Nitrogen Fertiliser Supply – emerging options for regional sufficiency

Kangaroo Island Landscape Board

Delivered with funding support from the Commonwealth of Australia through the Department of Climate Change, Energy, the Environment and Water under the Carbon Farming Outreach Program

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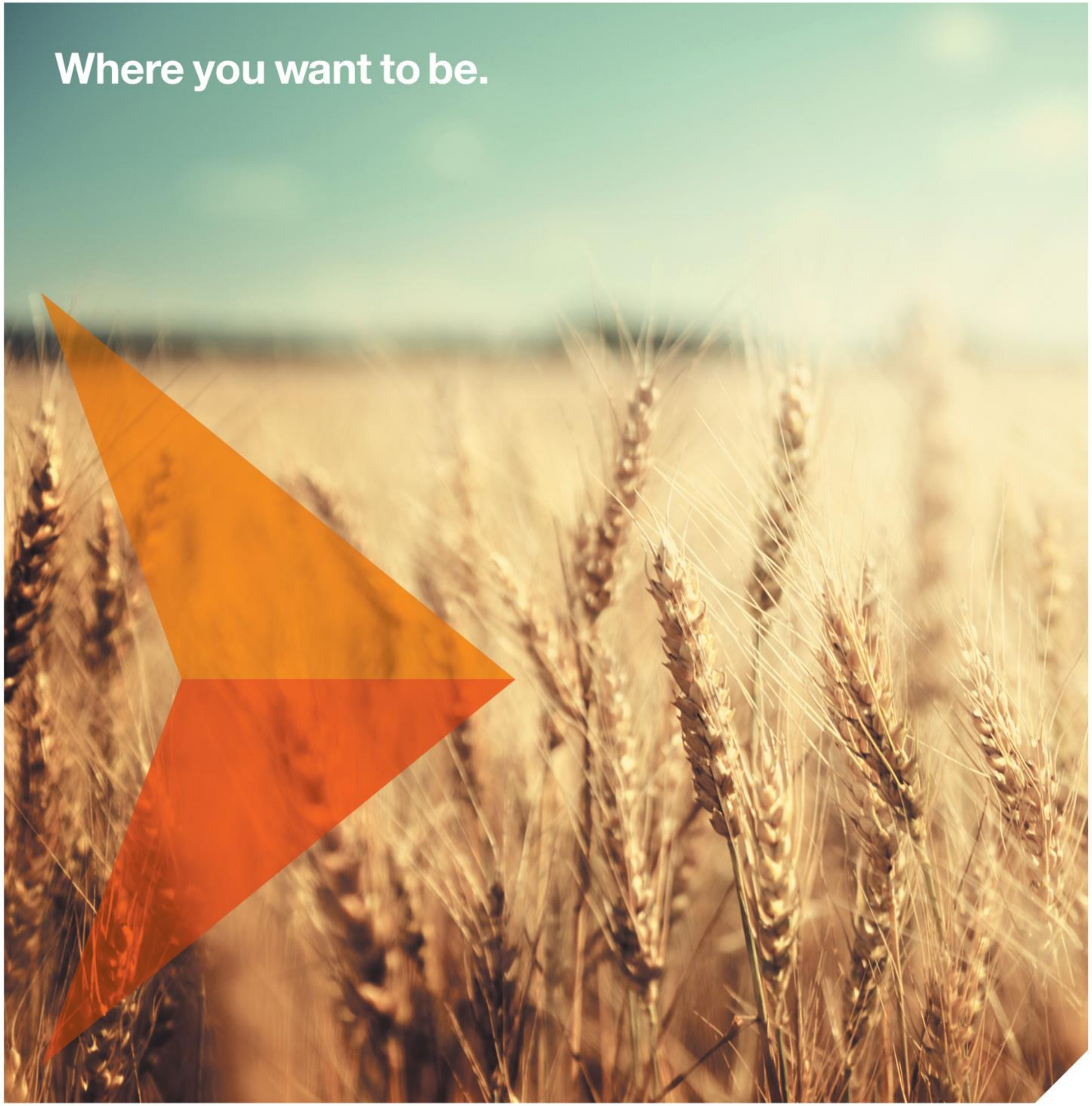

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The Economics of Nitrogen Fertiliser Supply and Usage

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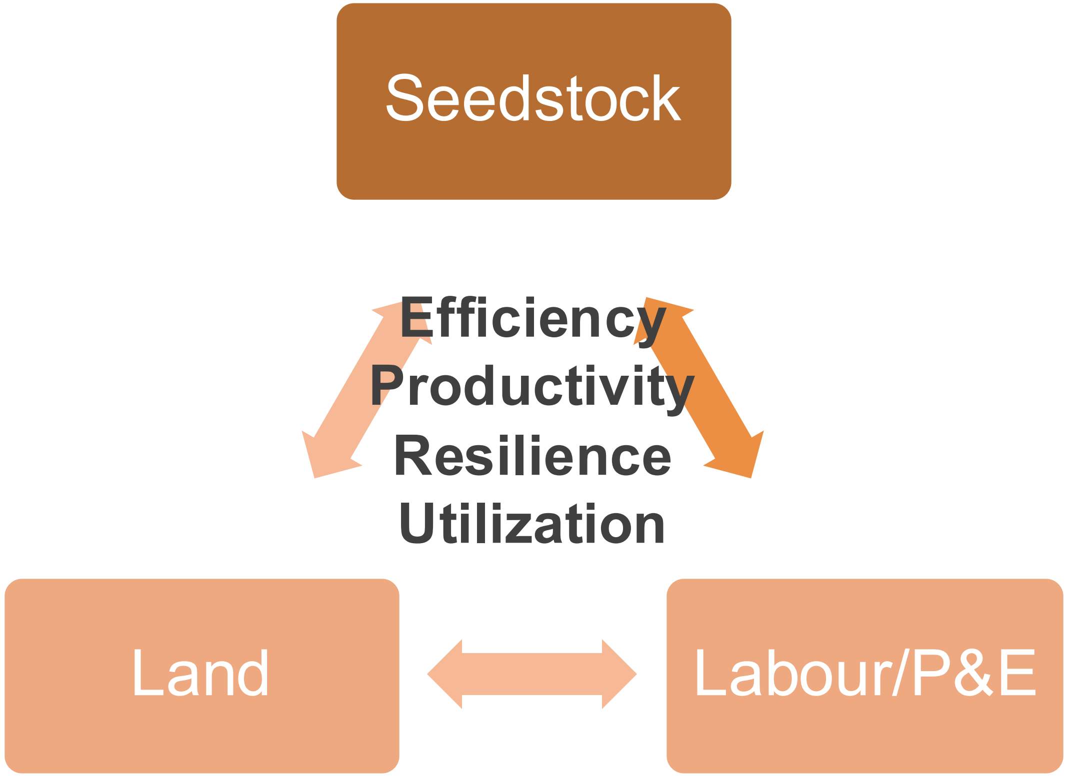
Advisors Accountants Auditors

Asked to consider:

- Business model outline, how do we think about the farming and financial interplay
- Cash flow cost of securing forward nitrogen supply
- What price points make sense relative to seasonal production returns
- What is the lost opportunity of not applying nitrogen due to price or supply constraints

Farm financial performance



Can control or influence:

- Timing
- Plant productivity
- Land productivity
- Key inputs:
  - Plant
  - Overheads
  - Scale
  - Volume of application

Can't control:

- Weather/rain
- Pricing

Higher yield from lower costs

Source:https://www.mla.com.au/contentassets/8d84d0f394c143188e2995be535ce445/p.psh.0718_final_reort_.pdf

Farm financial performance

- Net profit = Sales – Variable costs – Overhead costs
- Variable costs move (should move!) with the output of the farm
  - Fuel, fertilisers, chemicals, freight
- Overhead costs are fixed
  - Plant and equipment
  - Sheds and infrastructure
  - Land holding costs
  - Administration and marketing
- Financial decisions are made to:
  - Increase yield
  - Reduce costs

Farming is increasingly about security

Bentleys™ THINKING AHEAD

- Security of supply:
    - Land
    - Key inputs (Fuel, Fert, chem)
    - Storage
    - P&E
- Funds are being locked up to ensure access, most farms are likely over capitalised
- This adds a cost, scale is required to allow this to be absorbed
- Security adds optionality, optionality allows choices, choices allow circumstantial value creation

Nitrogen from Air

Nitrogen Technology

FARM N

Greg Butler
Chief Technology Officer

Carl Richardson
Managing Director

Nitrogen Fertiliser

Ammonia Fuel

www.farmn.com.au

Disclaimer

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Nitrogen Fertiliser as a Priority

- Nitrogen is a substantial, volatile and recurring expense.
- When used to advantage, Nitrogen is a key productivity driver with a significant ROI.
- At critical times, Nitrogen supply can be constrained.
- Conventional Nitrogen fertiliser is embedded with cost and a carbon footprint from manufacturing, transport & use.

What options to Disrupt Manufacturing, Reduce Transport & Improve Use.

FUN FACT

All the raw **Nitrogen**
used to make **Nitrogen Fertilizer**
comes out of the **Air**

FARM N

Atmospheric Nitrogen can be synthesized into fertiliser using

Hydrocarbon

+100yrs / Conventional / Geo-centralized / Intensive.

(CH_4 / Natural Gas, Coal, ..)

Electricity

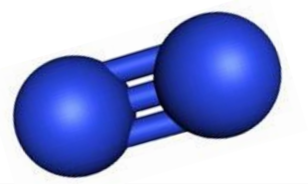
Emerging / Centralized or Decentralised / Intensive or Renewable.

(Grid, Wind, Solar, Hydro Nuclear / +Water)

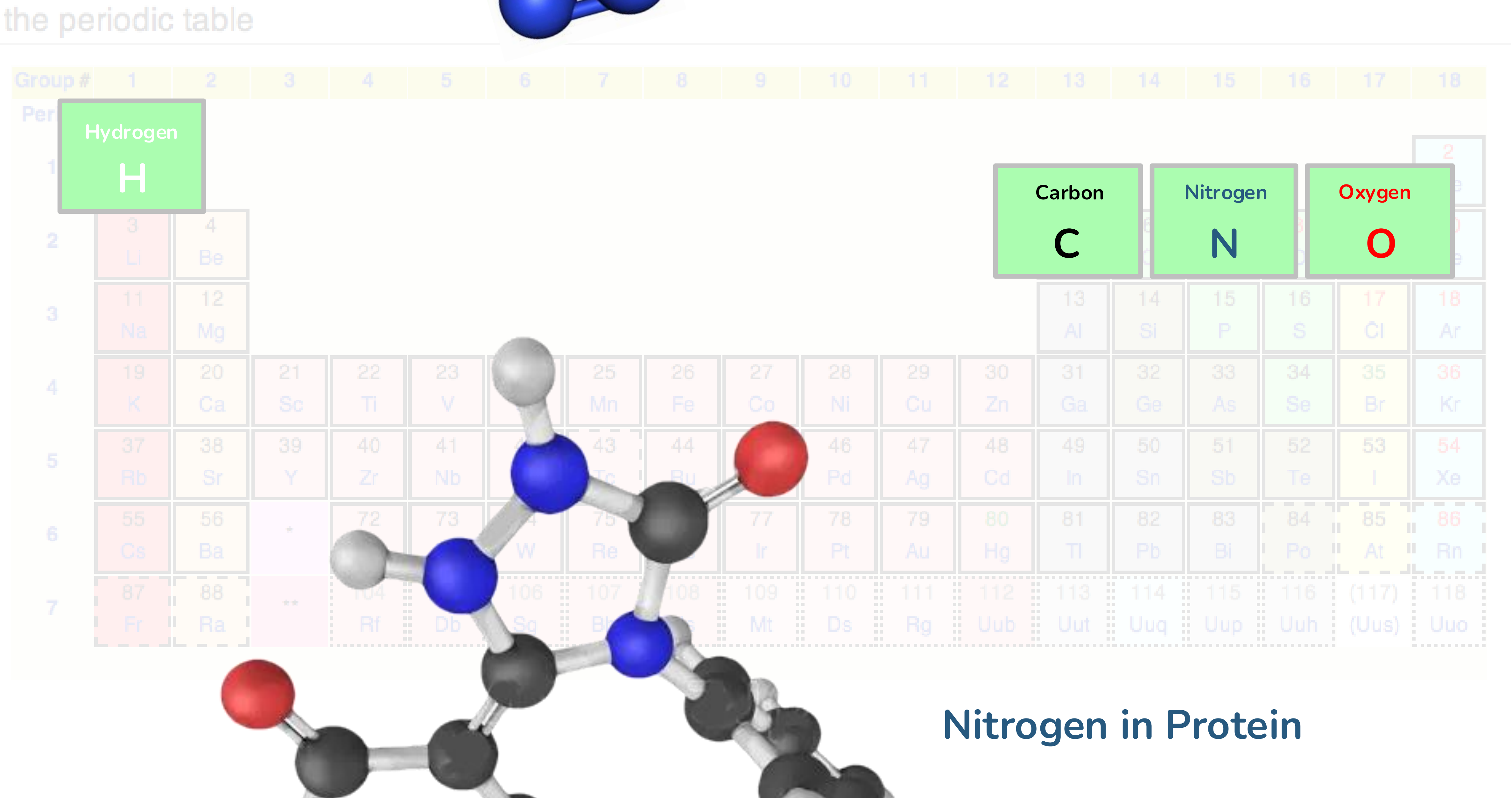
Biomass

Poor cousin of hydrocarbon / Decentralised / Renewable.

