Ammonia: Transitioning to a Net-Zero Future

Feeding &
Fueling the Future

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Nutrien is uniquely positioned to impact:

2 ZERO HUNGER

SUSTAINABLE DEVELOPMENT GOALS

Brings the world together to address global challenges.

We know the world can't solve for one SDG without impacting another – that's why we have taken a **systems-based approach to transform agriculture**.

SDG 13.2.1 looks at the system of climate change and food production together: "…**adapt to the adverse impacts of climate change**, and foster climate resilience and low greenhouse gas emissions development **in a manner that does not threaten food production."**

Read More

Nutrien's *Feeding the Future Plan*

We have developed strategic sustainability priorities that support key transformations and address our most material environmental, social and governance (ESG) risks and opportunities

Our Global Impact

Feeding the Planet Sustainably

Strengthen food security by scaling sustainable and productive agriculture

Environment & Climate Action

Provide solutions and platforms to achieve emissions reductions in alignment with climate science

Inclusive Agriculture

Support rural livelihoods and increase participation of underrepresented stakeholders in agriculture

Our Commitments and Targets Include:

ACHIEVE

Achieve at least a 30 percent reduction in greenhouse gas (GHG) emissions (Scope 1-2) per tonne of our products produced*.

INVEST

Invest in new technologies and pursue the transition to low-carbon fertilizers, including low-carbon and clean ammonia**.

REDUCE

Reduce GHG emissions in nitrogen production by one million tonnes CO2e by the end of 2023

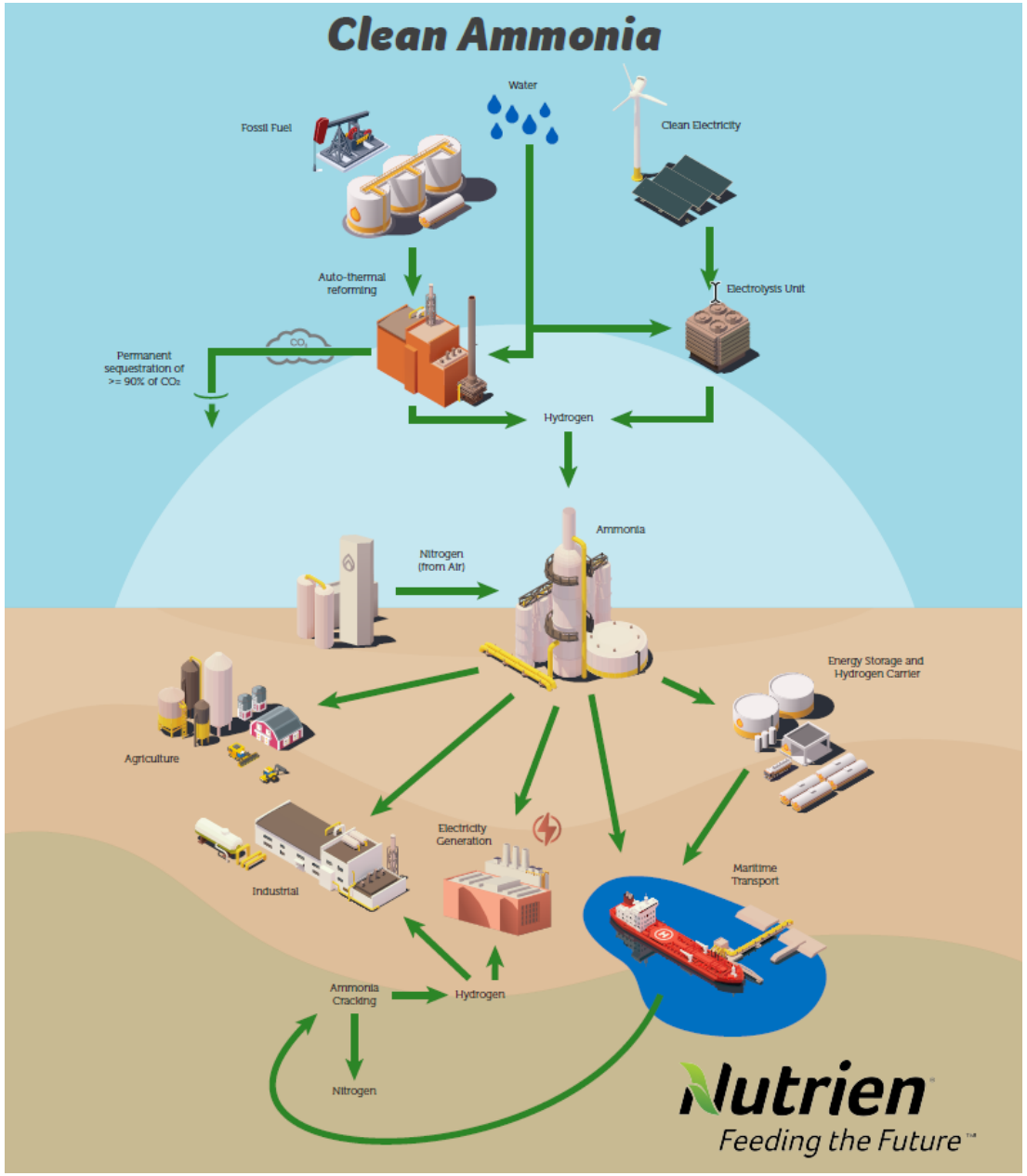
* from a baseline year of 2018.

