Knowledge grows

The role of Ammonia, in a Hydrogen Economy

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Climate Neutral Solutions
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Responsibly Feed the World and Protect the Planet

Our Ambition: towards climate neutrality

Established in 1905 Yara produced green ammonia between 1927 and 1991

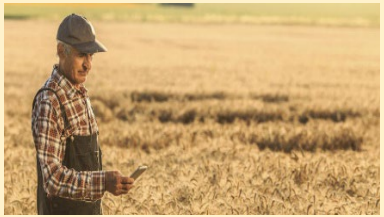
History

Yara's total greenhouse gas emissions halved by almost eliminating N_2O

Past 15 years

Further improving on world leading performance by CO_2 reduction target

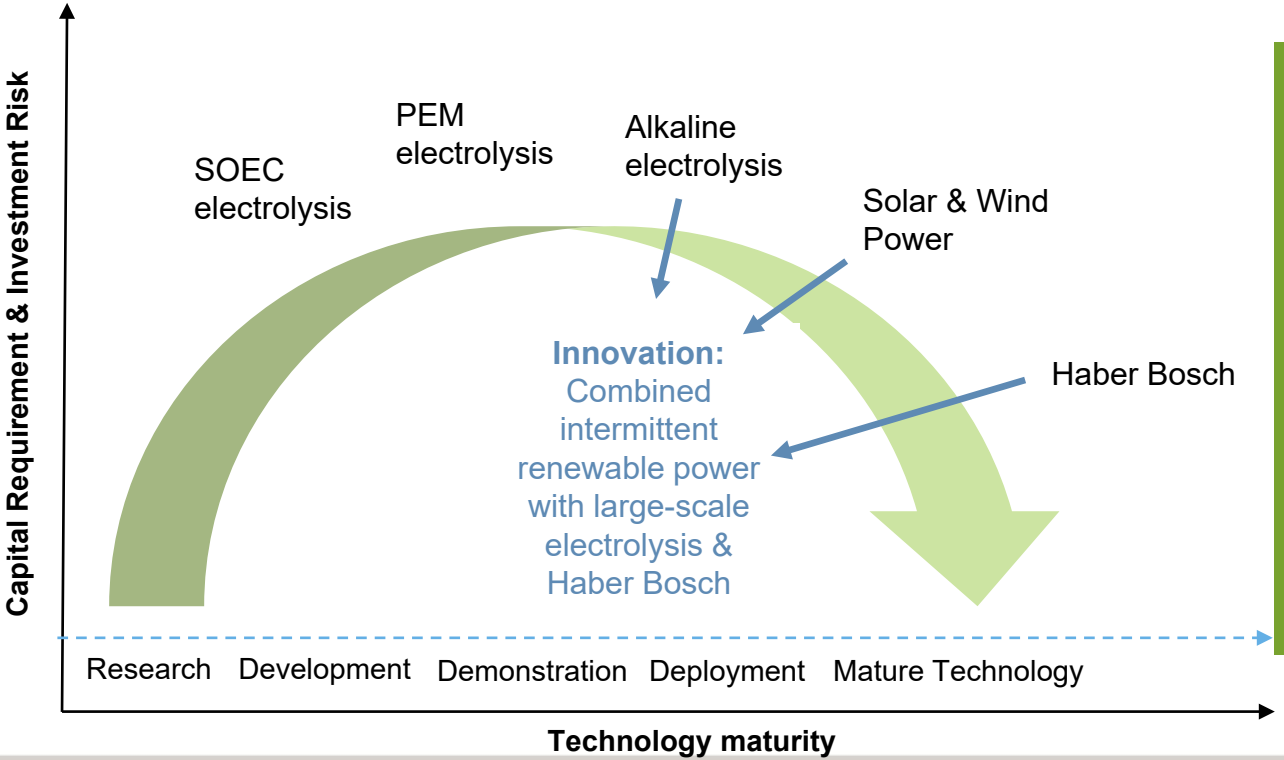
Present



Ambition to become climate neutral by 2050

Future

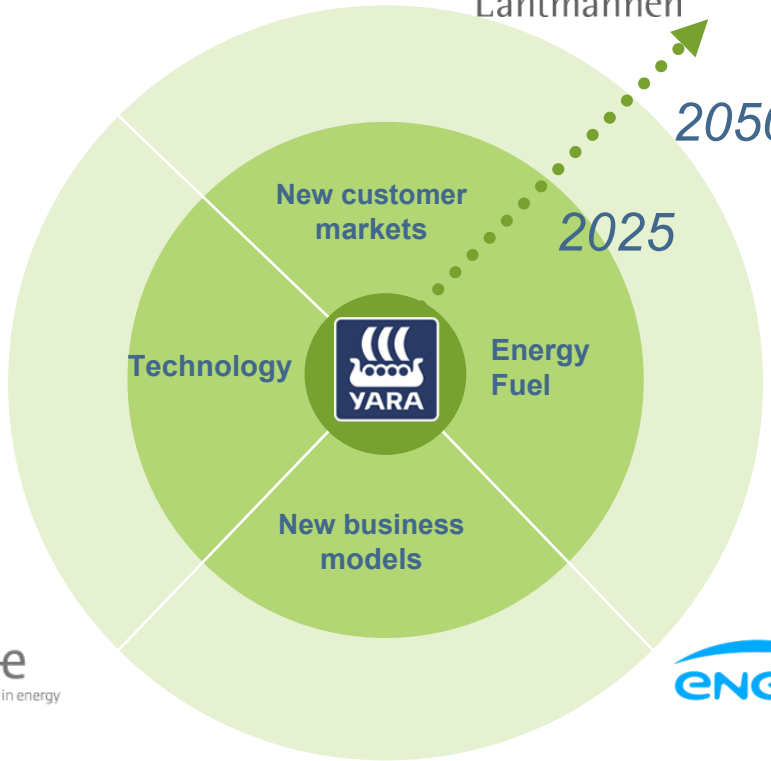
Green Ammonia: High TRL components, never been combined at large-scale in an intermittent renewable power context



- ✓ **Building blocks are at high TRL, yet the combination & integration of the building blocks needs to be developed and deployed at scale**
- ✓ **All alternative technologies to electrolysis + HaberBosch are at low TRL level***

Drive Innovative growth by decarbonizing Yara by 2050

Reduce-Reframe-Reimagine