(Husks, straw, chip,)



Nitrogen in Air



Nitrogen in Protein

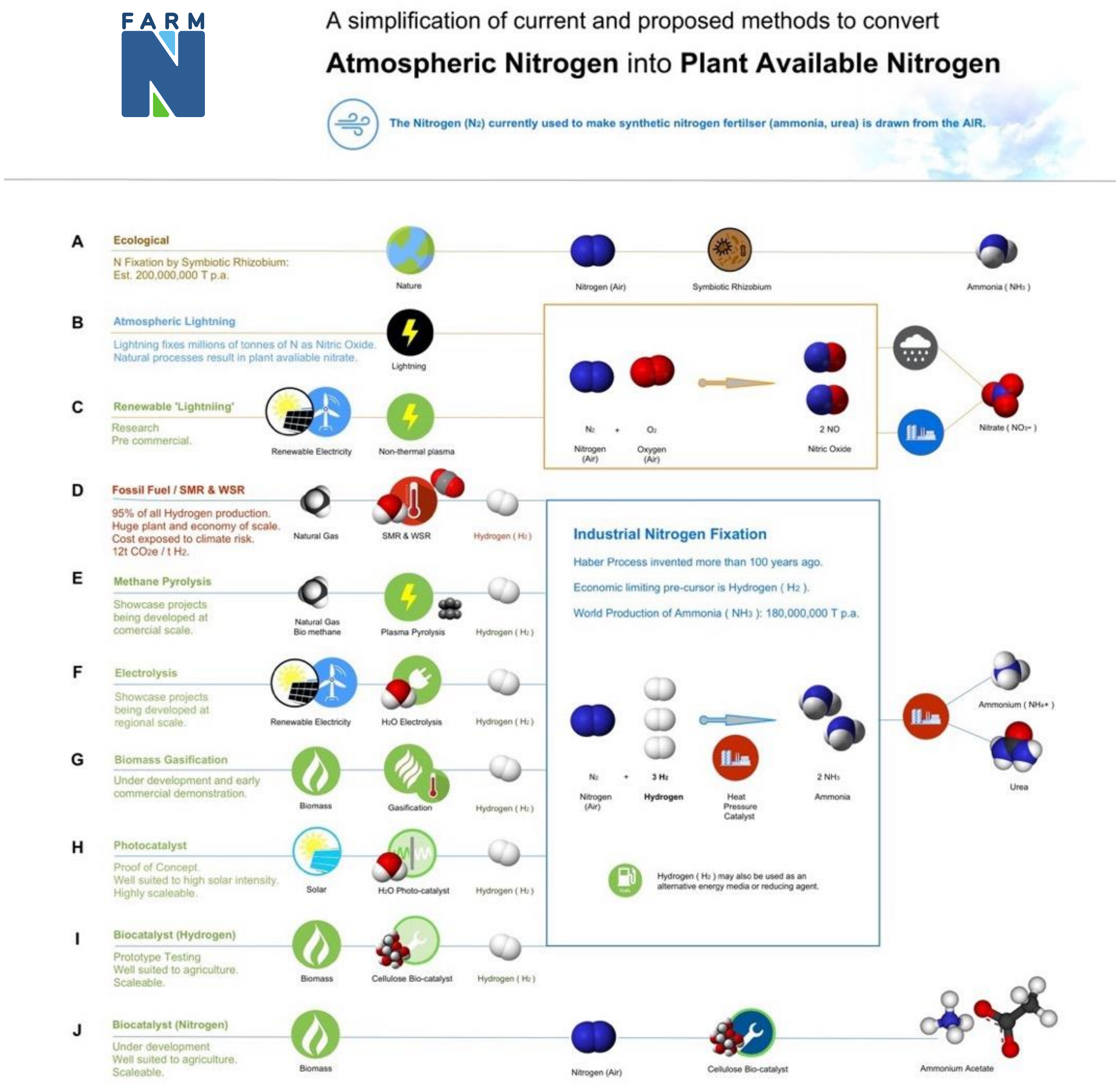
the periodic table

Hydrogen
H

Carbon
C

Nitrogen
N

Oxygen
O


FARM N
A simplification of current and proposed methods to convert
Atmospheric Nitrogen into Plant Available Nitrogen
The Nitrogen (N_2) currently used to make synthetic nitrogen fertilser (ammonia, urea) is drawn from the AIR.
A
Ecological
N Fixation by Symbiotic Rhizobium: Est. 200,000,000 T p.a.
Nature
Nitrogen (Air)
Symbiotic Rhizobium
Ammonia (NH_3)
B
Atmospheric Lightning
Lightning fixes millions of tonnes of N as Nitric Oxide. Natural processes result in plant avaliable nitrate.
Lightning
C
Renewable 'Lightniing'
Research
Pre commercial.
Renewable Electricity
Non-thermal plasma
N_2 + O_2
Nitrogen (Air)
Oxygen (Air)
2 NO
Nitric Oxide
Nitrate (NO_3^-)
D
Fossil Fuel / SMR & WSR
95% of all Hydrogen production.
Huge plant and economy of scale.
Cost exposed to climate risk.
12t CO2e / t H_2.
Natural Gas
SMR & WSR
Hydrogen (H_2)
E
Methane Pyrolysis
Showcase projects being developed at comercial scale.
Natural Gas Bio methane
Plasma Pyrolysis
Hydrogen (H_2)
F
Electrolysis
Showcase projects being developed at regional scale.
Renewable Electricity
H_2O Electrolysis
Hydrogen (H_2)
G
Biomass Gasification
Under development and early commercial demonstration.
Biomass
Gasification
Hydrogen (H_2)
H
Photocatalyst
Proof of Concept.
Well suited to high solar intensity.
Highly scaleable.
Solar
H_2O Photo-catalyst
Hydrogen (H_2)
I
Biocatalyst (Hydrogen)
Prototype Testing
Well suited to agriculture.
Scaleable.
Biomass
Cellulose Bio-catalyst
Hydrogen (H_2)
J
Biocatalyst (Nitrogen)
Under development
Well suited to agriculture.
Scaleable.
Biomass
Nitrogen (Air)
Cellulose Bio-catalyst
Ammonium Acetate
Industrial Nitrogen Fixation
Haber Process invented more than 100 years ago.
Economic limiting pre-cursor is Hydrogen (H_2).
World Production of Ammonia (NH_3): 180,000,000 T p.a.
N_2 + 3 H_2
Nitrogen (Air)
Hydrogen
Heat Pressure Catalyst
2 NH_3
Ammonia
Ammonium (NH_4^+)
Urea
Hydrogen (H_2) may also be used as an alternative energy media or reducing agent.


H2

Elements

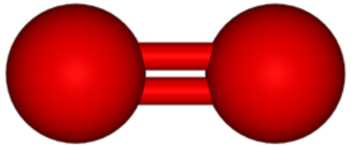
Hydrogen (Earth 0.03% / Universe 74%)

Nitrogen (Earth 0.1% / Universe 0.1%)

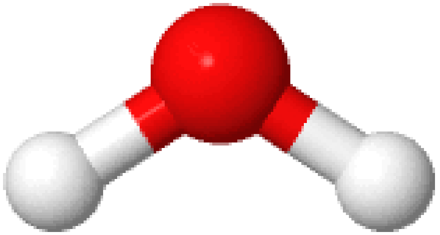
Oxygen (Earth 30% / Universe 1%)

Carbon (Earth 0.1% / Universe 0.5%)

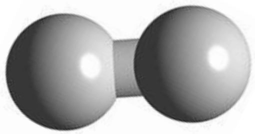
Molecules



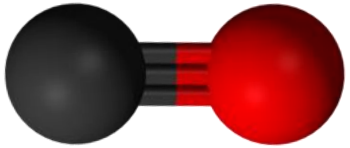
Oxygen



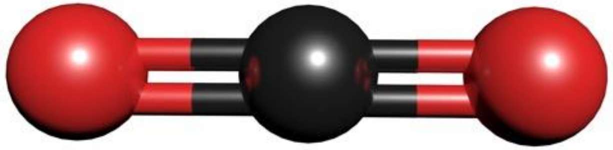
Water



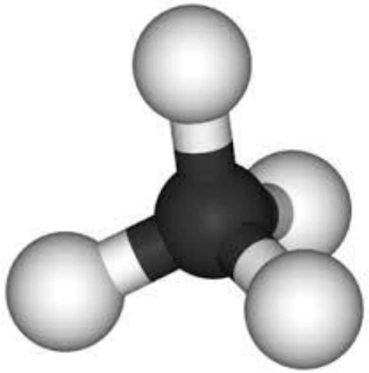
Hydrogen



Carbon Monoxide

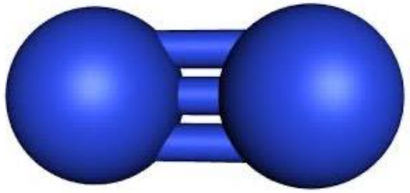


Carbon dioxide

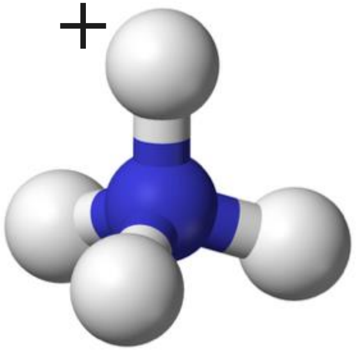


Methane

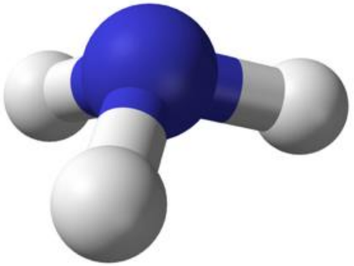
Nitrogen Forms



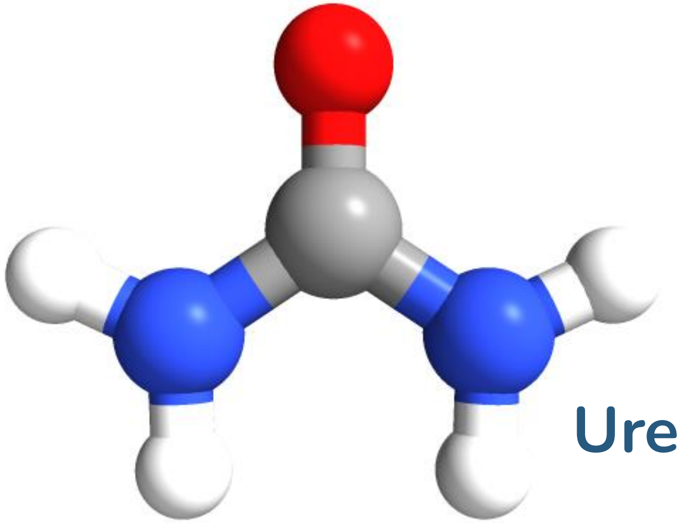
Nitrogen (N_2)



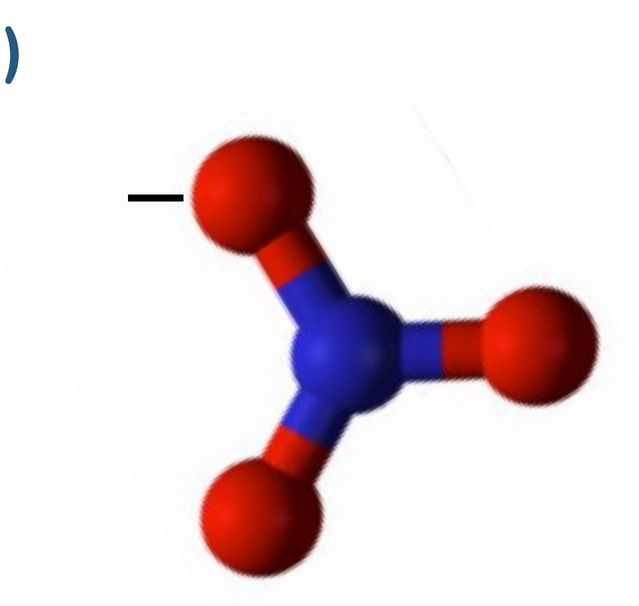
Ammonium



Ammonia



Urea

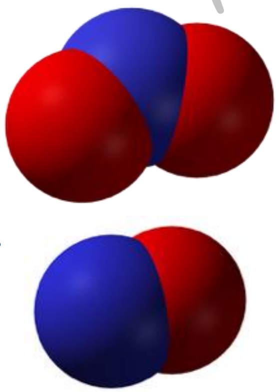


Nitrate

Nitrous Oxide

(-)

NOx



Global annual consumption of Nitrogen (N) fertilizers by major product type

Fertiliser	Estimated Usage	Notes
Urea	54–60	Dominant globally (esp. Asia). 46% N.
UAN (Urea Ammonium Nitrate solutions)	~8–12	Liquid form, growing. 28–32% N.
CAN (Calcium Ammonium Nitrate)	~5–8	Stabilized nitrate. 26–28% N.
Direct Anhydrous Ammonia	~2–4	Pressurized. 82% N.
DAP (Diammonium Phosphate)	~3–5	Major N+P source. 18% N.
MAP (Monoammonium Phosphate)	~2–4	Major N+P source. 11% N.

Best Available Technology (BAT) comparison table for major ammonia production methods (per tonne NH_3)

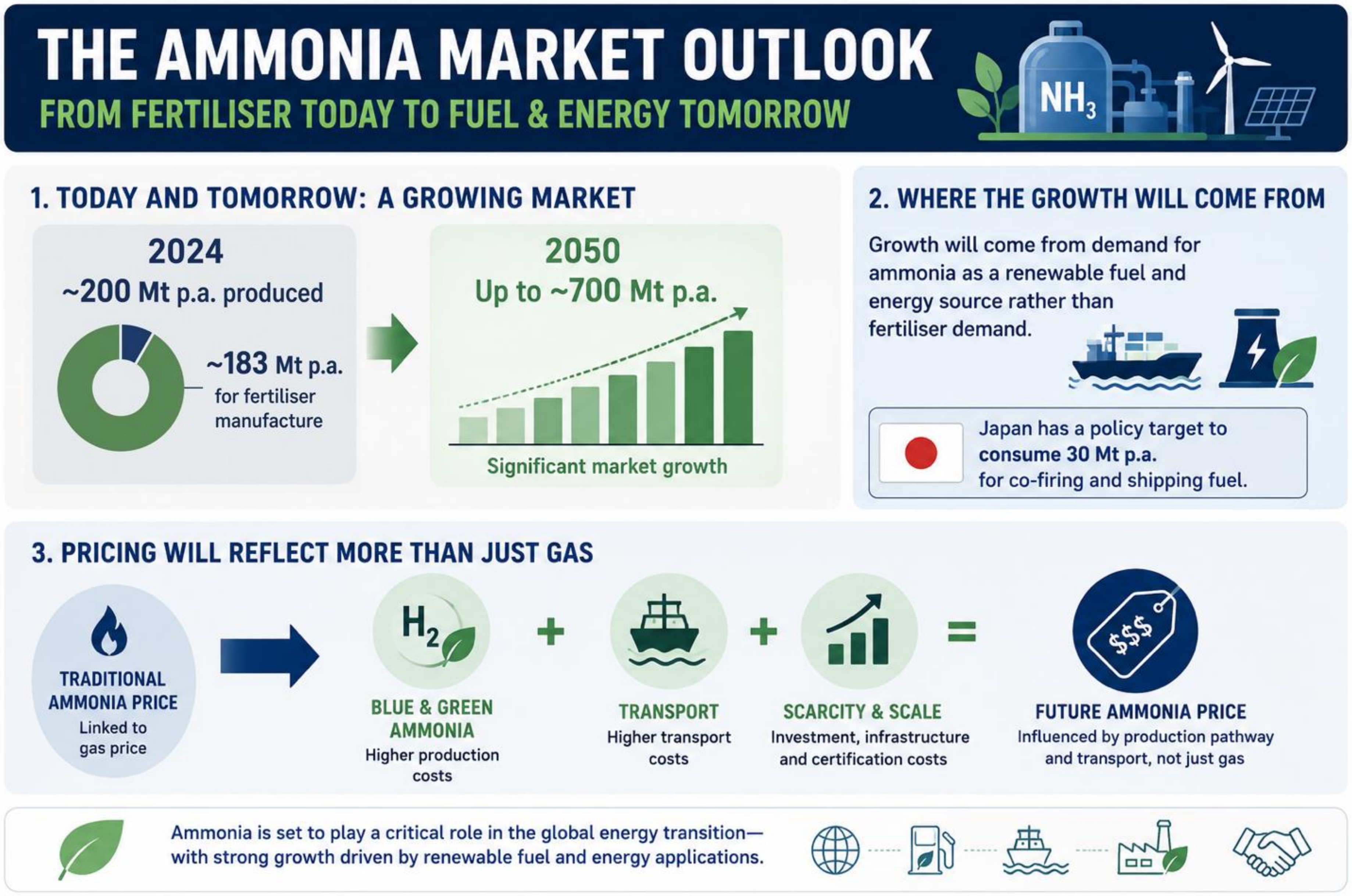
Production Method	Feedstock (+ Water)	Energy Consumption (GJ/ t NH_3)	Relative CAPEX	Footprint (t CO_2/ t NH_3)	Key Characteristics
Steam Methane Reforming (SMR + WGSR)	Natural Gas	**28–31** (+95% energy in the Gas)	Baseline (lowest)	1.5–2.5 (process + fuel)	Dominant globally (~70% urea supply). Fossil CO_2 for urea.
Blue Ammonia (SMR + WGSR + CCS)	Natural Gas + Carbon Capture	**29–33** (incl. capture penalty)	Moderate (0.2–0.5× SMR)	0.2–0.5	Fossil CO_2 for urea. NH_3 Energy in WA
Green Ammonia (Electrolysis)	Electricity	**35–45** Needs Energy Source	Very High (2–3× Baseline)	0 – 8 Source dependent.	Fast growing for new projects. Needs cheap power. **No CO_2 for urea.**
Coal Gasification	Coal	**36–42** (+95% energy in the Coal)	High	3.2–3.8	Highest emissions. Fossil CO_2 for urea.
Biomass Gasification (SynGas + WGSR)	Biomass	**35–50** (+90% in the Biomass)	High	0.2–1.0	Scale constraint. **Renewable CO_2 for urea.**

Source: Fertilizers Europe BREF, IFA, IEA, and techno-economic studies, 2020–2024.