**low-carbon and clean ammonia previously communicated as blue and green ammonia.

Nutrien's Definition of Clean Ammonia

A sustainable development scenario[1] for ammonia production requires the development of:

- **300 MW** of electrolyzer's **every month AND**;
- **≥ 1 Mmt CO_2 Capture** and sequestration project **every 4 months**



Clean Ammonia

- ✓ ≥90% CO_2 Emissions Reduction
- ✓ Path to Net-Zero Emissions
- ✓ Aligned with Sustainable Development Scenario and Compatible with Paris Agreement

Geismar clean ammonia

90% CO_2 Emissions Reduction

Low-Carbon Ammonia

- ✓ Conventional Ammonia Production with Carbon Capture and Sequestration

Redwater low-carbon ammonia

- ✓ Utilization of By-product Hydrogen

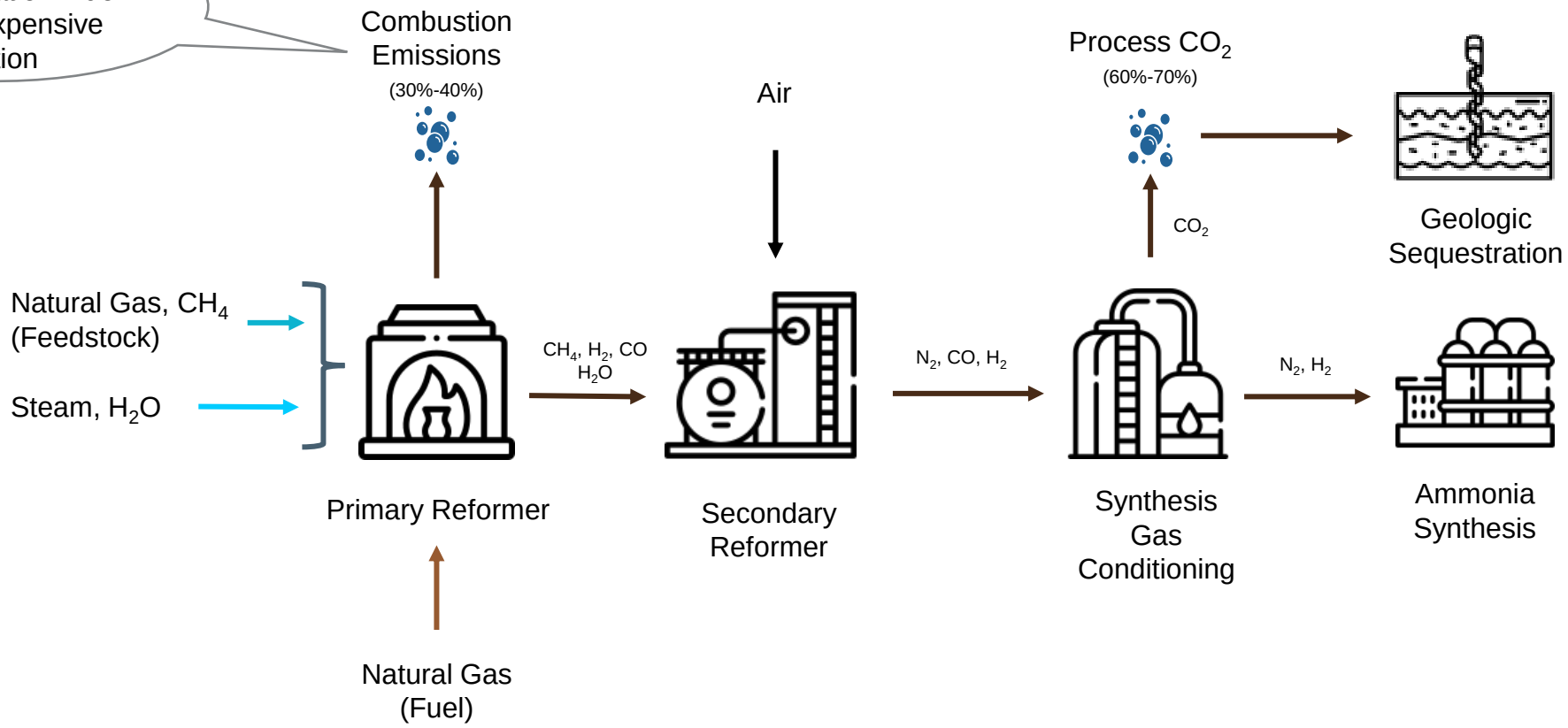
Joffre low-carbon ammonia

1 – IEA Technology Roadmap - Towards more sustainable nitrogen fertilizer production