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battolyser

Institute for Sustainable Process Technology

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ShipFC

FCH

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

HORIZON 2020

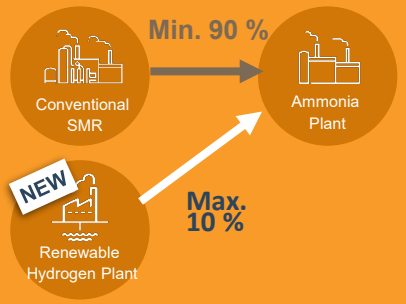
gasunie

crossing borders in energy

ENGIE

Steps towards climate-neutral production in 2050

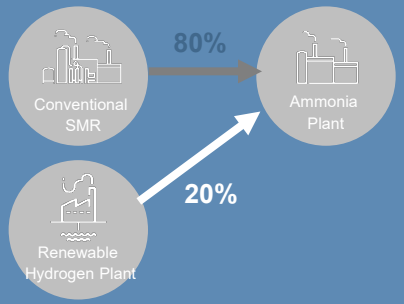
PHASE 1
Hybridisation



Demonstrate operationality of REN powered H2-Ammonia
Typically up to 10%

2020-2030

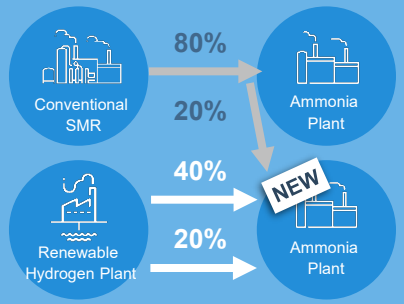
PHASE 2
Maximal Hybridisation



Scale-up
Requiring investment in N2 production (ASU) and modifications HB loop

2025-2035

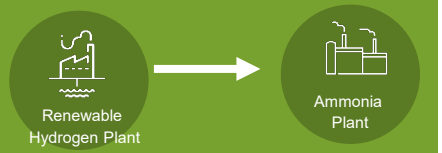
PHASE 2B
Potential intermediate



Scale-down of SMR feed: **70% SMR load feeding 2 NH3 loops (uncertain this phase needed)**

2025-2035

PHASE 3-4
Greenfield & roll-out



Greenfield front-ends in existing locations or new low cost areas

2030-2050

Clean Energy could double the global demand for ammonia

Energy&Fuel

- Ammonia Energy is receiving increasing attention and can shift the ammonia market*