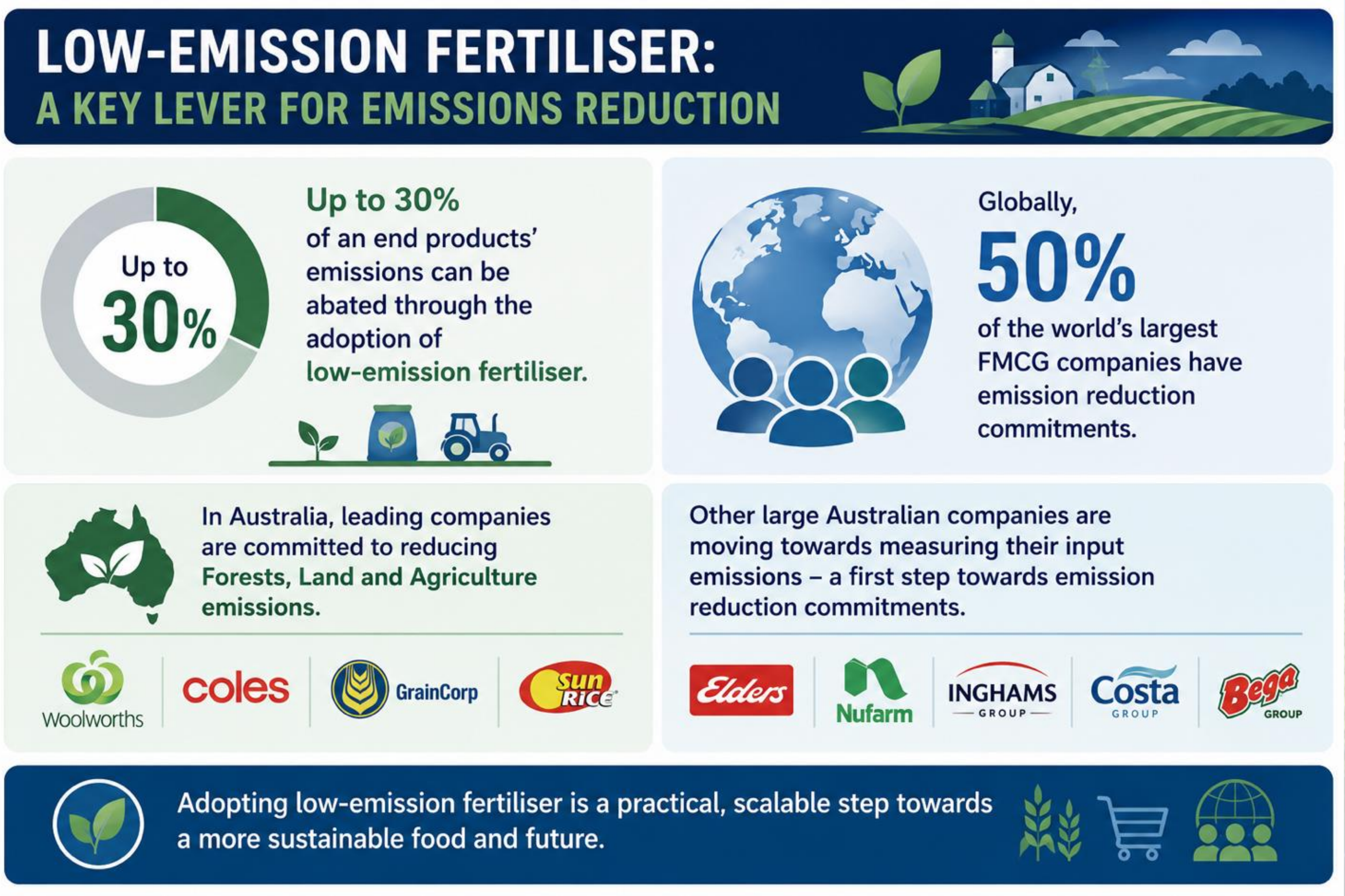
Nitrogen Fertiliser as a Priority

Emission Source: **Example SA Grain Farm (HRZ)**	**% of Total Footprint**	**Intensity** kg CO_2e / tonne grain	Notes
N Fertilizer **Total = Industrial Manufacturing + Transport + Use**	**~60%**	**~162**	Dominant; **Pre-farm (manufacturing / transport) ~29%** **On-farm use ~31%.**
Crop Residue Decomposition (N_2O, Scope 1)	11%	~34	Post-harvest residue breakdown. Retention practices can offset via soil health.
Diesel Fuel Use (Machinery/Operations, Scope 1)	8%	~24	From tractors, sowing, and harvest (~100-150 L/ha diesel at 2.7 kg CO_2e/L).
Lime Application (CO_2, Scope 1) + Embedded (Scope 3)	6% + 3%	~18 + 8	From soil acidification correction (~66 kg/ha in South); embedded in production.
Crop Protection Chemicals (Embedded, Scope 3)	7%	~21	Pesticides/herbicides; minor compared to N.
Other (e.g., Dams CH_4, Residue Burning, Waste)	3-5%	~9-15	Negligible compared to N.

Global demand for ammonia will impact nitrogen fertiliser



Low-emission fertiliser may advance access to future markets



FARM N

METHODOLOGY FOR THE PRODUCTION OF LOW EMISSION NITROGEN FERTILIZER

FARM N

Gold Standard®

Concept Submission	Complete
Full Methodology Design	Complete
1st Round International Peer Review	Complete
2nd Round International Peer Review	Pending
Public Consultation	Q3 2026
Methodology Pannel Final Approval	Q1 2027

Gold Standard and other Teir 1 Registries are aligning methods to the Paris Agreement, Article 6.

Business As Usual

UREA from Natural Gas (CH_4)

Industial Scale Urea

Methane Reforming (to make hydrogen)

Water Gas-Shift Reaction (15% - 30% extra hydrogen)

Haber-Bosch Synthesis (to make ammonia)

Bosch-Meiser Synthesis (to make urea)

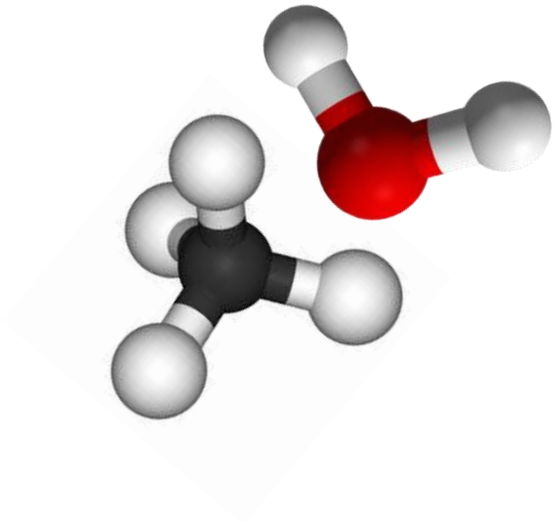
Facility Output ~ 1,000,000 T NH_3 p.a.

Fossil Fuel & Fossil Feedstock

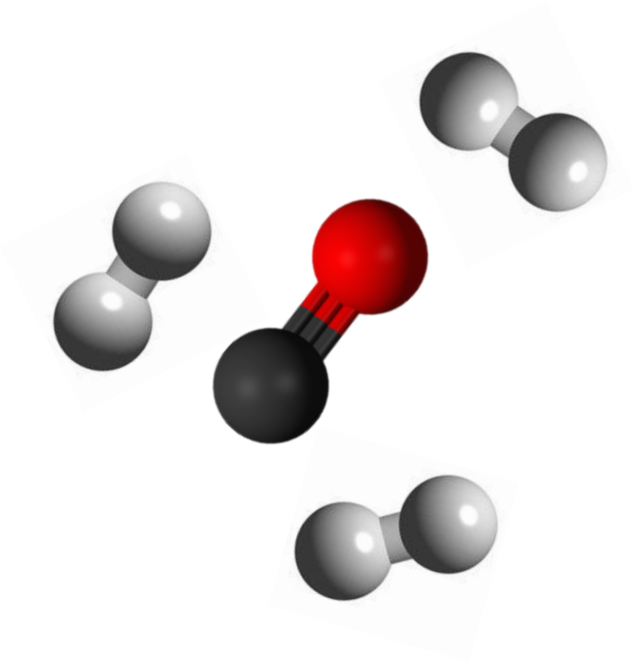
Long Transport to Market

Steam Methane Reforming

$CH_4 + H_2O > CO + 3H_2$



700–1000 °C with a nickel catalyst

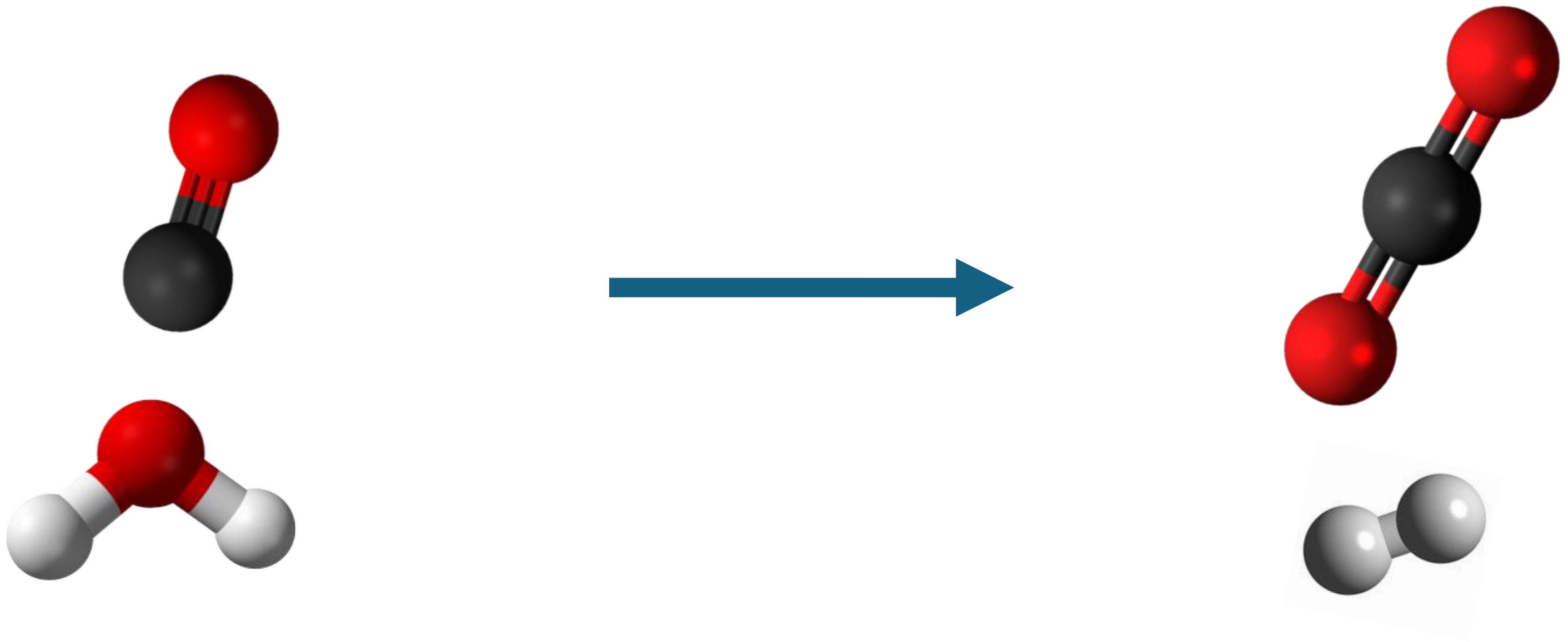


Methane (CH_4) & Steam (H_2O)

SynGas (mix of H_2 & CO)

