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A Literature Review by AFAP

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A Study to Identify Opportunities for Green Ammonia and E-Fertiliser Production in South Africa for the Domestic, Regional (SADC) and International Markets

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Introduction

- Overview
- Key Points
- Context
- Study Objectives

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Introduction

Overview	This literature review is part of a study commissioned by GIZ under the "Green Hydrogen South Africa" initiative. Its focus is on opportunities for green ammonia and e-fertilizer production in South Africa for domestic, regional (SADC), and international markets.
Key Points	Green ammonia is a sustainable alternative to traditional ammonia, primarily used in fertilizers, chemicals, and mining. South Africa aims to position itself as a leader in green hydrogen and ammonia production to support domestic industry decarbonization and global exports.
Context	Green ammonia is emerging as a critical solution for sustainable energy and agricultural development. Given its potential to reduce carbon emissions, enhance energy security, and contribute to a circular economy, it is gaining traction in both global and African markets.
Study Objectives	This review explores the opportunities for green ammonia and e-fertiliser production in South Africa, assessing its feasibility for domestic use, regional trade within SADC, and international export markets.

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Production of Ammonia

- Production of Ammonia
- Cost drivers
- Viability factors of decentralised green ammonia

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Production of Ammonia

Key Market Trends:

- The global ammonia market was valued at **$79.47 billion** in 2024 and is projected to grow to **$91.95 billion** by 2029.
- Current production emits **235 million tons of CO_2 annually**, emphasizing the need for green alternatives.
- **80% of ammonia** is used in nitrogen fertilisers, with the rest serving industrial applications such as mining, pharmaceuticals, and chemical synthesis.

Traditional vs. Green Production:

- **Grey Ammonia:** Produced using fossil fuels, contributing significantly to global carbon emissions.
- **Green Ammonia:** Produced through renewable energy-powered electrolysis, offering a sustainable alternative with near-zero carbon emissions.

Production Process

1. Ammonia is produced using the Haber-Bosch process
2. Electrochemical, electromagnetic, photo-electrocatalytic methods are emerging technologies.

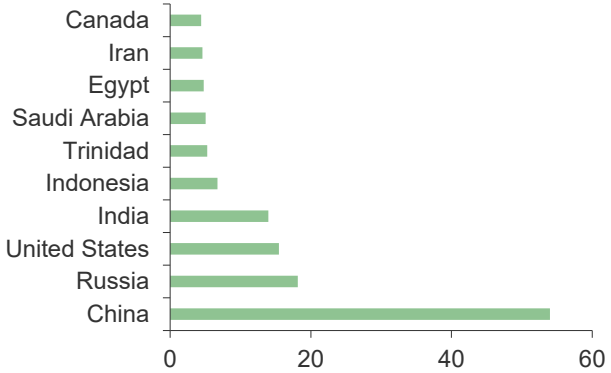

Figure 1: Top 10 ammonia producers, production, Mt Adapted from CRU and AFAP 2019

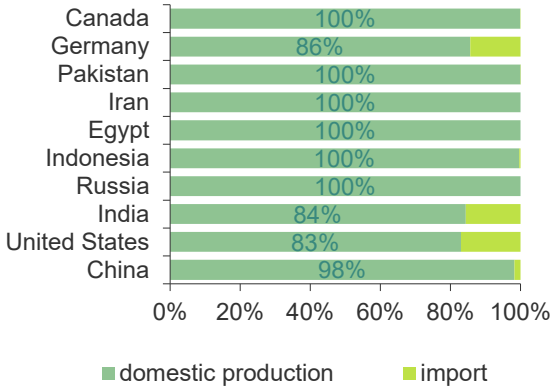

Figure 2: Share of ammonia production consumed domestically, % Adapted from CRU and AFAP 2019