Low Carbon Ammonia: Conventional Steam Methane Reforming Plant

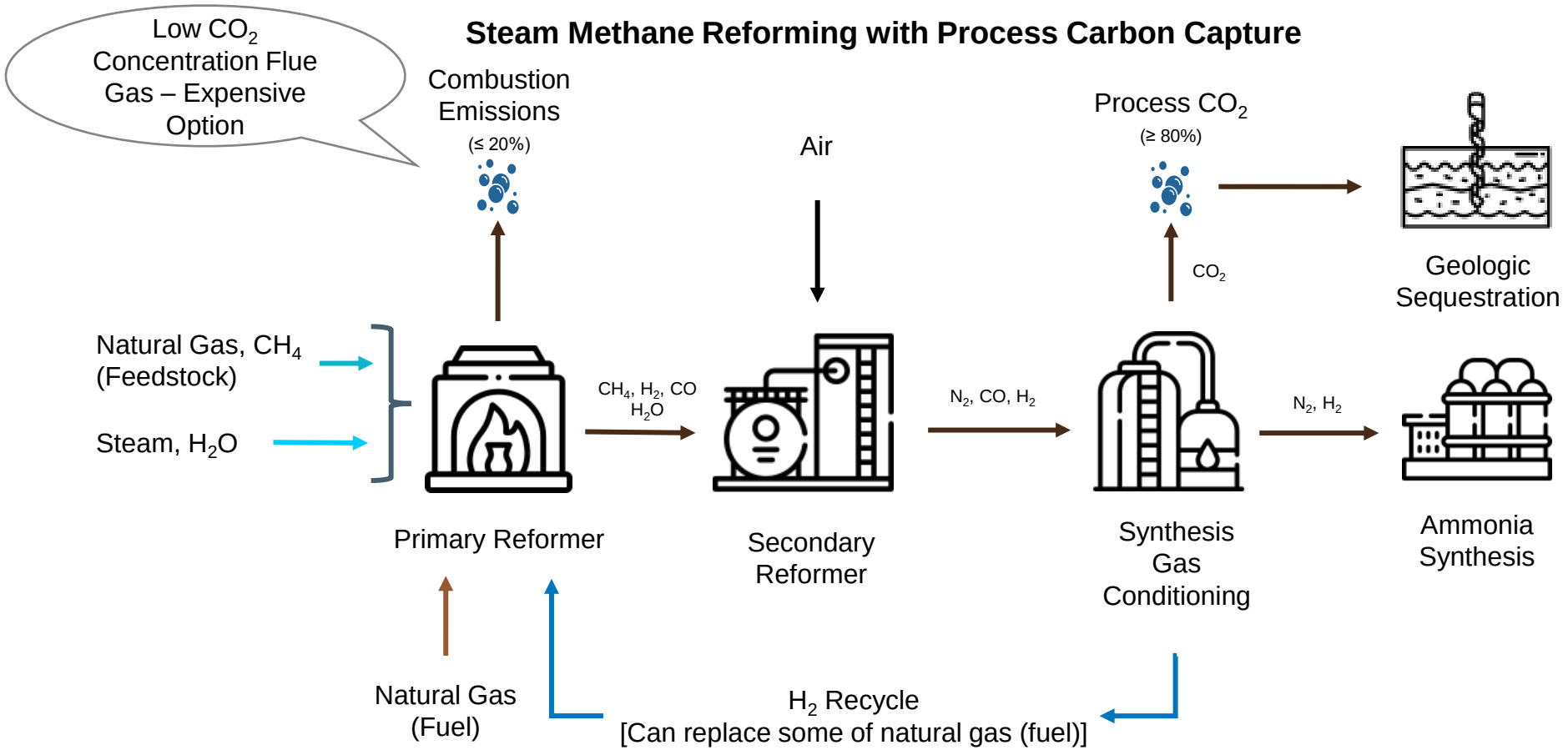
Low CO_2 Concentration Flue Gas – Expensive Option

Steam Methane Reforming with Process Carbon Capture



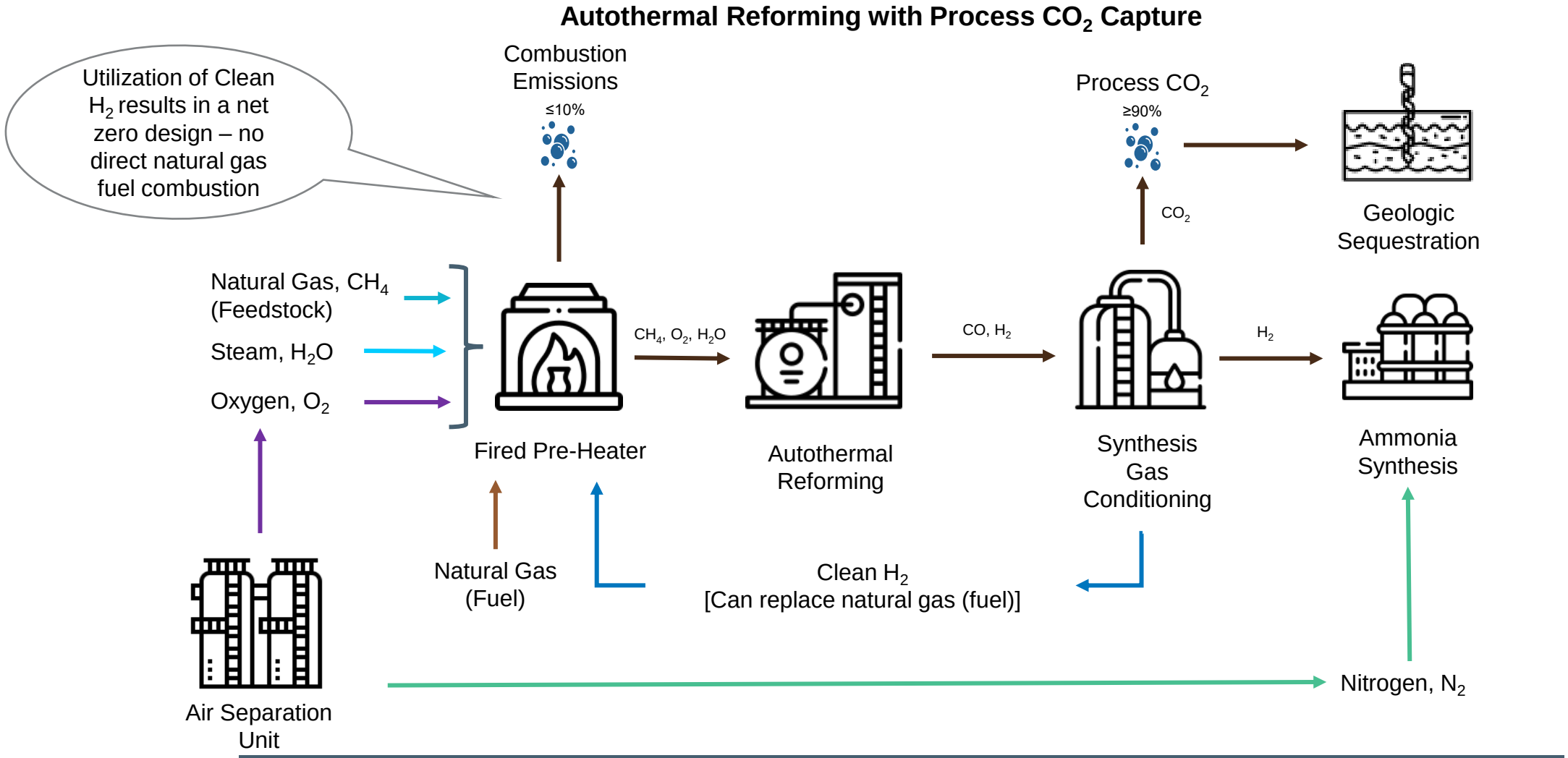
Steam methane reforming generates significant CO_2 emissions from the combustion of natural gas – limiting GHG reduction to ~60%