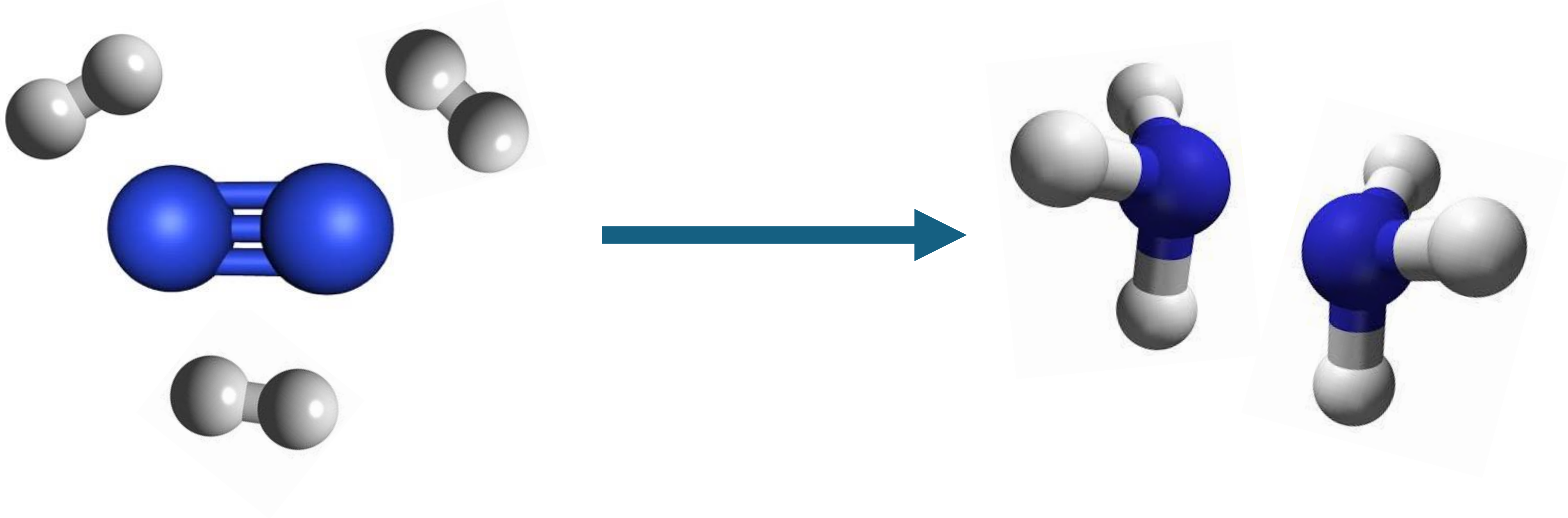
Water Gas-Shift Reaction

$CO + H_2O > CO_2 + H_2$



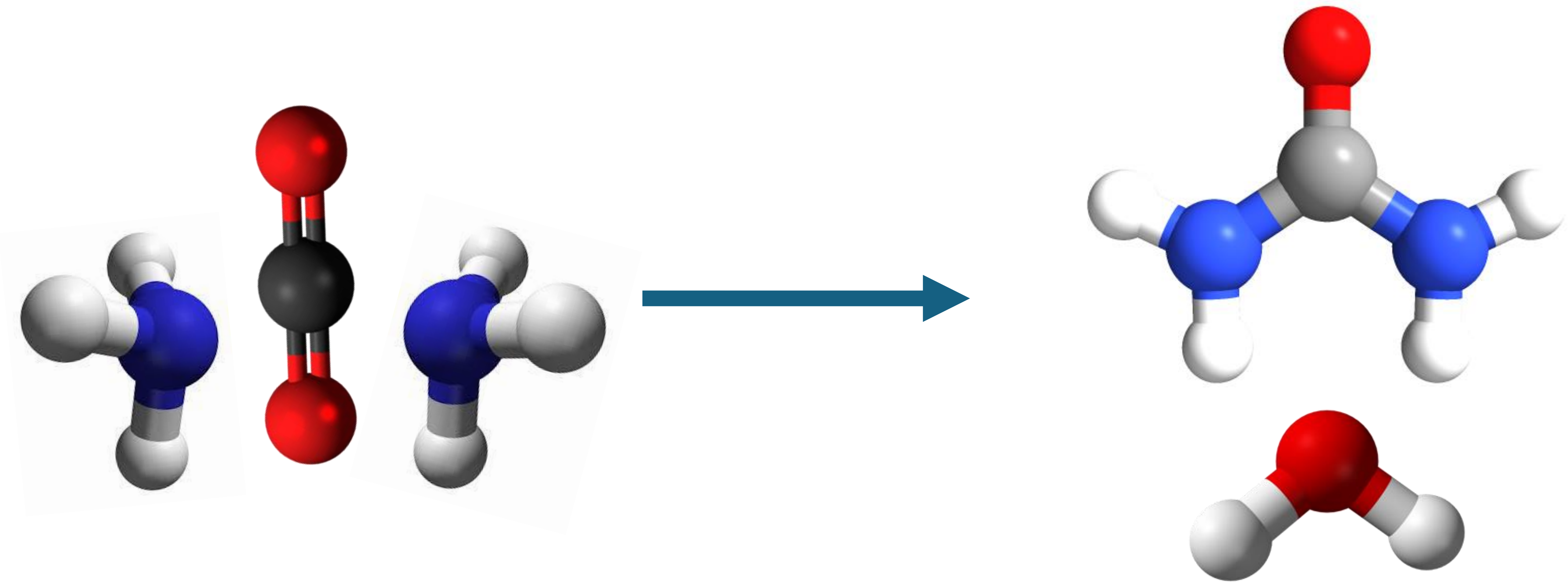
Haber Bosch Ammonia Synthesis

$3H_2 + N_2 > 2NH_3$

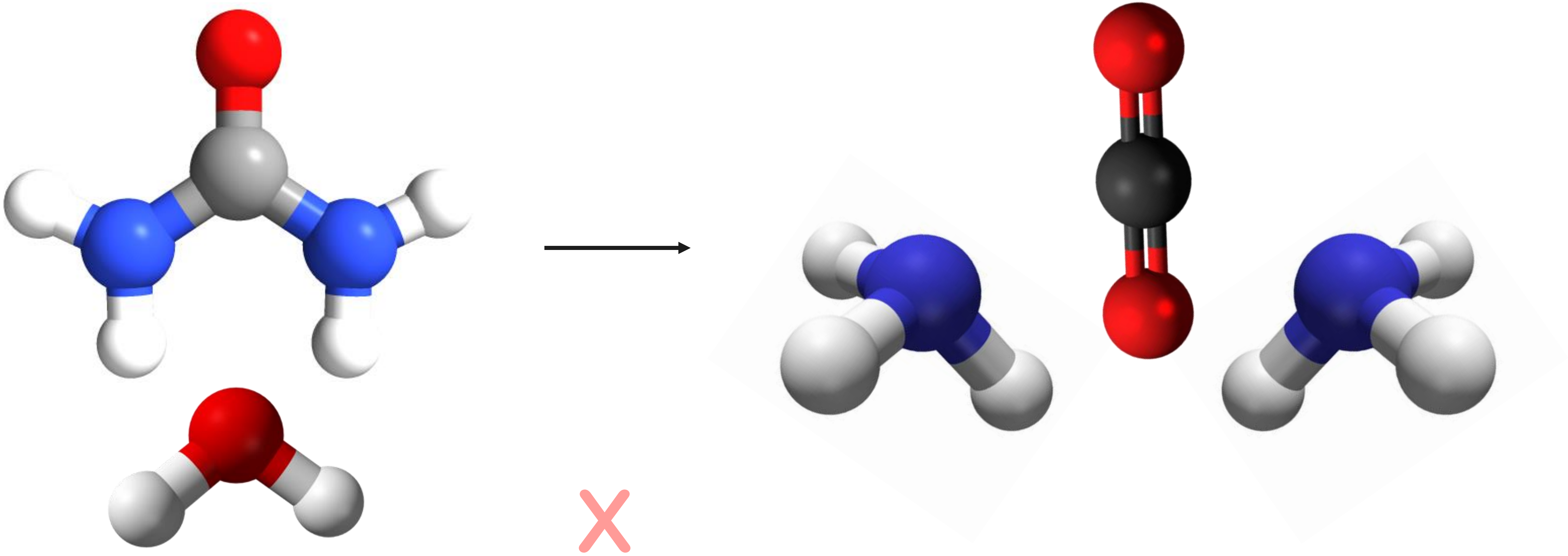


Bosch-Meiser Urea Synthesis

$2NH_3 + CO_2 > NH_2CONH_2 + H_2O$



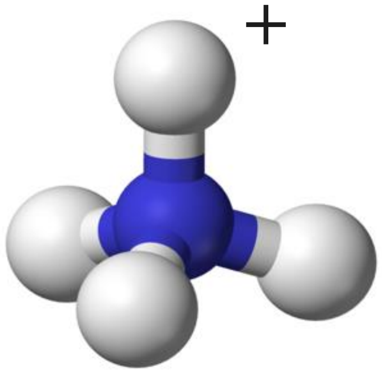
Urea Use in the Field



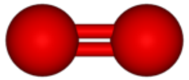
$Urea + H_2O \rightarrow 2\ NH_3 + CO_2$

Urease Inhibitors (NBPT)

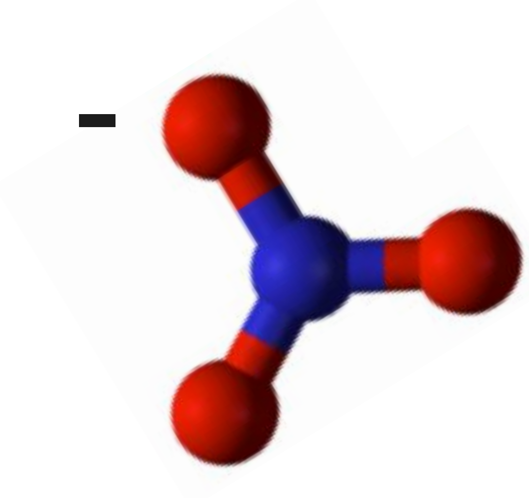
Urea Use in the Field



Ammonium
NH_4^+



Biological Oxidation



Nitrate
NO_3^-

Nitrification Inhibitors (DCD)

Urea Use in the Field

Urease Inhibitors

Slow the enzyme urease from rapidly breaking down urea into ammonia (NH_3), which can volatilize (escape as gas) especially on the soil surface.
Main active ingredients: NBPT (N-(n-butyl) thiophosphoric triamide) — the most common and widely used.
NPPT (N-(n-propyl) thiophosphoric triamide) — often used in combination with NBPT for broader effect.

Common products: Agrotain (NBPT), Limus (NBPT + NPPT), and others like Sustain or AmiPlus. They are especially useful for surface-applied urea or UAN (urea ammonium nitrate) in warm, moist conditions without immediate incorporation.

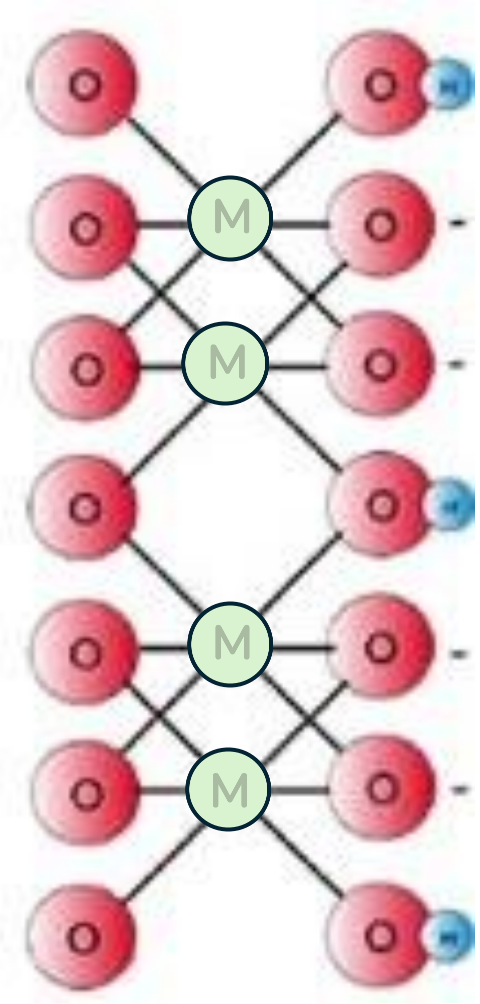
Nitrification Inhibitors

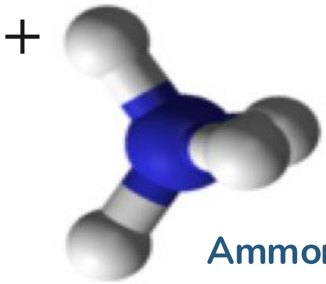
Slow soil bacteria (mainly *Nitrosomonas*) from converting ammonium (NH_4^+) to nitrate (NO_3^-).
Nitrate is prone to leaching and denitrification (loss as N_2O gas).
Main active ingredients: DCD (Dicyandiamide) — very common. Nitrapyrin (long-established option). Pronitradine (newer).
DMPP (3,4-dimethylpyrazole phosphate) in some regions.

Common products: Instinct/N-Serve (nitrapyrin), Centuro (pronitradine), SuperU or Agrotain Plus (DCD), and various DCD-based options. They are useful for reducing below-ground losses, especially in wet soils or with ammonium/urea sources.

Soil and Plant Availability

Clay Surface (CEC)

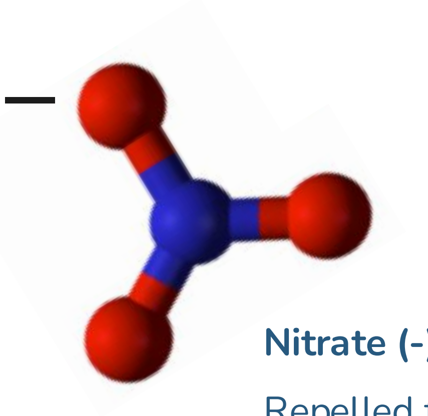




Ammonium (+)

Bound to the soil CEC

Less available to plants



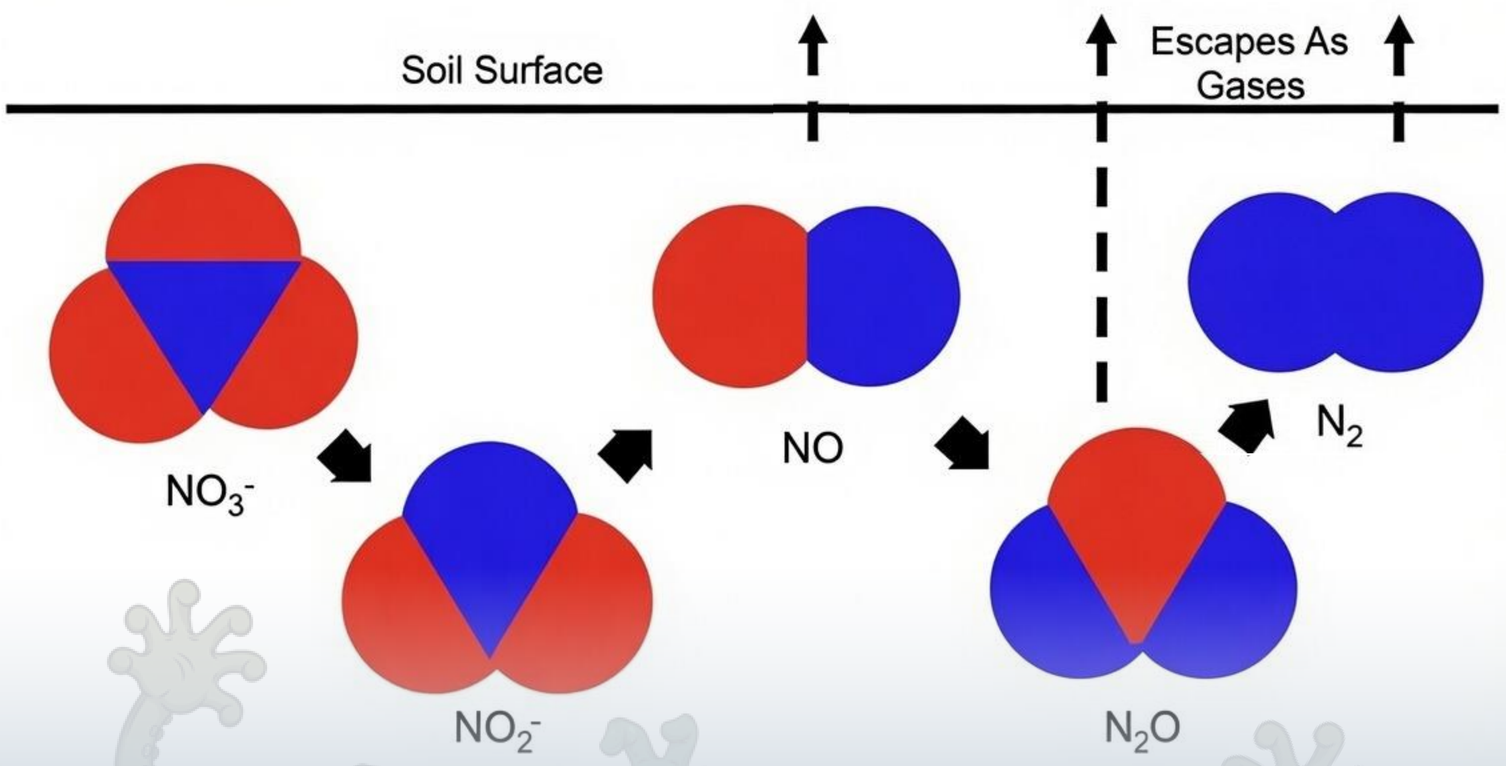
Nitrate (-)