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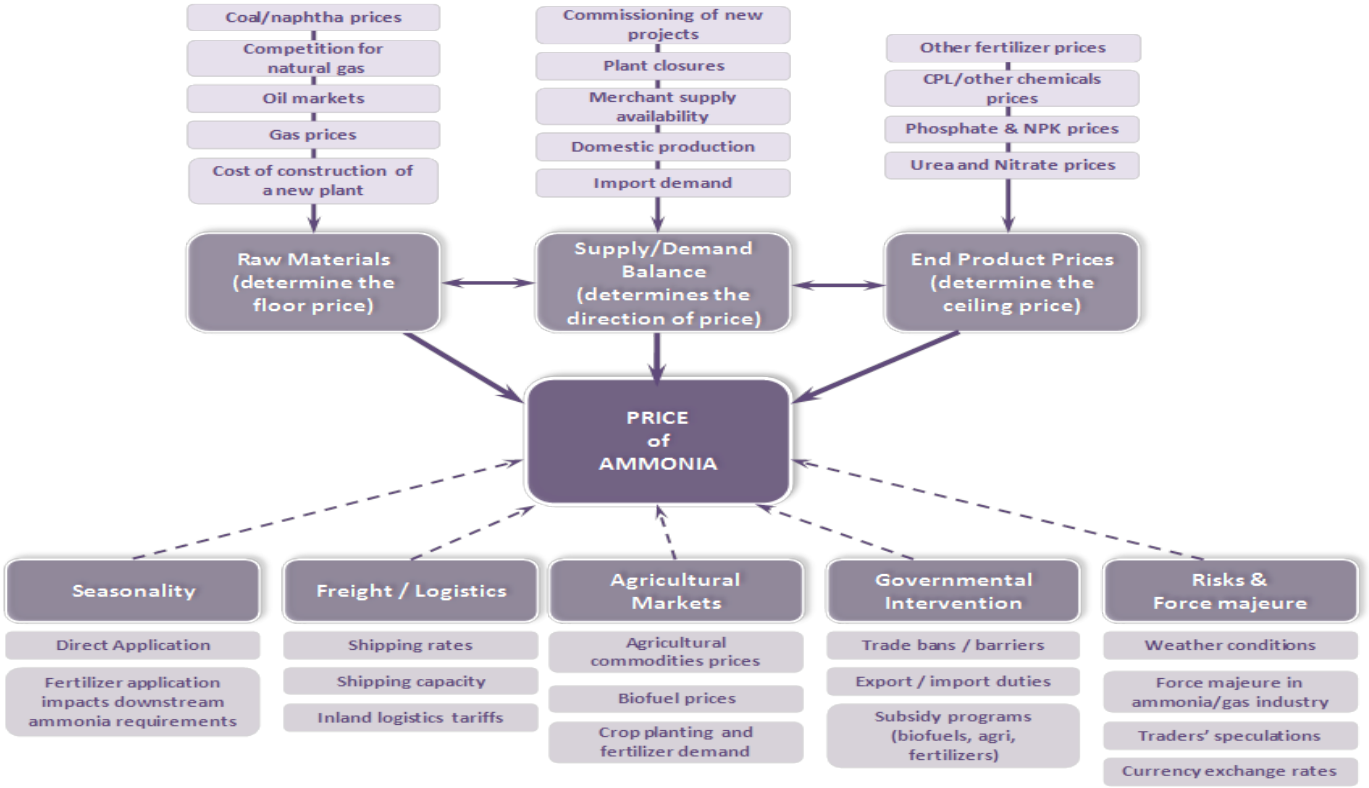
Production of Ammonia | Cost drivers



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Production of Ammonia | Viability factors of decentralised green ammonia

