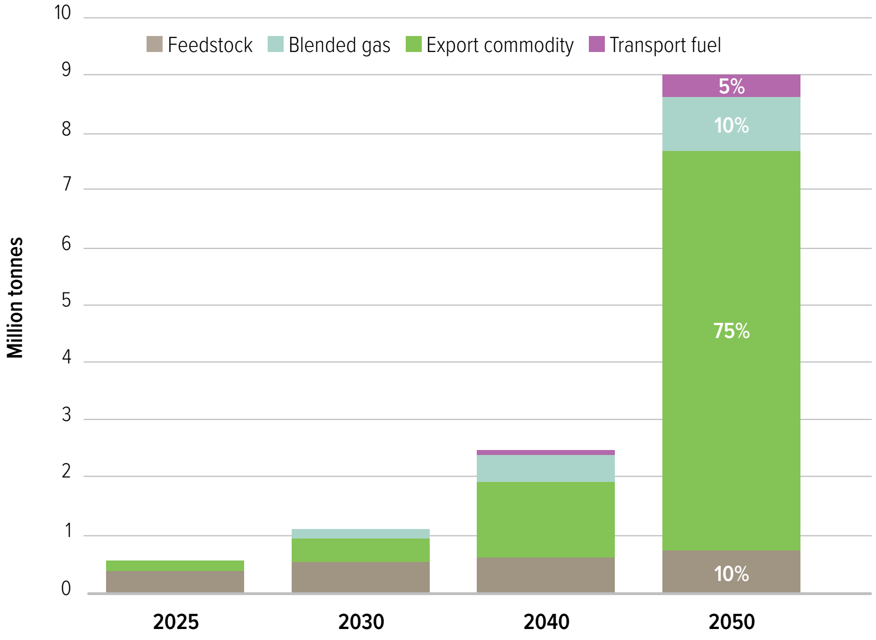
Green urea production

The conventional Haber-Bosch method of ammonia (NH3) production combines hydrogen made from natural gas or coal with nitrogen from air. Ammonia can then be combined with carbon dioxide to produce urea (Fig.1).

Producing hydrogen through electrolysis of water generates far fewer greenhouse gas emissions, whether the electricity is generated by burning fossil gas ('blue' hydrogen) or from renewable sources such as wind and solar ('green' hydrogen).

Other hydrogen sources include 'grey' hydrogen made using fossil fuels with carbon capture and storage (CCS) and using microorganisms for 'dark fermentation' of waste or biomass. Both routes require significantly more development than electrolysis.

FIGURE 2. Australian forecast demand level for clean hydrogen.



Source: PWC, *Embracing clean hydrogen for Australia*, 2020. pwc.com.au/infrastructure/embracing- clean-hydrogen-for-Australia-270320.pdf

Green hydrogen demand

Replacing conventional hydrogen production with green hydrogen would significantly reduce greenhouse gas emissions from fertiliser production and agriculture overall.

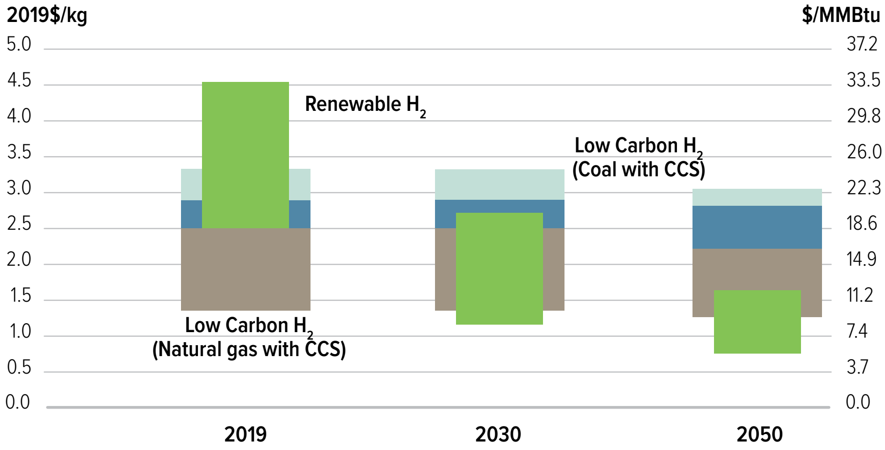
Green hydrogen production technologies are seeing a great wave of interest, due mainly to government and industry interests in their potential to decarbonise economic activity across power generation, heavy industry, transportation and more.