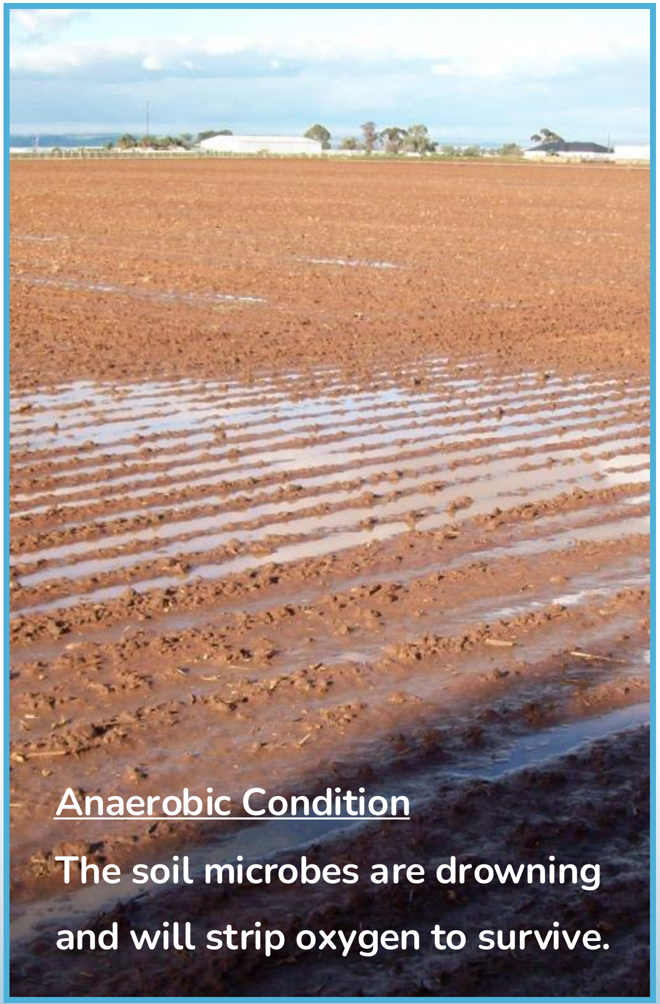
Repelled from the soil CEC

Highly available to plants

Vulnerable to leaching

Nitrate Loss via Anaerobic Condition

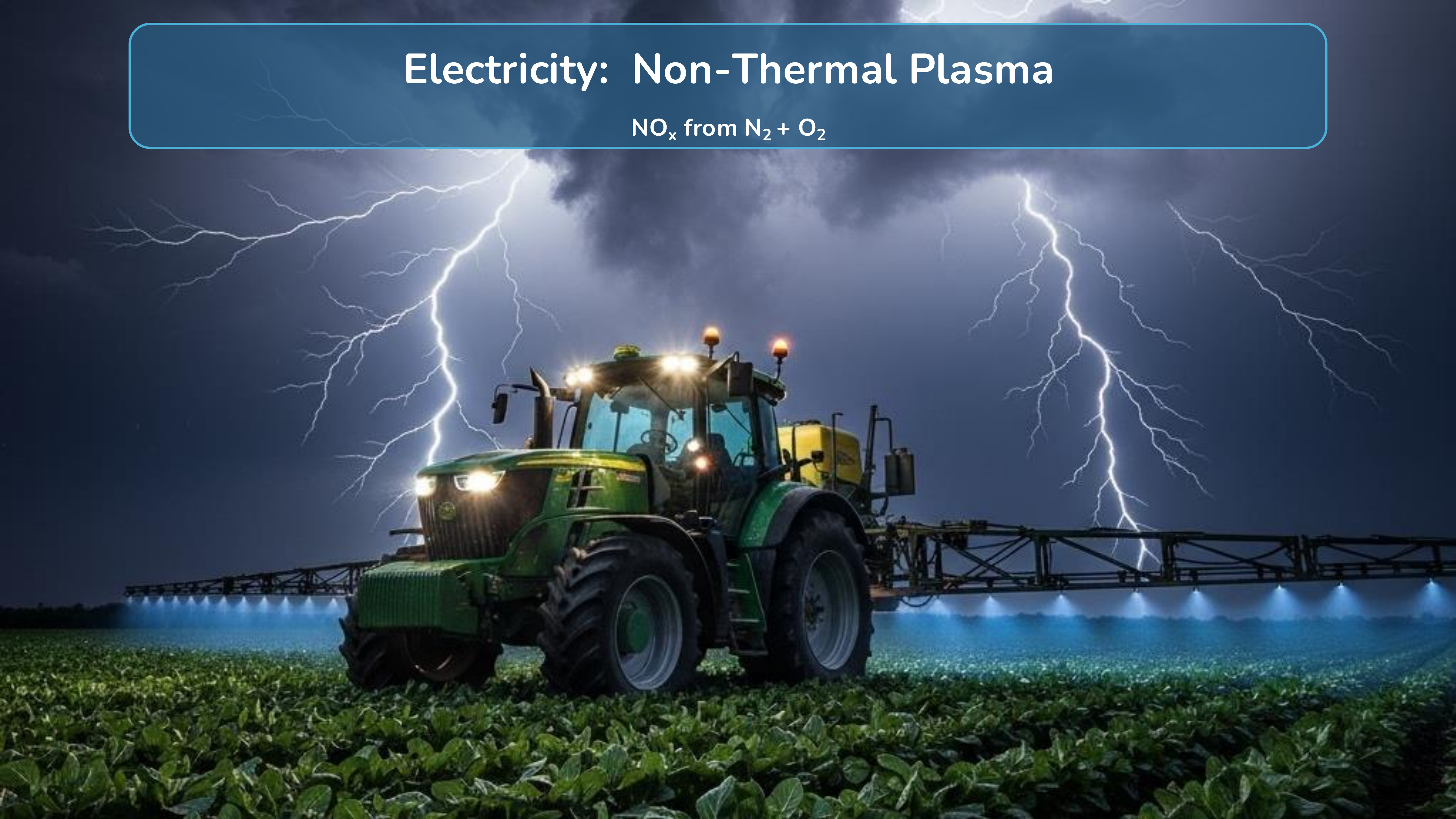




BREAK TIME

Electricity: Non-Thermal Plasma

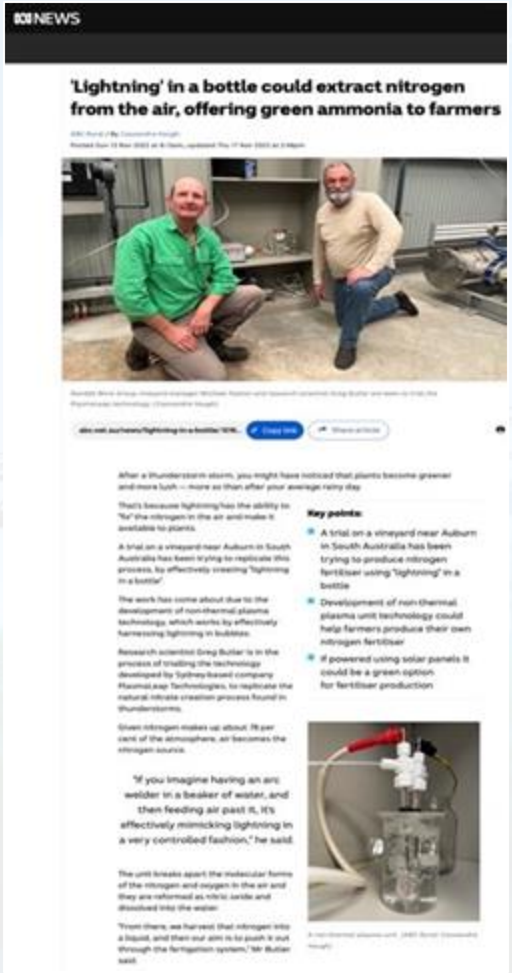
NO_x from $N_2 + O_2$



Technology and Energy Consumption Ballpark: Non-Thermal Plasma (NTP) for Nitrogen Fixation.	MJ / mol N	kWh / kg N
Ammonia Output		
Theoretical minimum energy for Ammonia via Haber Bosch	0.35	7
Early-stage industrial (1920s) energy for Ammonia via Haber Bosch	1.7	34
Conventional energy consumption for Ammonia via Haber Bosch	0.5	10
NTP for ammonia (published industry claim of 20 kWh/kg Ammonia)	1.2	24
Nitrate Output		
Lightning induced nitrogen fixation (nature)	+2,000	+40,000
Theoretical minimum energy for NTP nitrogen oxidation	0.2	4
Optimistic level to be competitive with conventional nitric acid pathway	1	20
NTP for nitrogen oxidation (published industry claim of 10kWh/kg Nitrates)	2	40

References:
1. K. H. R. Rouwenhorst, F. Jardali, A. Bogaerts, and L. Lefferts, *Energy Environ. Sci.* **16**, 6170 (2023).
2. X. Pei, D. Gidon, Y.-J. Yang, Z. Xiong and D.B. Graves, *Chem. Eng. Journal* **362**, 217-228 (2019).
3. https://www.innovationnewsnetwork.com/harnessing-plasma-power-for-nitrogen-fixation-and-fertiliser/61912/

“Lightning in a Bottle”



ABC NEWS

'Lightning' in a bottle could extract nitrogen from the air, offering green ammonia to farmers

Key points:

- A trial on a vineyard near Auburn in South Australia has been trying to produce nitrogen fertiliser using "lightning" in a bottle
- Development of non-thermal plasma unit technology could help farmers produce their own nitrogen fertiliser
- If powered using solar panels it could be a green option for fertiliser production

"If you imagine having an arc welder in a beaker of water, and then feeding air past it, it's effectively mimicking lightning in a very controlled fashion," he said.

Image Courtesy: FarmN, Quelltaler Estate (Randall wine group) & ABC Country Hour . Stuart Paxton (L) and Greg Butler (R).

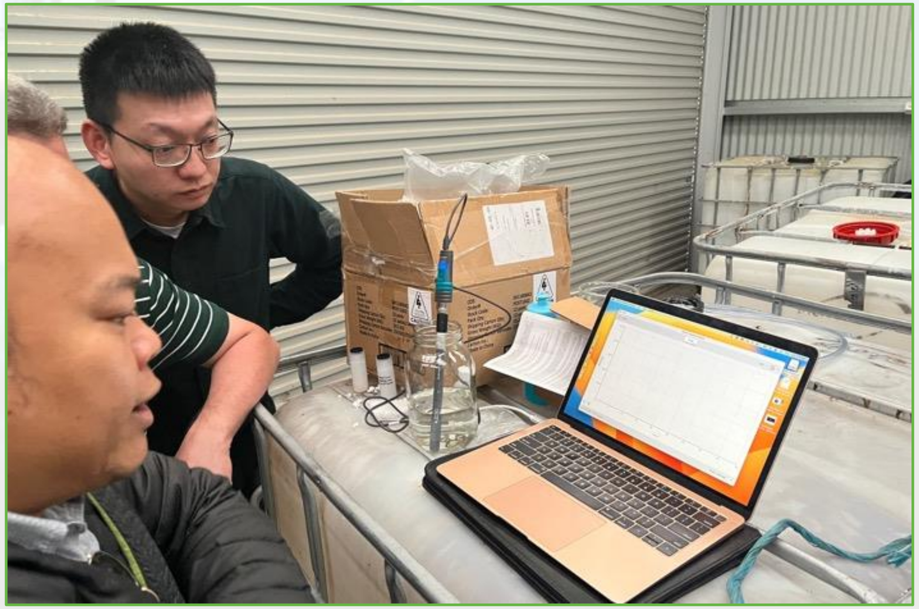
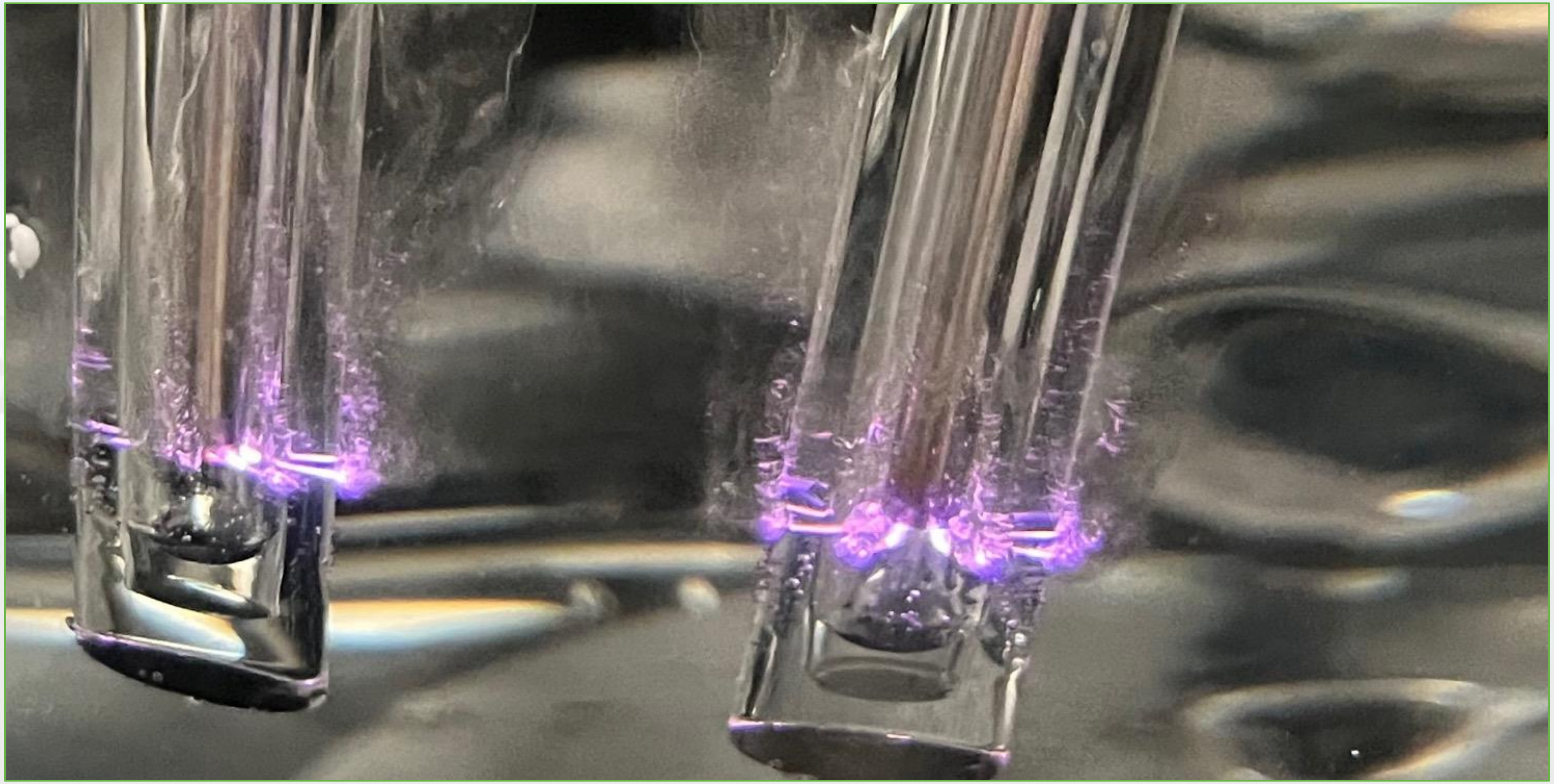


Image Courtesy: Hessel Research Group. Dr Nam Tran (L) and Changping Zhuang (R)

Electricity: Non-Thermal Plasma



Plasma Leap 100. Image Courtesy: FarmN

Electricity: Non-Thermal Plasma

Practical Learnings

If a peripheral fails, relatively more expensive equipment may be damaged. The quality and reliable of components like air compressors and water pumps matters in the context of continue use, even on hot days.

In terms of nitrogen output, there is room for improvement.

Liquid Storage:

Keep the plasma solution cool to avoid algae.
Blackout sunlight to avoid algae.

Keep cool to avoid NO_2^- degradation via off-gas (NO).
Control ventilation to inhibit off-gas escape.