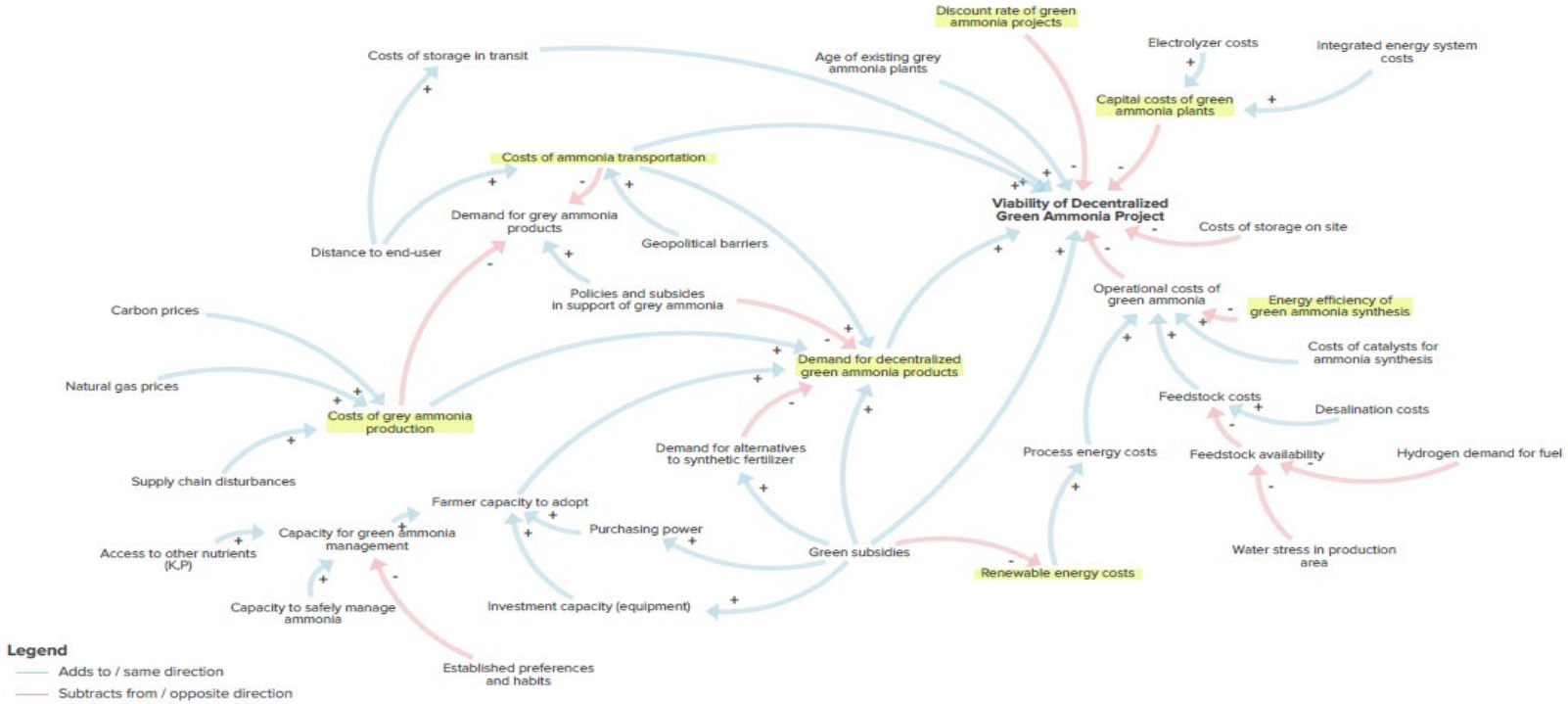

Figure 4: Viability factors of decentralised green ammonia projects

Adapted from Alho et al, 2024

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Cost comparison of the Grey & Green Ammonia | Talus model

Product	Cost of production/import ($/MT)	Unit cost of N($)	Cost per bag of N at Naivasha (Assume transport cost of $35/mt)
Anhydrous ammonia (82N)	900	10.97	0
CAN (26N)	369	14.19	15
Urea (46N)	477	10.36	11

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Consumption & Uses of Ammonia

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Consumption & Uses of Ammonia

Current Applications:

- Fertilizer production (majority use case-80%).
- Industrial uses: Explosives, refrigeration, synthetic fibers, pharmaceuticals.
- Mining explosives, refrigeration, pharmaceuticals, textiles, cleaning agents.

Future Potential for Green Ammonia:

- Hydrogen fuel: A clean alternative for transportation and power generation.
- Green mining explosives: Supporting sustainable mining operations.
- Synthetic fibres & plastics: Reducing carbon-intensive industrial outputs.

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Consumption & Uses of Ammonia

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Urea	83	86	90	94	92	97	97	94	94	96	98	100	102	104
Nitrates	28	30	30	31	31	31	32	32	32	33	34	34	35	36
AS	5	5	5	6	6	6	7	7	7	7	7	7	7	8
Phosphates	10	11	11	11	11	11	11	12	12	11	12	12	12	12
Direct application	5	5	5	5	5	5	5	5	5	5	5	4	4	4
Technical and others	31	30	31	28	27	31	28	31	32	33	33	34	35	36
Total	161	167	172	175	173	181	179	180	182	185	189	192	196	199

Adapted from CRU and AFAP 2019

Table 1: Ammonia demand by sector worldwide, 2010-2023, million tonnes (Mt)