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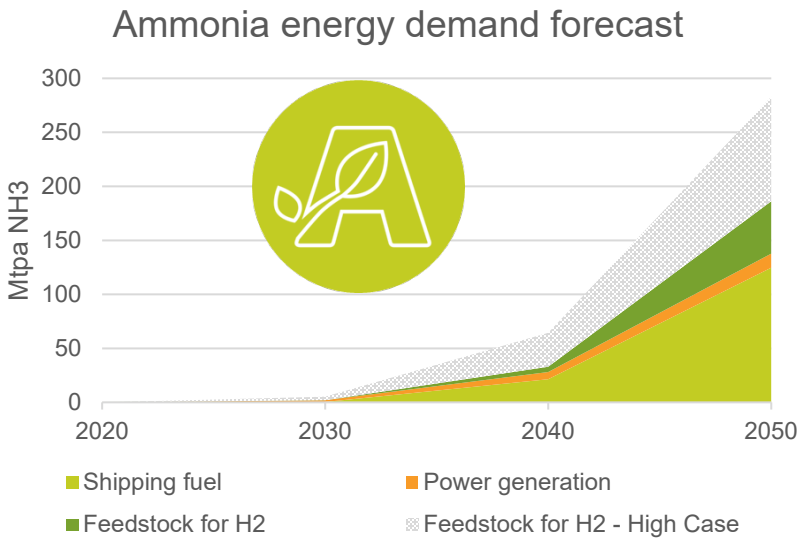
- **Power generation**
  - Ammonia for direct power generation
- **Shipping fuel**
  - Ammonia as marine fuel

    (DNVGL 25% of 2050 shipping fuel can be ammonia, Getting to Zero Coalition >600 million tons by 2070)
- **H2 carrier**
  - Ammonia as energy storage and transport vector (H2 economy) can emerge as deep decarbonization begins



(NH3) Shipping fuel has become more bullish since June 2019

* Lloyd's/Umas/IMO/DNVGL/IEA/GettingtoZero-WEF-GMO etc

Yara is unique with presence in the entire value chain

Producer

- Total ammonia production including JV share ~ 8 million tons / 26 units
- High level of know-how of Yara plants (1 unit now +/- 5 yrs in contin. operation)
- Lower gas consumption compared to other producers

Exporter

- 4 fully-owned ammonia export plants in Europe (export cap. ~ 1 mln t)
- Yara JV ammonia export capacity ~ 2,7 mil t

Fleet & storage

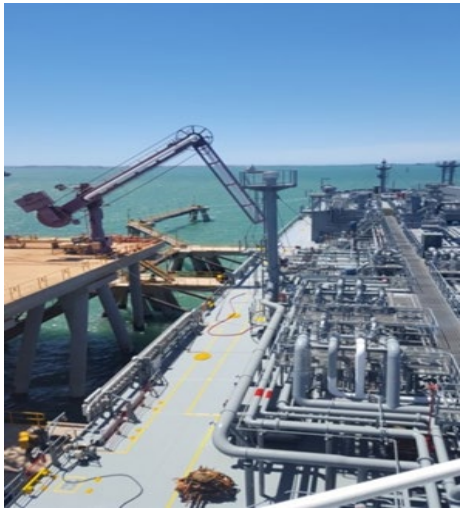
- Yara NH3 maritime transport capacity > 200 kt (momentum)
- Own storage ammonia capacity 580 kt
- 17 marine ammonia terminals

Importer

- World's largest importer with total imports of ~ 2 mln t / year (2019)
- Flexibility to produce or import ammonia

Trader

- Truly global
- Truly international
- With own back-up supply system



Yara is developing partnerships to explore and remove barriers for ammonia as shipping fuel

	Bunkering infrastructure	Fuel cost	Perception Safety	Regulatory	Technology
Barrier description	**Security of supply** and **scalability** of infrastructure	Ammonia fuel will need long term high carbon price. Today **beyond 250 USD/tn CO2** to compete with LNG IC	Perceived ammonia **safety risks can be a barrier for uptake** of NH3 fuel	**Currently no rules for use ammonia as fuel**; an IMO process for NH3 fuel is expected to take 10 years.	**No proven technologies at marine full scale** yet.
How to close the gap?	Starting point is decent with 20 Mtn/ yr global trade. Industry collaboration required to gradually develop infrastucture to match demand	Access to **low cost** renewable **energy** and/or large scale development of CCS will be the key to bring fuel costs down.	**Demonstration projects** must be handled with utmost caution, building on global best practice and competence.	Establish first projects based on the **IGF code** for alternative design must be applied (as for LNG until recently).	Both SOFC and ICE technologies are being developed, and should be demonstrated whithin 3-5 years

- The key to overcoming the barriers is to identify the viable demonstration concepts
- Yara aims to participate in strong consortia to establish viable demonstration cases
- Yara can offer a fuel value chain perspective as well as expertise in ammonia handling and safety

The future will be different…