Plasma Leap 100. Image Courtesy: FarmN

Electricity: Non-Thermal Plasma

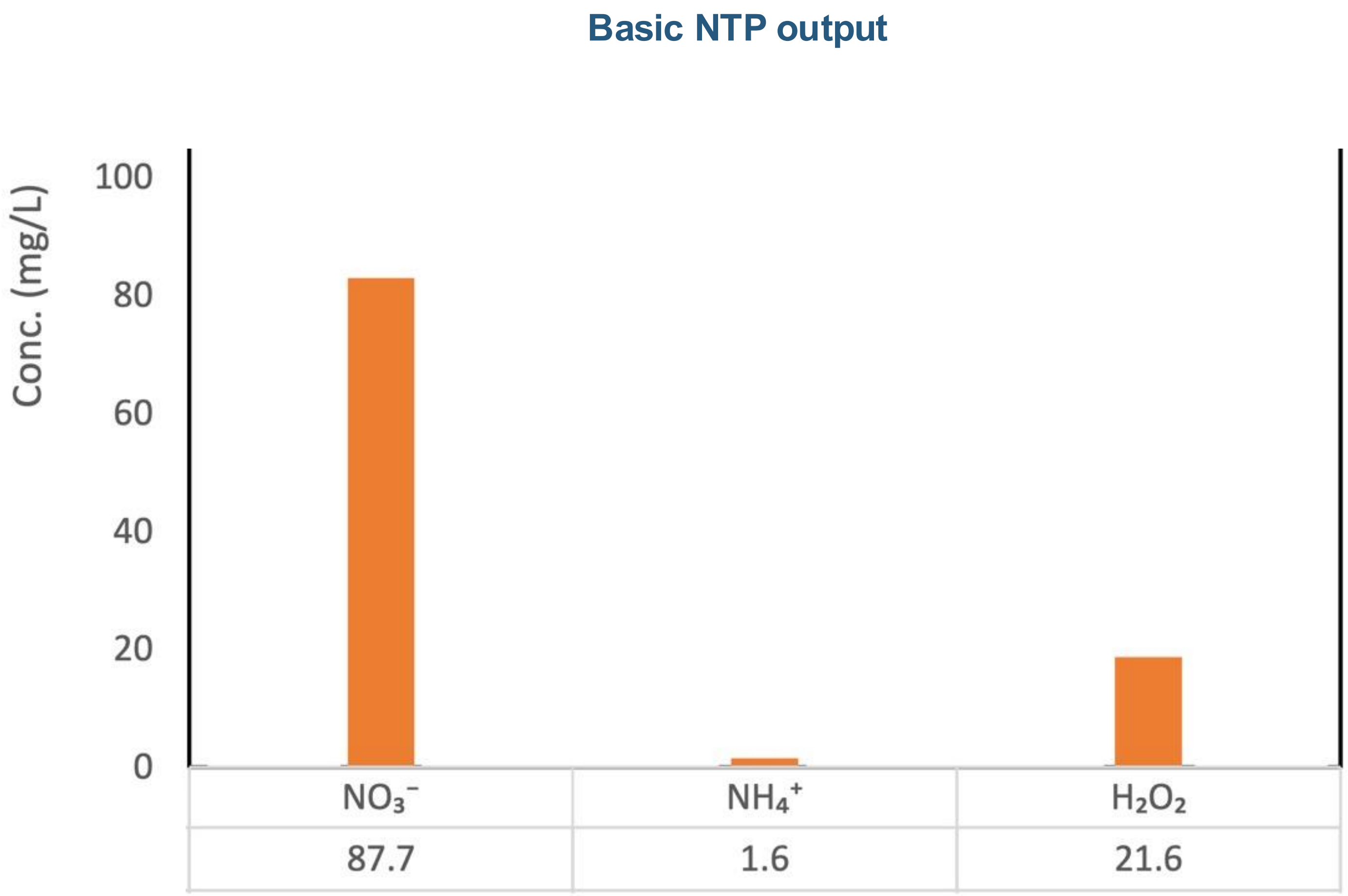
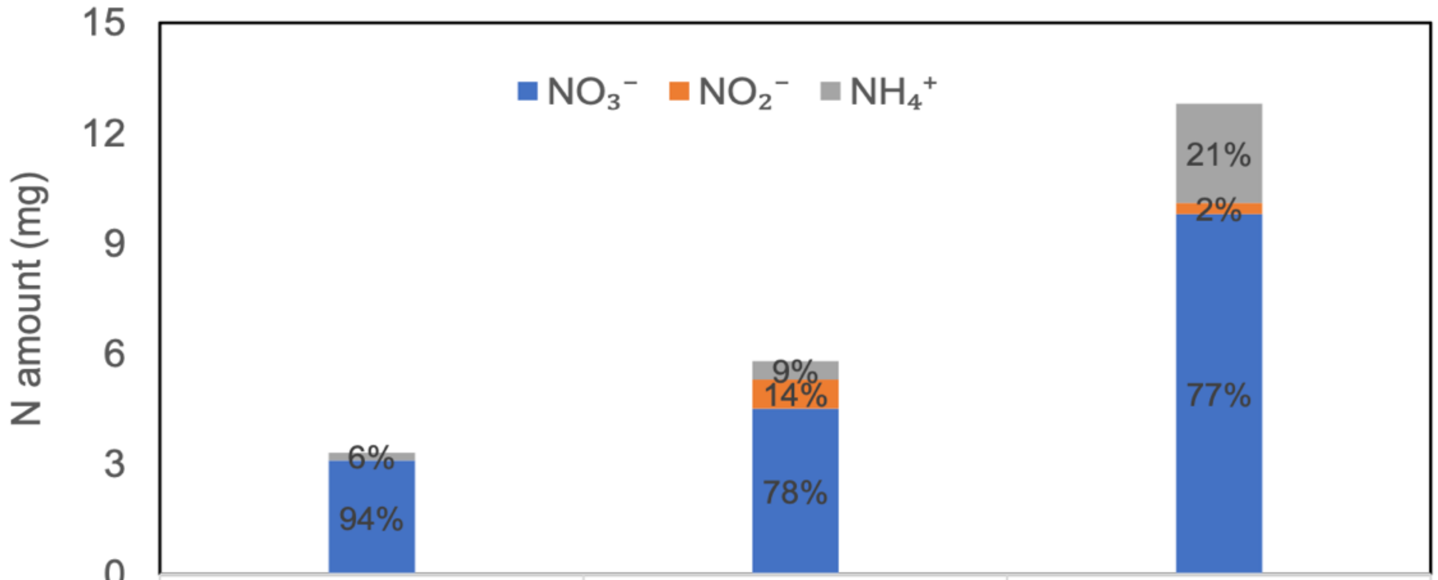


Image and Data Courtesy: Hessel Research Group, University of Adelaide.

Electricity: Non-Thermal Plasma

Processing method and nitrogen output.



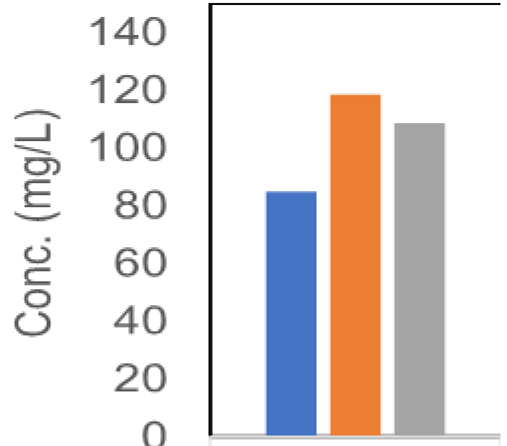
	Batch-20min	Recycling-20min	Recycling-1h
NH_4^+	0.2	0.5	2.7
NO_2^-	0	0.8	0.3
NO_3^-	3.1	4.5	9.8

Image and Data Courtesy: Hessel Research Group, University of Adelaide.

N / Min	**0.165** (3.3 / 20)	**0.290** (5.8 / 20)	**0.210** (12.8 / 60)

Electricity: Non-Thermal Plasma

Catalysts can lift electrical efficiency and nitrogen output.



	NO_3^-
No Catalyst	84.8
Catalyst (in tube 20min)	118.4
Catalyst (out tube 20min)	108.5

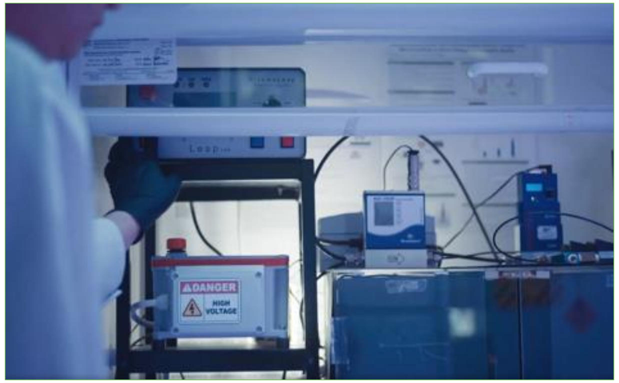
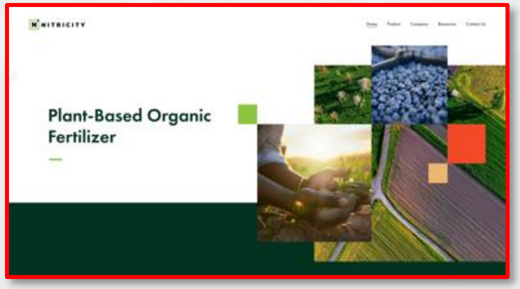


Image and Data Courtesy: Hessel Research Group, University of Adelaide. Professor Volker Hessel (R).

Electricity: Non-Thermal Plasma

A range of PLASMA products are emerging in the market to service the demand for on-farm nitrogen.



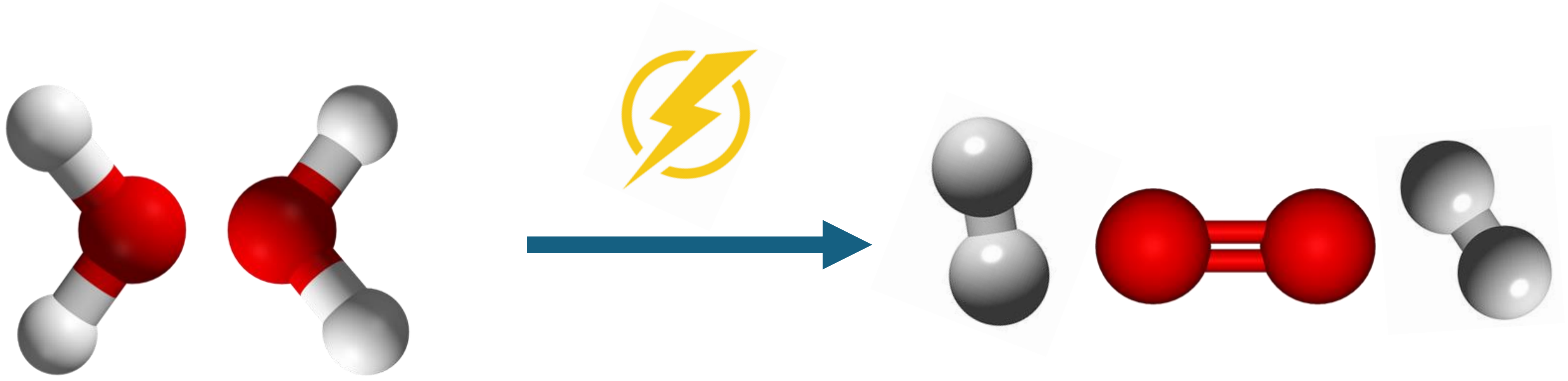
Electricity: Electrolysis

H_2 from H_2O

1. Electrolysis of water
2. Haber Bosch or Equivalent

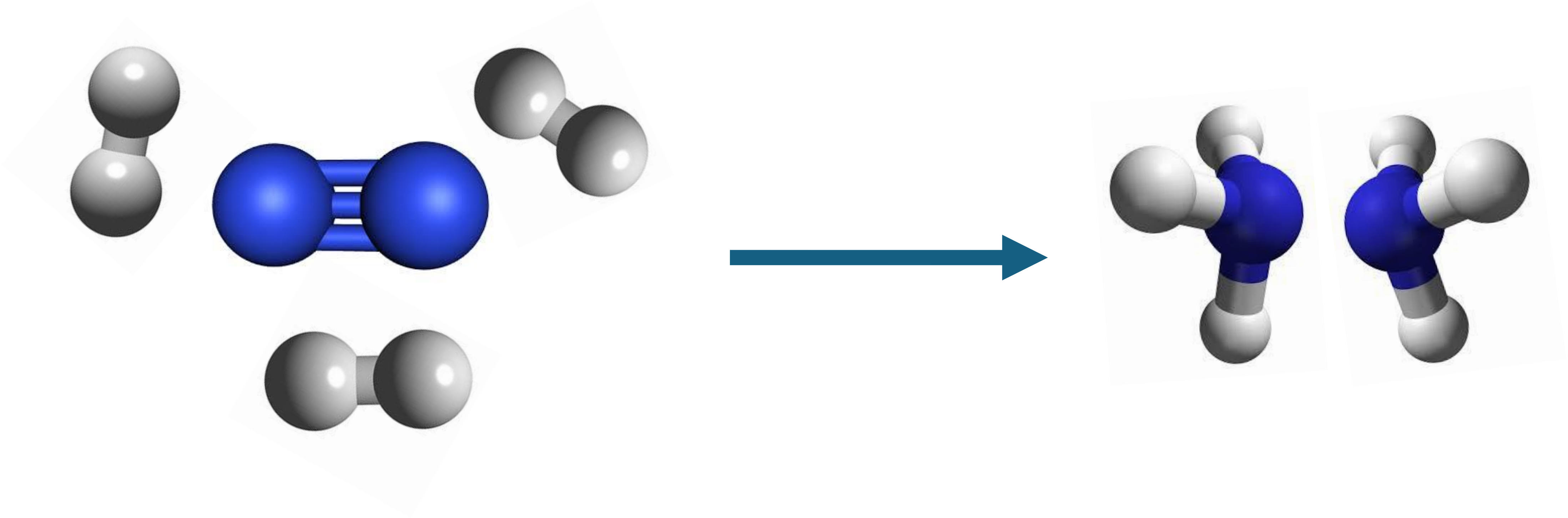
Electrolysis

$2\ H_2O\ >\ CO_2 + 2H_2$



Haber Bosch Ammonia Synthesis

$N_2 + 3H_2 > 2NH_3$



Good Earth Green Hydrogen and Ammonia (GEGHA)

HIRINGA

GOOD EARTH COTTON

Good Earth Green Hydrogen and Ammonia (GEGHA)

GEGHA Project Specifics

Project Status
UNDER CONSTRUCTION

Power & Firming
36 MW Solar
41 MWh BESS

Plant Capacity/Production
Electrolysis: 15 MW
Ammonia production: 4,500 TPA

Onsite Storage
Hydrogen: ~3t
Ammonia: 600t

FARM N

Completed LCA to ISO 14067 and the GEGHA project is forecasting a material emissions reduction for both nitrogen production and avoided transport.