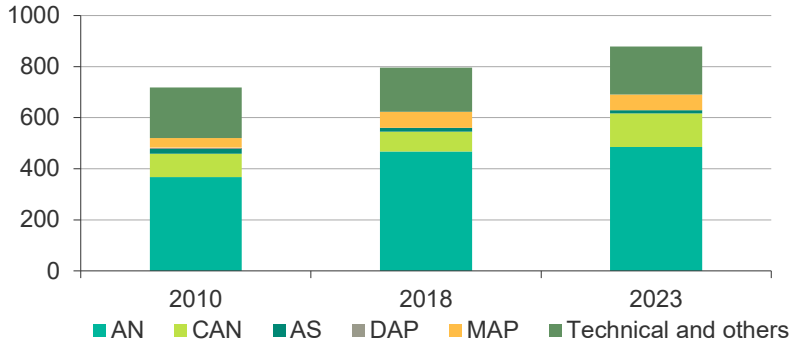

Figure 5. Ammonia demand by sector in South Africa, 2010-2023, kt *Adapted from CRU and AFAP 2019*

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Potential application of green ammonia in SA

- E-Fertilizer
- Chemical Industry
- Mining Sector

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Potential application of green ammonia in SA | E-Fertilizer

Overview:

- Green ammonia can replace grey ammonia in fertilizer production.
- South Africa is a net importer of fertilizers, creating an opportunity for local green fertilizer production.

Production & Application:

- **Urea vs. Green Alternatives:** Eliminating CO_2 emissions by replacing fossil fuel-based ammonia.
- **Anhydrous Ammonia & Aqueous Ammonia:** Potential applications for smallholder and commercial farmers.

Challenges & Opportunities:

- Price volatility of imported fertilizers makes local production more viable.
- Potential to supply the SADC region with sustainable fertilizers.

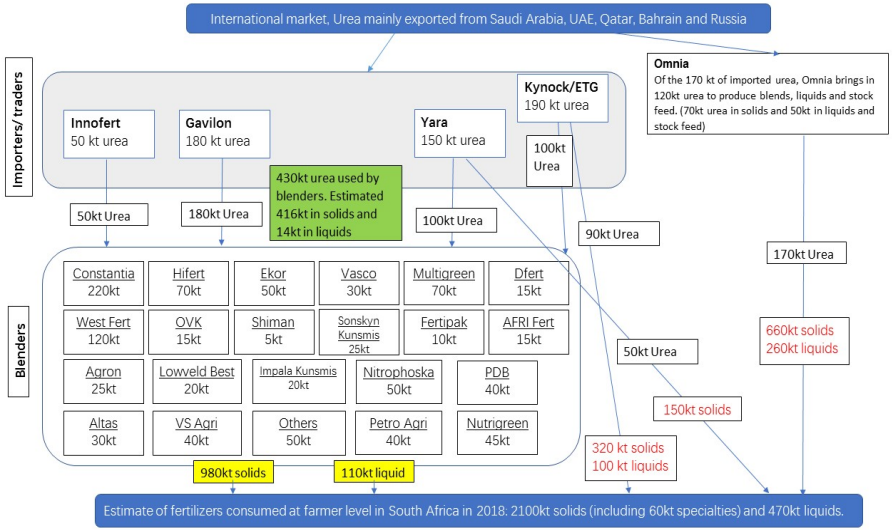

Figure 6: South Africa Fertiliser Market
Adapted from CRU and AFAP 2019

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Potential application of green ammonia in SA | Chemical Industry

Green Ammonia Applications in Chemicals:

- Fuel: Is used in the production of hydrogen fuel.
- Cleansing agent: Is used in detergent manufacturing because of its antiseptic properties.
- Textile: Is used for dyeing, scouring, and finishing fabrics.
- Pharmaceutical industry: Is used in the synthesis of amines and amides that are precursor compounds in drug synthesis.

Potential Impact:

- Reduces reliance on fossil fuels, thus reduces carbon footprint.
- Decarbonise the chemical sector.
- Wastewater treatment processes to remove nitrogen compounds, contributing to cleaner water discharge.

Challenges & Oppotunities:

- High production cost compared to traditional ammonia production process.
- Infrastructure development to integrate renewable energy sources, scaling up production.
- Ammonia toxicity that require strict safety measures during production, storage, and transportation, which can increase costs and complexity.

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Potential application of green ammonia in SA | Mining Sector

Ammonium Nitrate in Mining:

- Essential for producing industrial explosives (ANFO, emulsion, slurry explosives).
- South Africa consumed nearly 1 million tons of mining explosives in 2022.