Low Carbon Ammonia: Conventional Steam Methane Reforming Plant with Hydrogen Recycle



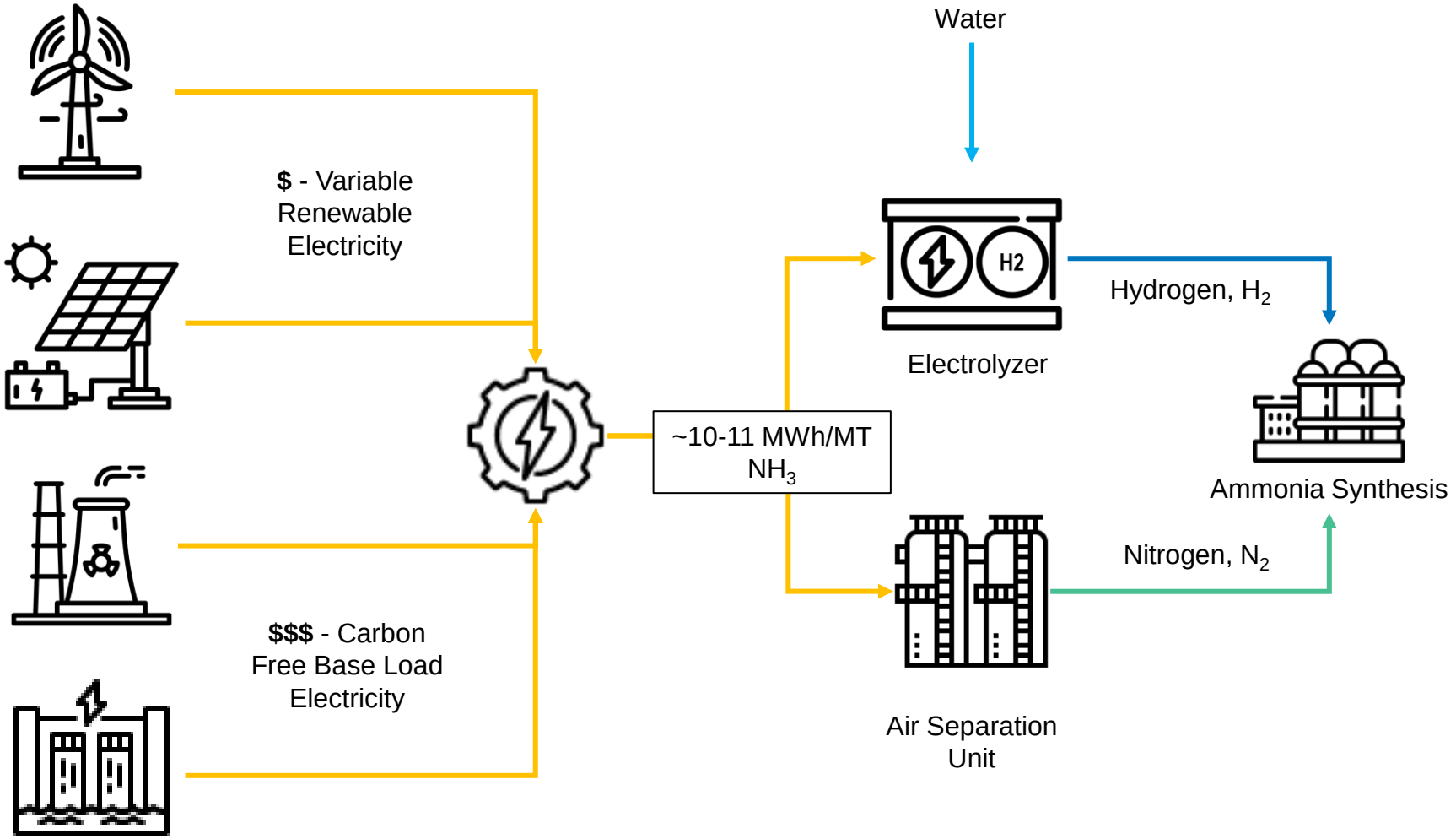
New conventional ammonia plants can be designed for higher carbon capture rates, but flue gas capture is still required to reach a net zero design

Clean Ammonia: Autothermal Reforming



Autothermal reforming avoids significant combustion of natural gas, maximizing CO_2 capture