HIRINGA

GOOD EARTH COTTON

atome

145MW Villeta Project Highlights

Developing the world's first dedicated green fertiliser facility

Green Power

Long-term 145MW PPA for supply of low cost baseload hydroelectricity

Location

75-acre Free Trade Zone site next to substation and main import/export terminals

Engineering

EPC Contract with CASALE for a fixed priced lumpsum US$465 million

Offtake

Long-term offtake agreed with Yara International for entire 260k tonnes-per-year annual production

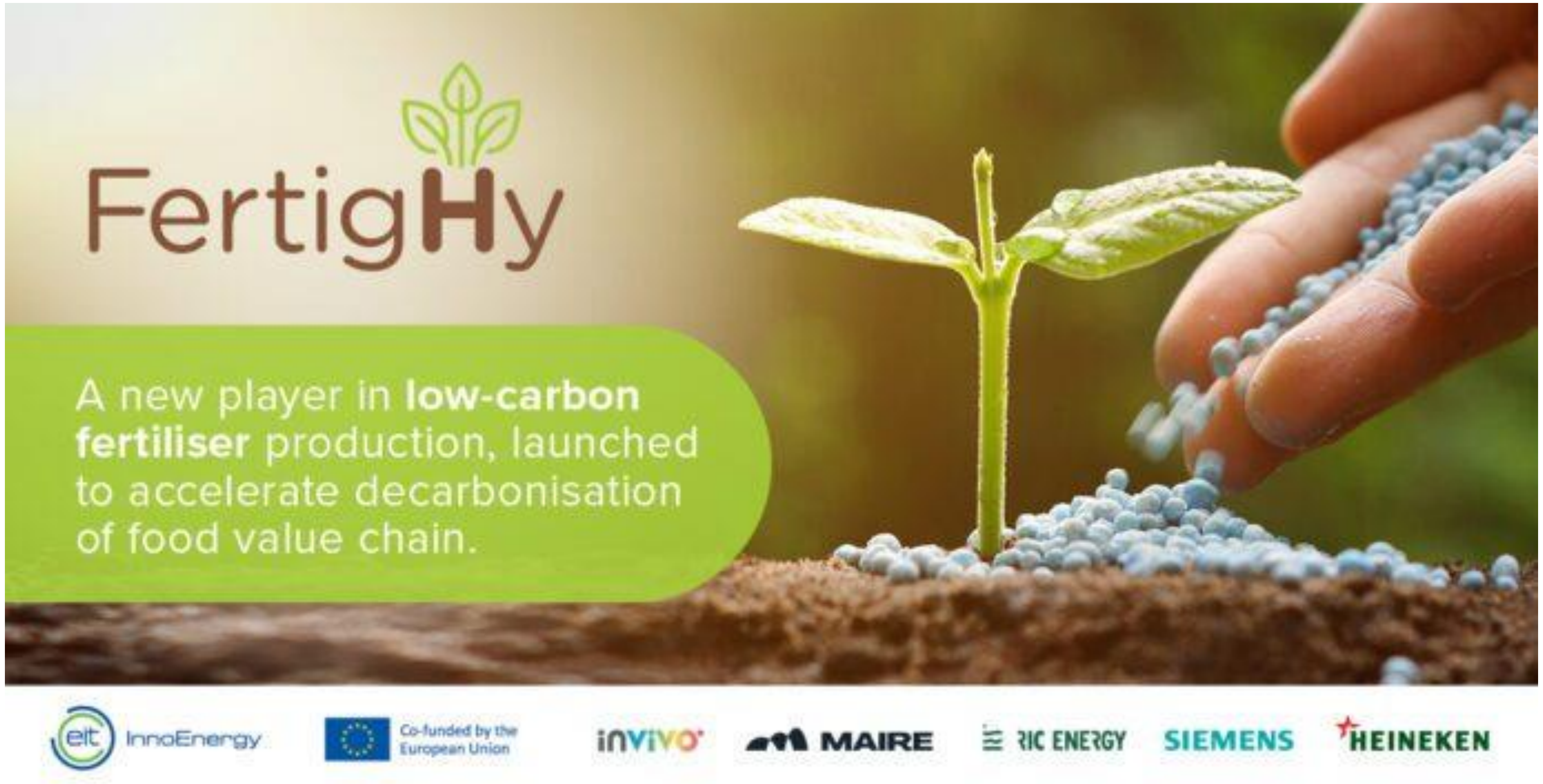
Finance

Project equity and debt finance progress with debt interest 5x oversubscribed

Impact

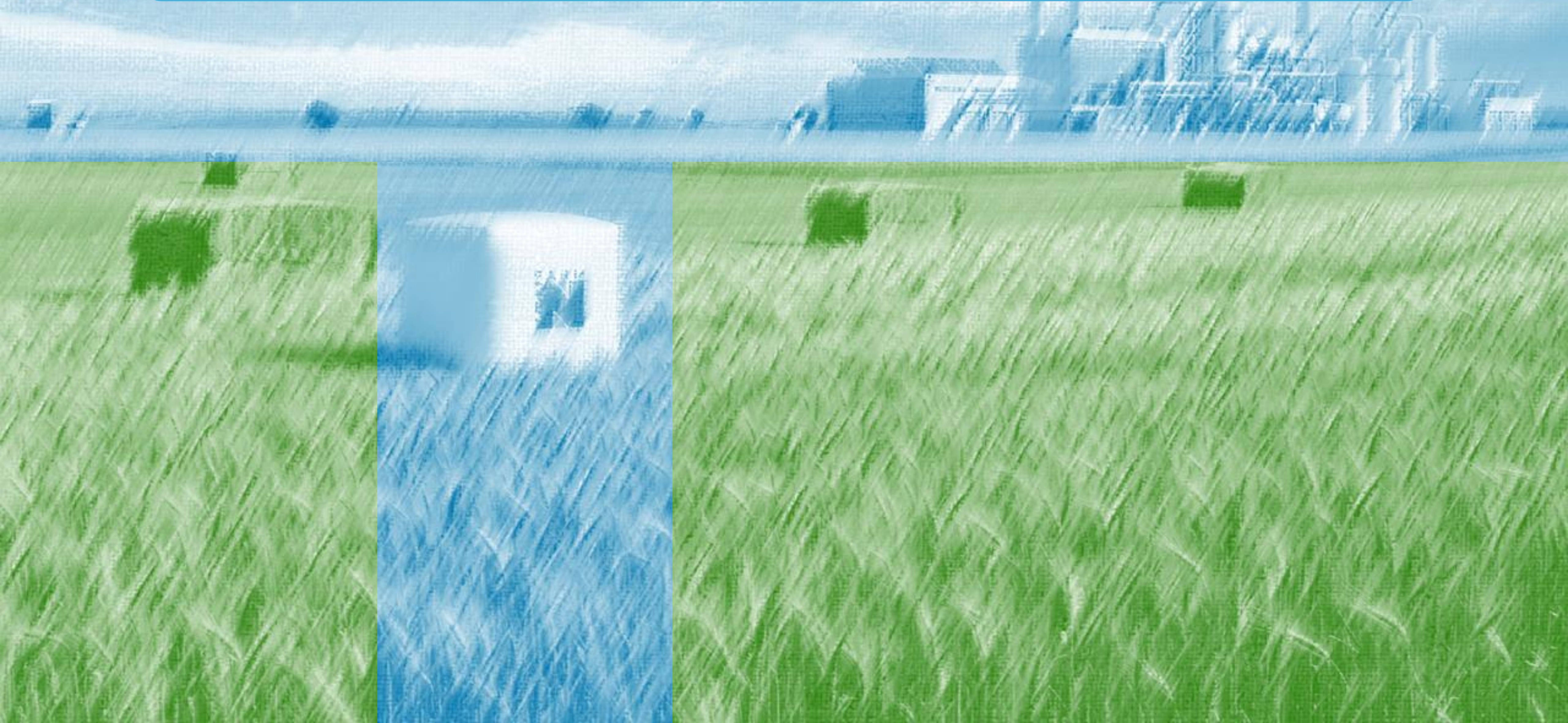
Environmental & Social impact Assessment completed to IFC performance standards

145 MW of renewable hydropower, producing around 80,000 tons per year of ammonia; then converted to 260,000 tons of CAN (~150,000 t Urea).



200 MW electrolyser using nuclear & RE electricity, producing around 170,000 tons per year of ammonia; then converted to 500,000 tons of CAN27 (~290,000 t Urea).

Biomass Pathways to Nitrogen Fertiliser



Biomass Pathways to Nitrogen Fertiliser

- Centralized processing residues like shells & husks are compatible.
- Straw removal requires close evaluation (transport & soil perspective).
- Non-uniform feedstock is more problematic than uniform feedstock.
- Mixed urban waste and plastic increases complexity, yield and contamination risk.

Biomass pathways to Nitrogen fertiliser

Biomass Composition

$$C\ H_{1.6}\ O_{0.4}$$

Cellulose	Hemicellulose	Lignin	Ash / Other
35–45%	20–35%	15–25%	5–25%

Biomass: Cellulose

H_2 from Cellulose & Hemicellulose

1. Carbohydrate to H_2

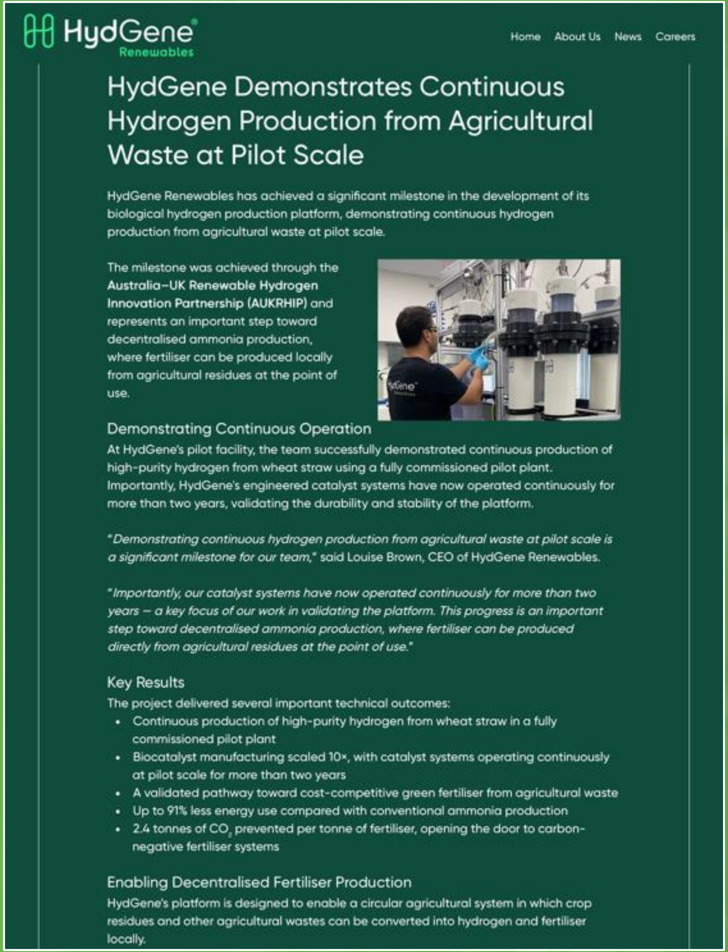
2. Haber Bosch or Equivalent

Stage: Pilot Plant
Youtube Search: ‘SANoTIll Hydrogen’

Cellulose

H_2 from Cellulose & Hemicellulose

Feedstock	H_2 / t feedstock (kg)
Straw (current aim / status)	***30***
Actual Chaff Cart (Barley)	**22.6**
Actual Chaff Cart (Lentils)	**11.4**



HydGene Renewables

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HydGene Demonstrates Continuous Hydrogen Production from Agricultural Waste at Pilot Scale

HydGene Renewables has achieved a significant milestone in the development of its biological hydrogen production platform, demonstrating continuous hydrogen production from agricultural waste at pilot scale.

The milestone was achieved through the **Australia–UK Renewable Hydrogen Innovation Partnership (AUKRHIP)** and represents an important step toward decentralised ammonia production, where fertiliser can be produced locally from agricultural residues at the point of use.

Demonstrating Continuous Operation

At HydGene's pilot facility, the team successfully demonstrated continuous production of high-purity hydrogen from wheat straw using a fully commissioned pilot plant. Importantly, HydGene's engineered catalyst systems have now operated continuously for more than two years, validating the durability and stability of the platform.

"*Demonstrating continuous hydrogen production from agricultural waste at pilot scale is a significant milestone for our team,*" said Louise Brown, CEO of HydGene Renewables.

"*Importantly, our catalyst systems have now operated continuously for more than two years – a key focus of our work in validating the platform. This progress is an important step toward decentralised ammonia production, where fertiliser can be produced directly from agricultural residues at the point of use.*"

Key Results

The project delivered several important technical outcomes:

- Continuous production of high-purity hydrogen from wheat straw in a fully commissioned pilot plant
- Biocatalyst manufacturing scaled 10×, with catalyst systems operating continuously at pilot scale for more than two years
- A validated pathway toward cost-competitive green fertiliser from agricultural waste
- Up to 91% less energy use compared with conventional ammonia production
- 2.4 tonnes of CO_2 prevented per tonne of fertiliser, opening the door to carbon-negative fertiliser systems

Enabling Decentralised Fertiliser Production

HydGene's platform is designed to enable a circular agricultural system in which crop residues and other agricultural wastes can be converted into hydrogen and fertiliser locally.

Biomass: Gasification / Thermolysis

H_2 from Cellulose, Hemicellulose & Lignin plus WGSR

1. Biomass to Syn Gas ($CO + H_2$)
2. Water gas-shift reaction
3. Haber Bosch Ammonia Synthesis
4. Bosch-Meiser Urea Synthesis

Biomass: Gasification / Thermolysis

H_2 from Cellulose, Hemicellulose & Lignin plus WGSR

- Scale matters and influences the cost of production.

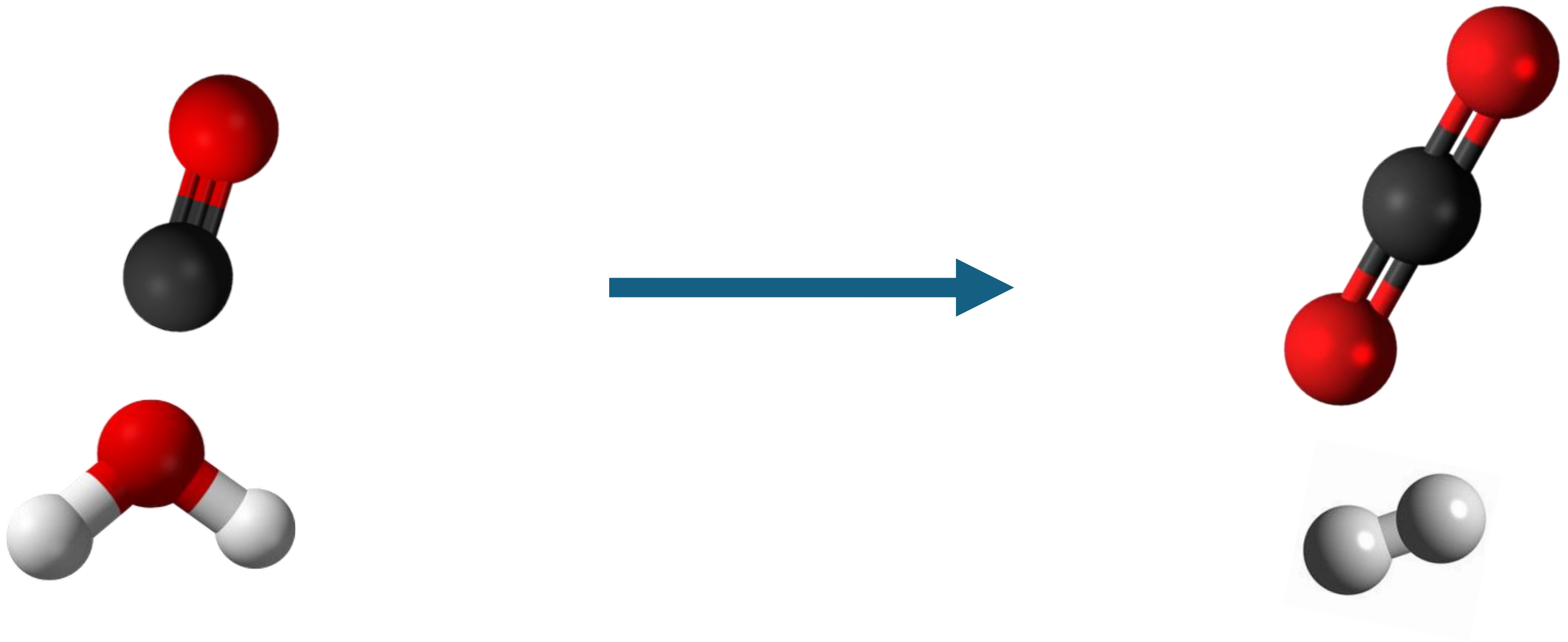
- Front-end material handling and back-end ammonia technology components exist. Many components are mature due to decades of biomass-to-energy and traditional urea production.