Potential for Green Ammonia in Mining:

- Reduces carbon footprint of ammonium nitrate-based explosives.
- Key South African producers: AECI, DuPont, Omnia.

Challenges & Opportunities:

- Green ammonia adoption aligns with decarbonization targets.
- Could lower reliance on fossil fuels in explosive production.

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Risks and barriers of transitioning to green ammonia and e-fertilizer production

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Risks and barriers of transitioning to green ammonia and e-fertilizer production

- There is substantial initial investment required to establish production facilities and infrastructure.
- Ammonia in comparison to conventional fertilisers (Urea, CAN,AN,DAP, MAP etc) is highly toxic to human health.
- Market acceptance: What is the level of awareness about green ammonia technology? What is the rate of adoption by farmers of green fertilisers?
- The availability of freshwater for the electrolysis process
- Green ammonia is offered in liquid or aqueous form, which introduces the need for careful consideration regarding safe usage, application techniques, and distribution methods.
- Continual use of nitrogen-based fertilizers leading to soil acidification and reduced microbial diversity

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Status of the Enabling Environment for Green Ammonia and e-Fertilizers in South Africa

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Status of the Enabling Environment for Green Ammonia and E-Fertilizers in South Africa (I)

Policy & Investment Climate:

- General policy options available to governments (tax breaks, subsidies)

South African governments approach:

➢ (I) Policy Framework
- Green Hydrogen Commercialisation Strategy (GHCS) 2022

➢ (II) Support for R&D
- Hydrogen SA (HYSA) Initiative (2007) – Research and Development
- Hydrogen Society Roadmap (2021)

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Status of the Enabling Environment for Green Ammonia and E-Fertilizers in South Africa (II)

Risks to investment

- Political instability, nonconductive regulatory frameworks corruption, macroeconomic environment

Policy instrument to overcome risks: De-risking

- De-risking = guarantees by the state to mobilize private capital for development
- Additional policy instruments are required to de-risk green hydrogen
- De-risking strategies are employed in RSA but are costly

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Conclusions and Recommendations for Future Research

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Conclusions and Recommendations for Future Research (I)

Key Findings:

- Abundant information on: production processes for green ammonia; current and potential uses by the fertiliser, chemical and mining sectors in South Africa.
- Strong policy and regulatory framework being developed for green hydrogen in South Africa.

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Conclusions and Recommendations for Future Research (II)

Key Research Gaps:

- What is the economic viability of South African green ammonia and e-fertiliser for domestic, regional and global markets?
- Which farmers are using e-fertilisers in South Africa? Rate of adoption of e-fertilisers?
- What is the potential market for e-fertiliser exports to the region? (level of acceptability of e-fertilisers versus other fertilisers; agronomic response of e-fertilisers compared to conventional? Are the application methods easily adopted by smallholder farmers?)
- Policy gaps: What specific policy risks are or could obstruct investment in green hydrogen production in South Africa? Which specific policies are in place to mitigate these risks? Are the de-risking strategies being applied by the government too costly vis-à-vis the benefits?

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Overview of Project and Next Steps

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Overview of Project and Next Steps (I)

Work Portfolio (WP) 1 = Research

- Literature review, identification of knowledge and data gaps, stakeholder mapping, primary data collection, site visits

Work Portfolio (WP) 2 = Policy Design and Recommendations

- 2 policy instruments on incentives to ramp up production of green ammonia and e-fertiliser
- 2 policy instruments on incentives to increase consumption of green ammonia

Work Portfolio (WP) 3 = Knowledge Products

- 1 written study which is targeted at policymakers and the private sector
- 2 policy papers with key recommendations from the written study; 4 policy papers drawing on the policy instruments from WP2
- 1 slide deck of 20 powerpoint slides summarizing the study for integration into GIZ trainings on green hydrogen and Power-to-X.
- Plan for the dissemination of the knowledge products by GIZ: use them during workshops, conferences and trainings.

Work Portfolio (WP) 4. Stakeholder Engagement and Knowledge Product Dissemination

- *Sounding Board* - discuss the status quo, share the research with key stakeholders and identify their pain points
- *Mining Indaba* – In-person workshop for stakeholders in the mining sector
- *2 workshops* – final results of the research will be presented to a broader audience in 2 workshops

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