Clean Ammonia – Clean Electricity and Electrolysis



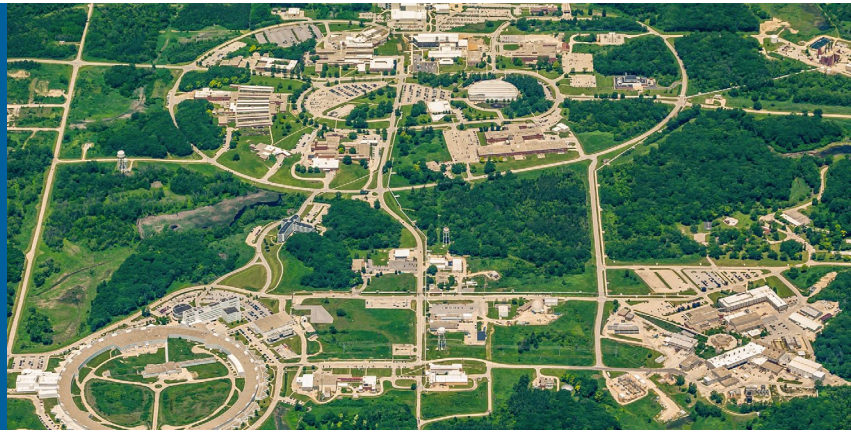
Clean Ammonia via electrolysis is sensitive to the price and carbon intensity of the electricity supply

Thank you for joining!

Learn more about Nutrien's proposed Geismar Clean Ammonia Facility

We Are Nutrien

Life cycle analysis (LCA) and technoeconomic analysis (TEA) of ammonia production

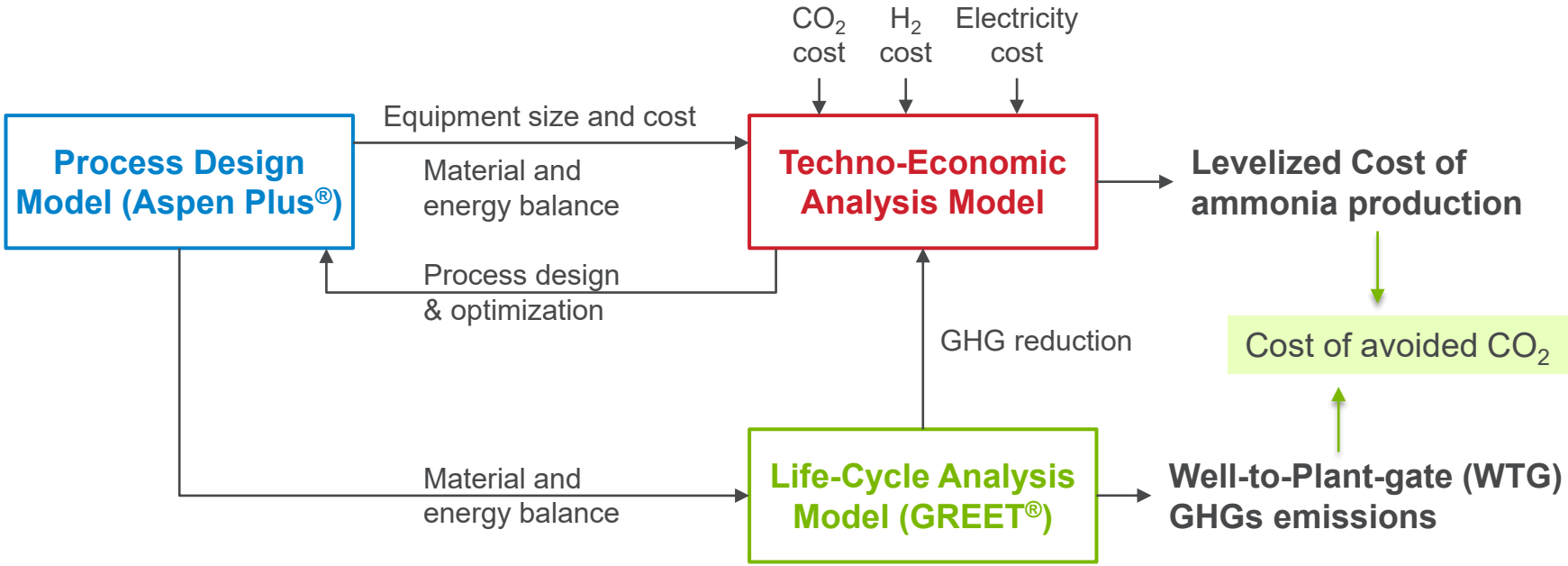


Amgad Elgowainy, Kyuha Lee, Xinyu Liu, Pradeep Vyawahare and Pingping Sun
Argonne National Laboratory