- Straw gasification / thermolysis requires more scrutiny.

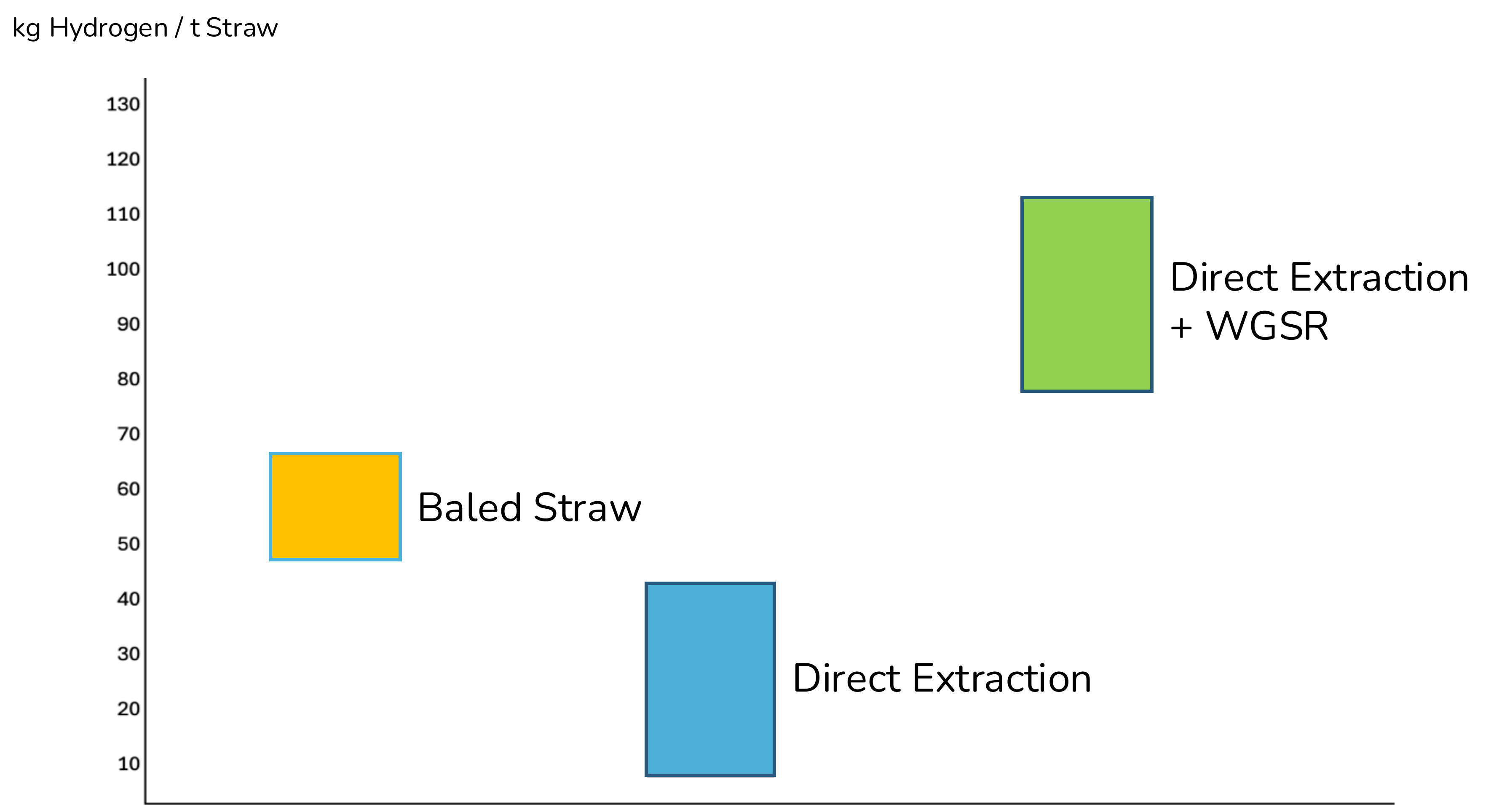


Water Gas-Shift Reaction

$CO + H_2O > CO_2 + H_2$



Biomass: Hydrogen Yield



Biomass at Regional Scale

GUESTIMATES ONLY

Water for WGSR

(assuming gross water use with no recovery)

Process Scale (Straw t.p.a.)	Production Guestimate (Urea t.p.a.)	WGSR Water Requirement per tonne urea. (t water / t urea)	WGSR Water cost per tonne urea ($)
150k - 200k	37.5k - 50k	2.96	9.96

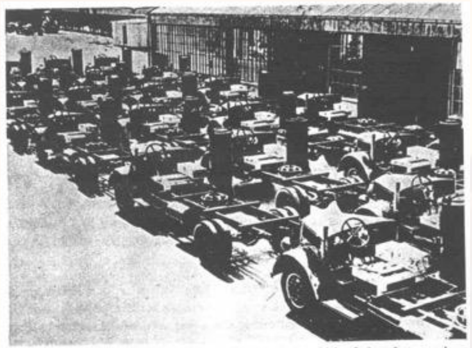
FARM N

Biomass: Gasification / Thermolysis

H_2 from Cellulose, Hemicellulose & Lignin plus WGSR

Natural Gas > Coal > Wood > Straw.

History of biomass at small scale and moderate scale.



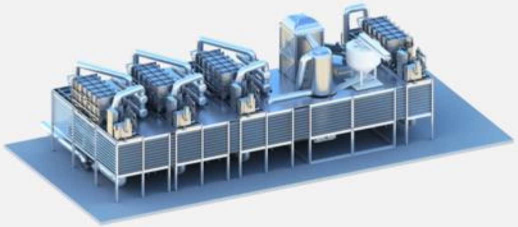
Germany, about 1943. Mass production of gas producer vehicles, Imbert factory, where some 500,000 gas producers were manufactured during World War II. (E. E. Donath)

Currently a dynamic space.

Hypergas® Module
(Thermolysis + Reforming)

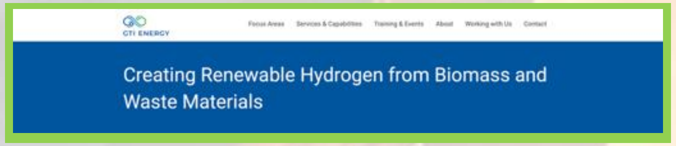
+

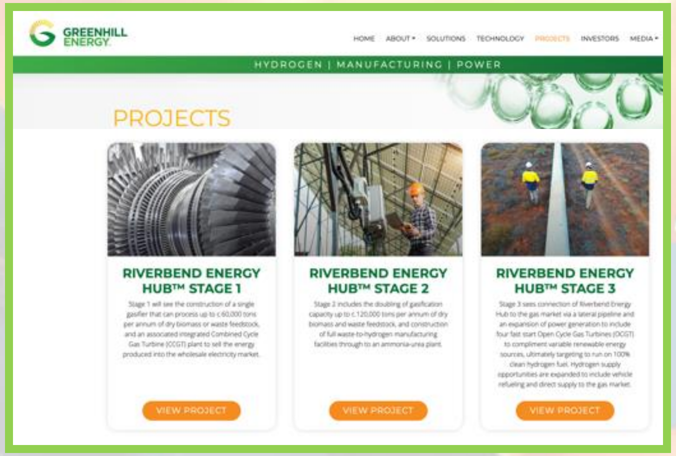
Complementary equipment



TEPC Module :

Treatment, Enrichment, Purification and Compression *(Included Water Gas Shift Reaction (WGSR) and Pressure Swing Adsorption (PSA))*





Ash

The residual ash from the energy processing will contain the non-volatile potash nutrients.

Macro = Phosphorous (1.66%), Potassium (18.5%)

Micro = Sulfur (1.19%), Zinc (0.03%)

The ash reflects the stable nutrients in the biomass.
Can be put back into a fertiliser blend.

Silicon	as	SiO_2	**69.0**
Aluminium	as	Al_2O_3	**1.67**
Iron	**as**	**Fe_2O_3**	**1.20**
Calcium	**as**	**CaO**	**2.68**
Magnesium	**as**	**MgO**	**1.59**
Sodium	as	Na_2O	**1.85**
Potassium	**as**	**K_2O**	**18.5**
Titanium	as	TiO_2	**0.11**
Manganese	**as**	**Mn_3O_4**	**0.17**
Phosphorus	**as**	**P_2O_5**	**1.66**
Sulfur	**as**	**SO_3**	**1.19**
Strontium	as	SrO	**0.03**
Barium	as	BaO	**0.04**
Zinc	**as**	**ZnO**	**0.03**
Vanadium	as	V_2O_5	**0.03**

Biomass at Regional Scale

Conservative GUESTIMATE at **25% conversion ratio**

Assume **Urea application at 150kg/ha**
to grow a wheat crop with a
grain yield of 3.5T
and a straw yield of 5T

Straw cut of 4T / ha (leaving 1T residue)

4T of straw at 25% conversion ratio = 1T Urea

At a urea application rate of 150kg/ha,
1T of urea services 6.67 hectares.

Material Only
1 Ha Straw @ 4T = 6.67 Ha @ 150kg Urea

Straw from 15% of Farm Area for 100% Farm Fertiliser

Straw Input (t)	Hectares of straw at 4t/ha **(ha)**	**Urea Output (t)**	Hectares at 150kg of Urea **(ha)**
50,000	**12,500**	**12,500**	**83,000**
100,000	**25,000**	**25,000**	**166,000**
150,000	**37,500**	**37,500**	**250,000**
200,000	**50,000**	**50,000**	**333,000**
250,000	**62,500**	**62,500**	**416,000**

Biomass at Regional Scale

Optimistic GUESTIMATE at **83% conversion ratio**

Assume **Urea application at 150kg/ha**
to grow a wheat crop with a
grain yield of 3.5T
and a straw yield of 5T

Straw cut of 4T / ha (leaving 1T residue)

1.25T of straw at 83% conversion ratio = 1T Urea

At a urea application rate of 150kg/ha,
1T of urea services 6.67 hectares.

Material Only
1 Ha Straw @ 4T = 21.34 Ha @ 150kg Urea

Straw from 4.7% of Farm Area for 100% Farm Fertiliser

Straw Input (t)	Hectares of straw at 4t/ha **(ha)**	**Urea Output (t)**	Hectares at 150kg of Urea **(ha)**
50,000	12,500	**41,500**	276,000
100,000	25,000	**83,000**	552,000
150,000	37,500	**124,500**	828,000
200,000	50,000	**166,000**	1,104,000
250,000	62,500	**207,500**	1,380,000

Cost Plus Business Model

What is the realistic 'Opportunity Cost' for straw and the 'Cost Plus' dollar figure for a bankable EPCM ?

Scale, location, catchment, technology set, farm participation intensity, biomass & electrical.

Potential business model: Local production

Potential savings from local production

- Use of own feedstock
- Freight and cartage
- Security: known quantities retained for local use/ability to quickly generate local supply
- Lower long term supply costs
- No currency exposure
- More discretion, increased access and flexibility
- No or low cost of power locally

Potential cost: base assumptions

Bentleys THINKING AHEAD

Acres	3000
Hectares	1215
Crop	Wheat
Price	$300/t
N per Ha	150kg
Yield	3.5t
Urea	$1000/t
Straw	4t/Ha
Urea need	182.25/t
Straw need	729t

Cost of straw 729t straw?

Bentleys
THINKING AHEAD

Item	Purchased	Contracted	Internally funded
Purchase cost	$120/t		
Bailing		$150/ha	
Raking		$20/ha	
Mowing		$50/ha	
Labour + O/heads			$3000yr
P&E & Variable			$18,000yr
Freight	$8,000	$8,000	$8000
Total	$95,480	$48,095	$29,000yr
Cost/t	$130/t	$65/t	$40/t

UNOFFICIAL

$1000/t Urea versus Internal straw + $300t

Bentleys THINKING AHEAD

t/Ha	3.5	4.5	5.5
Sales	**$ 1,275,303.64**	**$ 1,639,676.11**	**$ 2,004,048.58**
Urea	$ 182,186.23	$ 234,239.44	$ 368,090.56
Other	$ 366,194.33	$ 470,821.28	$ 493,650.33
Variable costs	$ 548,380.57	$ 705,060.73	$ 861,740.89
Gross profit	**$ 726,923.08**	**$ 934,615.38**	**$ 1,142,307.69**
Overheads	$250,000.00	$250,000.00	$250,000.00
EBITDA	**$ 476,923.08**	**$ 684,615.38**	**$ 892,307.69**
Finance	$ 100,000.00	$ 100,000.00	$ 100,000.00
P&E	$ 150,000.00	$ 150,000.00	$ 150,000.00
Net Profit	**$ 226,923.08**	**$ 434,615.38**	**$ 642,307.69**
	18%	27%	32%
t/Urea	182.19	234.24	368.09

t/Ha	3.5	4.5	5.5
Sales	**$ 1,275,303.64**	**$ 1,639,676.11**	**$ 2,004,048.58**
Urea	$ 83,805.67	$ 107,750.14	$ 169,321.66
Other	$ 366,194.33	$ 470,821.28	$ 493,650.33
Variable costs	$ 450,000.00	$ 578,571.43	$ 662,971.99
Gross profit	**$ 825,303.64**	**$ 1,061,104.68**	**$ 1,341,076.59**
Overheads	$250,000.00	$250,000.00	$250,000.00
EBITDA	**$ 575,303.64**	**$ 811,104.68**	**$ 1,091,076.59**
Finance	$ 100,000.00	$ 100,000.00	$ 100,000.00
P&E	$ 150,000.00	$ 150,000.00	$ 150,000.00
Net Profit	**$ 325,303.64**	**$ 561,104.68**	**$ 841,076.59**
	26%	34%	42%
t/Urea	182.19	234.24	368.09

Cost Delta

Bentleys
THINKING AHEAD

Straw production	Straw cost	Processing ($300/t)	Total (Local)	Urea (Ext)	Delta/t	Delta $
Internally generated	$29,150	$54,655	$83,805	$182,190	$540/t	$98,380
Contracted	$47,368	$54,655	$102,024	$182,190	$440/t	$80,161
Purchased	$94,736	$54,655	$149,392	$182,190	$180/t	$32,793

Savings from applying the model:

- Monthly hold cost of 182t/Urea = $1007.50/month
- Lower price volatility, higher maintainable margins over time
- Urea access for higher yielding years:
  - $420k between a 3.5t/ yield and a 5.5t yield – how much is attributable to N availability?
- Higher utilisation of current labour and P&E reducing input costs
- Increased profitability or increased distributable funds:
  - Increased resilience
  - Ability to grow (on or off farm wealth)

Nitrogen Fertiliser Plant Questionnaire

Bentleys
THINKING AHEAD

- https://www.surveymonkey.com/r/FSVKVHF