Demand for Australian hydrogen is forecast to pass one million tonnes per annum by 2030, then multiply to nine million tonnes per annum by 2050 (Fig.2) substantially driven by export potential.

Cost constraints

The production cost of green hydrogen, and therefore green urea, is not currently competitive. For example, 2019 natural gas prices ranged from $1.10 to $10.30 per metric million British thermal units (MMBtu). Coal ranged from $1.25 to $4.83/MMBtu (based on $30 to $116.00 and 24 MMBtu per tonne). In the same

FIGURE 3. Forecast of the global range of levelised cost of hydrogen production for large projects through 2050.



Source: BloombergNEF. Note renewable hydrogen costs based on large projects with optimistic projections for capex. Natural gas prices range from $1.1–10.3/MMBtu; coal from $30–116/t.

year, green hydrogen production cost $18.60 to $33.60 per MMBtu[6] (Fig.3).

Various supply and demand factors are forecast to reduce the green hydrogen cost to around $11.00/MMBtu by 2050, but cost competitiveness against gas or coal feedstock for 'grey' or even 'blue' hydrogen will depend heavily on future fossil fuel prices.[7] NEL, the world's largest producer and manufacturer of electrolysers, believes that green hydrogen production could achieve cost parity (or even superiority) with fossil fuels as early as 2025.[8]

In the short to medium term, the main barrier to using green ammonia over conventional sources will be its cost unless social, political or market forces enable buyers to justify (and pass on) the associated costs or charge a price premium.

However, because ammonia is being explored as a useful intermediary for transporting hydrogen, green fertiliser could be a convenient by-product of the hydrogen transition – although not a significant market segment or priority.

Summary

The cost of developing domestic green electricity, hydrogen, ammonia and fertiliser production is substantial. Goldman Sachs estimates a global investment of US$5 trillion by 2050.[9]

Given the current levels of investment in large scale green hydrogen production projects, as well as traditional conversion into fertiliser by government and private enterprise, GRDC investment in this space is unlikely to have significant impact. GRDC investment in production processes is better targeted toward innovative, early-stage research and development. Given the high technical risk and range of technological approaches, GRDC should take a balanced and considered portfolio approach to investments in this space.

Another possible area for GRDC investment could be to inform the grains industry on stable, sustainable, and affordable fertiliser suppliers. This could include investing in research to better understand techno-economic, regulatory and logistical challenges.

Meanwhile, RD&E will continue to be applied to improving farming systems and nutrient use efficiency in plants, to reduce fertiliser acquisition and application costs on-farm.

Key barriers to green hydrogen commercialisation

- Renewable electricity generation costs
- Inadequate transmission infrastructure
- Cost of electrolyser acquisition and operation
- Complexities of hydrogen storage and transportation
- Costly end-user plant upgrades and retrofits
- Investment and partnership opportunities
- Slow regulatory and approval processes

Photo: ©GRDC.

GLOSSARY

Btu (British thermal unit) – unit of energy, approximately equivalent to one metric kilojoule.

Haber-Bosch Process – industrial method of producing ammonia by combining atmospheric nitrogen with hydrogen under high pressure and temperature.

Electrolysis – electrical process where water molecules are split into hydrogen and oxygen.

Steam methane reformation – thermal reaction process where hydrogen Is produced by mixing methane and steam, with carbon monoxide as a by-product.

Black/brown hydrogen –production from coal gasification.

Grey hydrogen – production from fossil gas via steam methane reformation.

Blue hydrogen – production from fossil sources incorporating carbon capture and storage (CCS).

Green hydrogen – production from electrolysis powered by renewables.

Green ammonia, green urea – nitrogen compounds produced using green hydrogen.

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[6] Ibid

[7] Ibid.

[8] Ibid.

[9] Source: Clarke, Z. et al., Carbonomics: The clean hydrogen revolution, 2022, Goldman Sachs, goldmansachs.com/insights/pages/gs-research/carbonomics-the-clean-hydrogen-revolution/carbonomics-the-clean-hydrogen-revolution.pdf

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