AEA Webinar

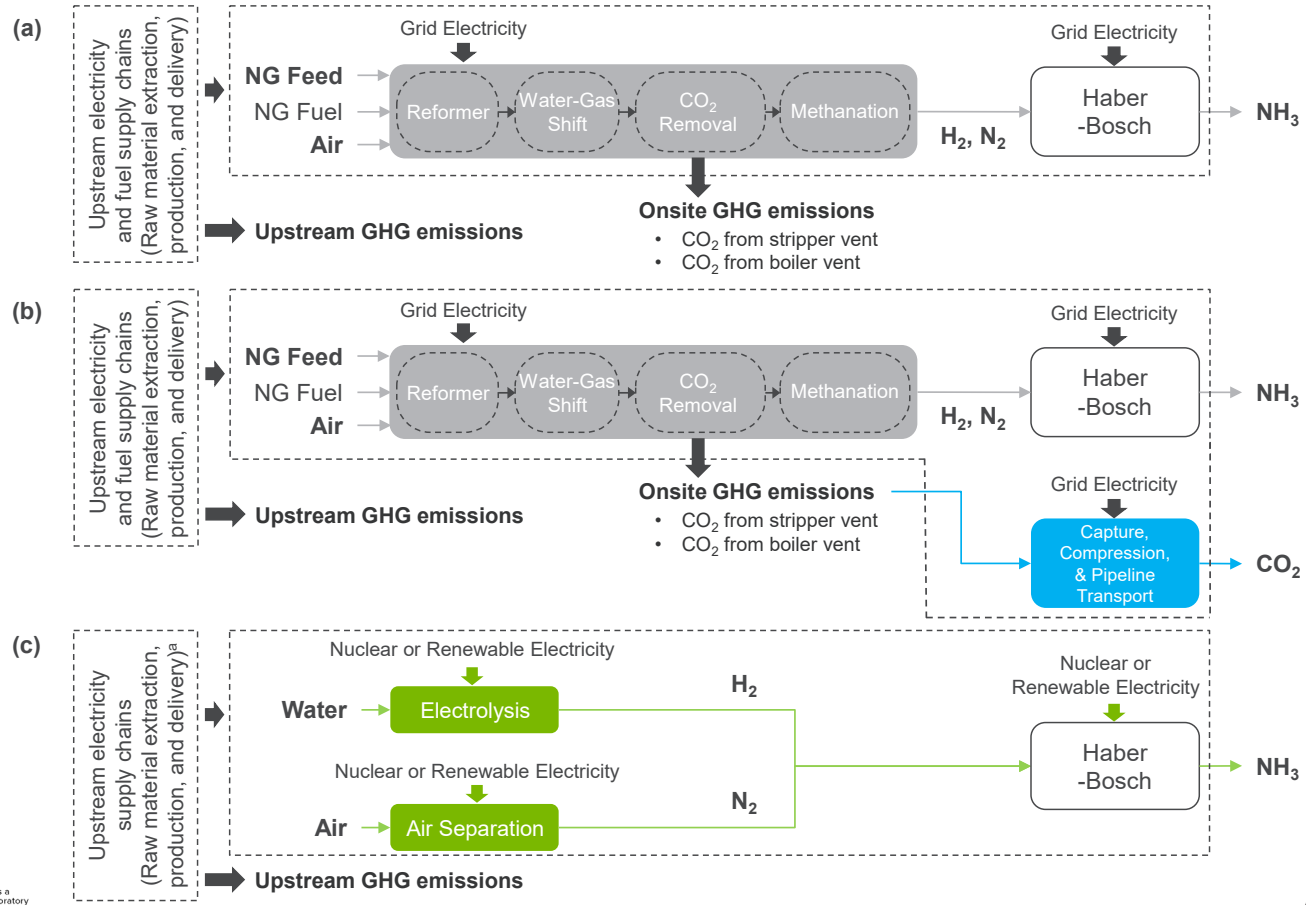
May 24, 2022

Overview

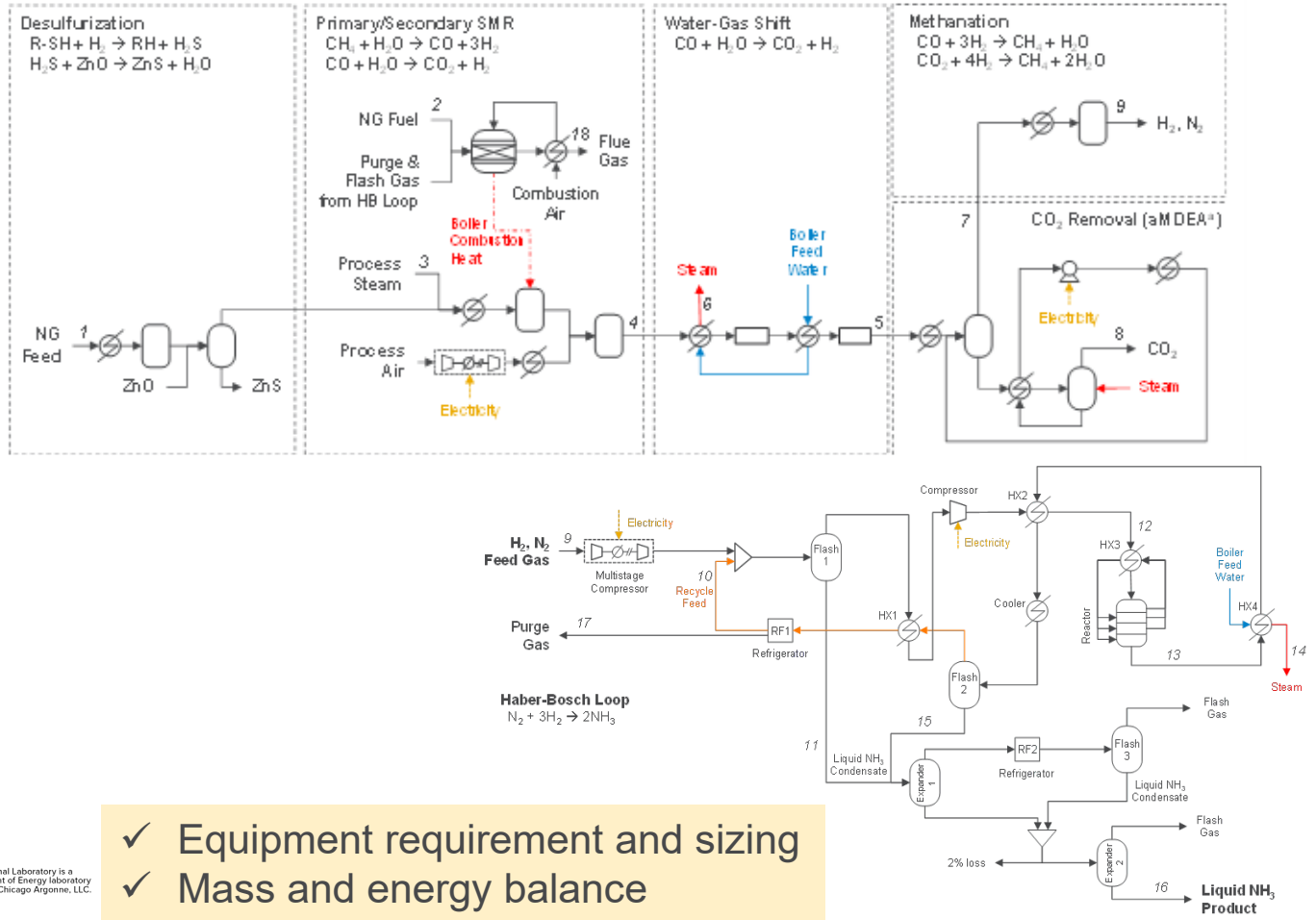


1. Process engineering models of conventional and low-carbon ammonia synthesis
2. Cash flows and levelized cost of ammonia using ANL's TEA modeling framework
3. WTG GHG emissions of ammonia technology pathways
4. Cost of avoided CO_2 emissions for low-carbon ammonia production

Conventional vs. low-carbon ammonia production pathways

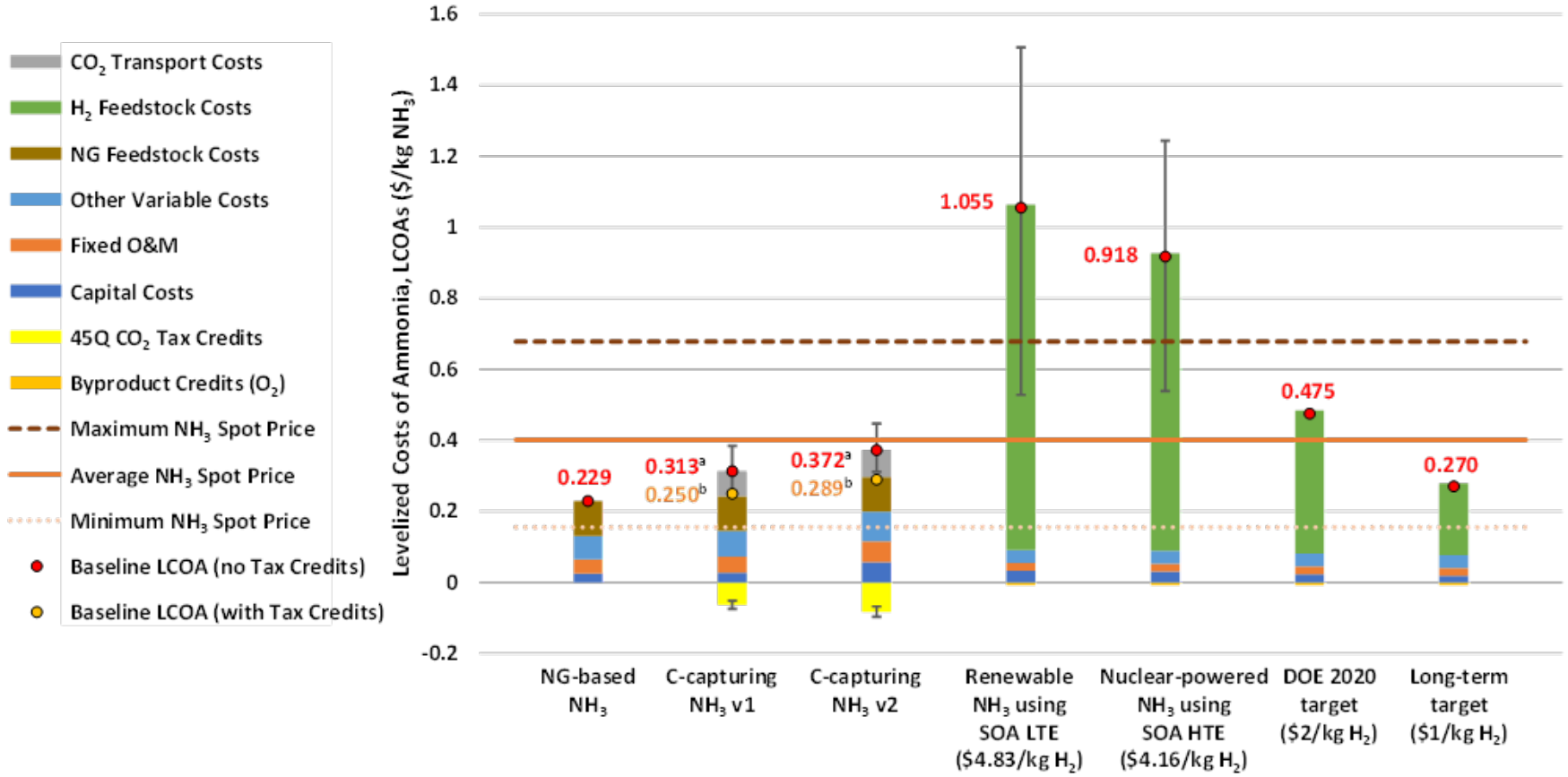


Process level modeling is key for both TEA and LCA

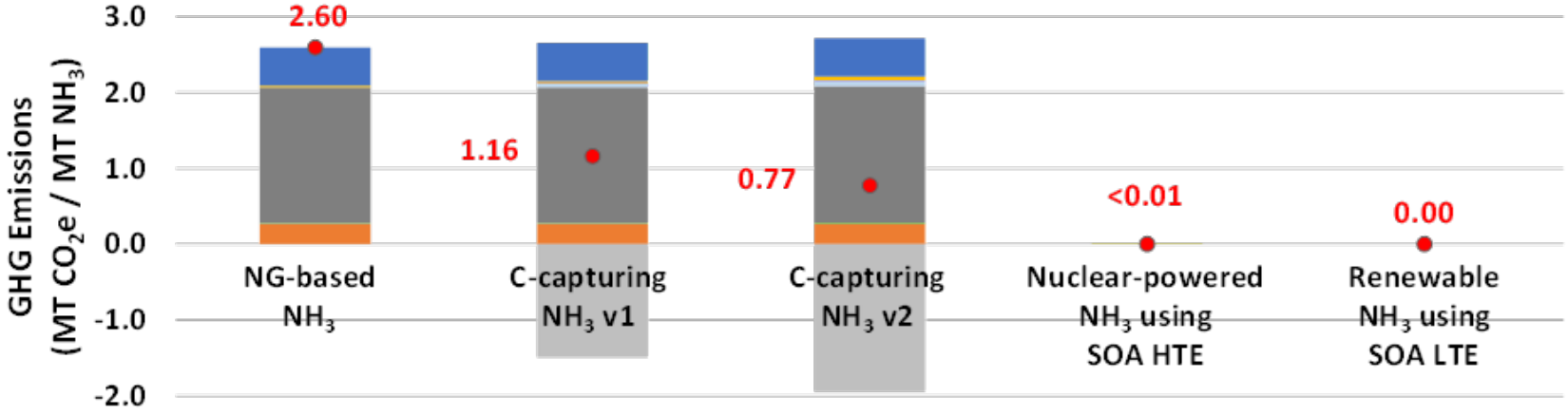


- ✓ Equipment requirement and sizing
- ✓ Mass and energy balance

Levelized Cost of Ammonia (LCOA)

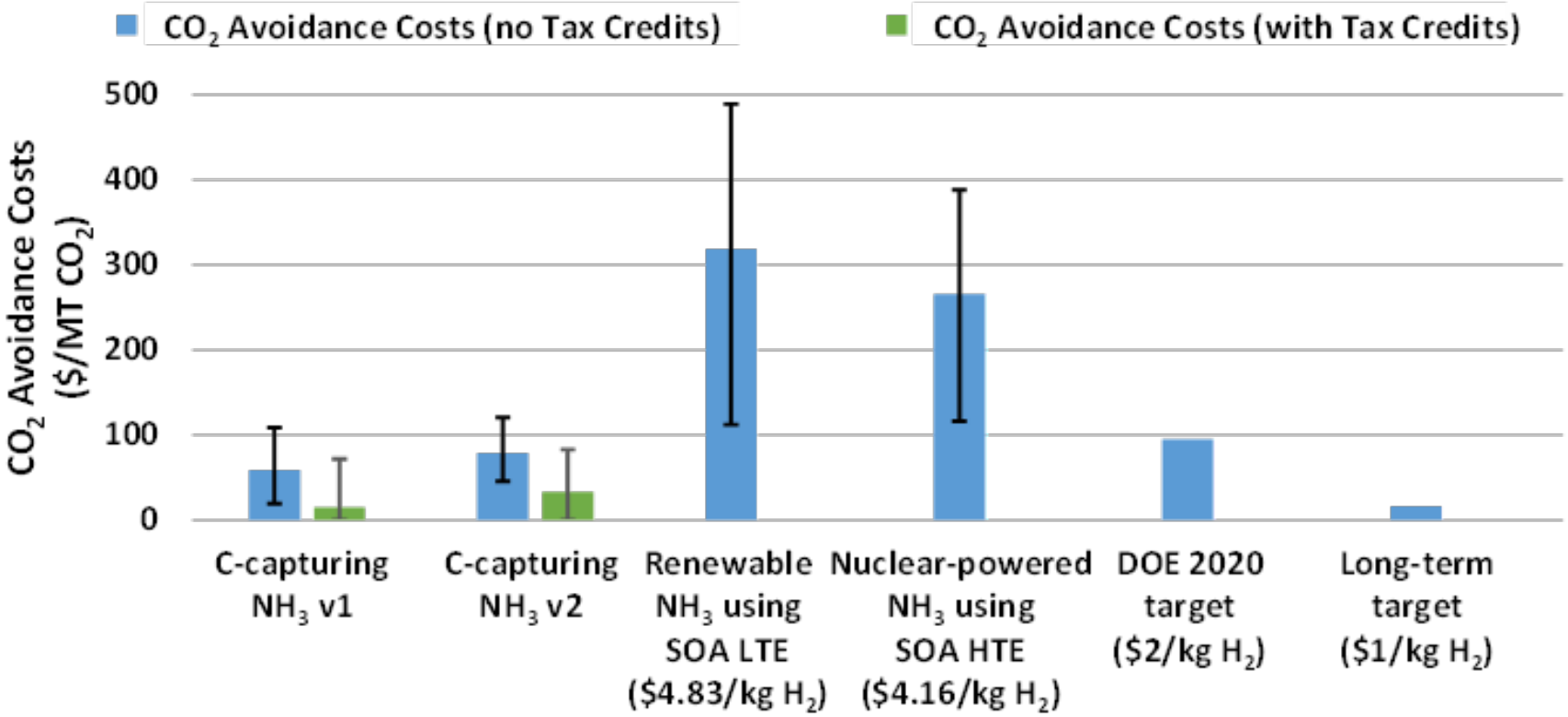


WTG GHG emissions vary by technology pathway



- H_2, N_2 Production Upstream Emissions for NG Use
- H_2, N_2 Production Upstream Emissions for Electricity Use
- H_2, N_2 Production Onsite Emissions
- HB Loop Upstream Emissions for Electricity Use
- Boiler Flue Gas Onsite Emissions
- CO_2 Capture and Compression Upstream Emissions for Electricity Use
- CO_2 Transport Upstream Emissions for Electricity Use
- Captured Onsite CO_2 Emissions
- Net WTG GHG Emissions

Cost of avoided CO_2 emissions



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