Before We Begin…

Please ask **questions** by typing it in the **chat window**

Speaker will **answer** the questions **after the presentation**

This presentation will be **shared with everyone** after the session

You can contact the speakers at **Daniel.Morris1@kbr.com**

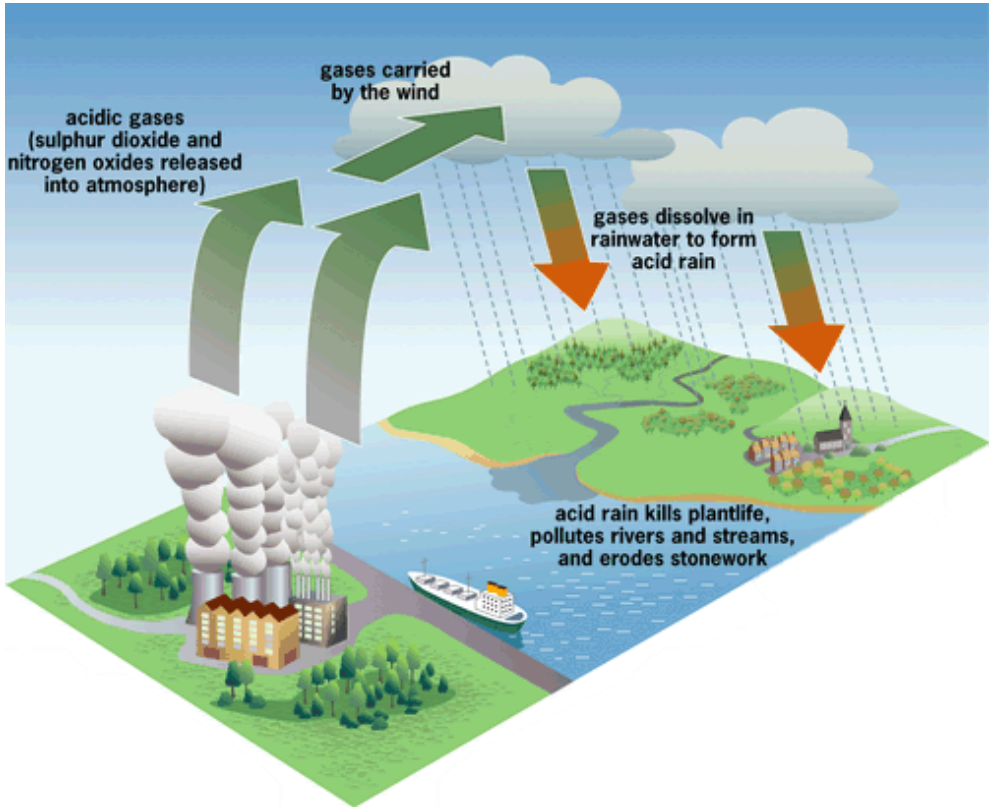
Before We Begin…

Daniel Morris	Consultant – Energy Transition
Anthony Teo	Technology and LNG Business Development Director
Oliver Hatfield	VP Business Development
Michael Goff	Technology Manager

Ammonia Asset Transition for New Markets

November 2020

Can we Learn From the Successes of the Past?



Acid Rain: An International Environmental Issue Solved

- Burning of coal produced significant acidic gases
- When in atmosphere, formed acid rain
- Acid rain affected pH in bodies of water threatening aquatic life

- International issue, UK gases falling in Scandinavia
- Required international government to government deals
- Required intervention with industry
- Appeared too expense, those who had most to lose challenged the science.

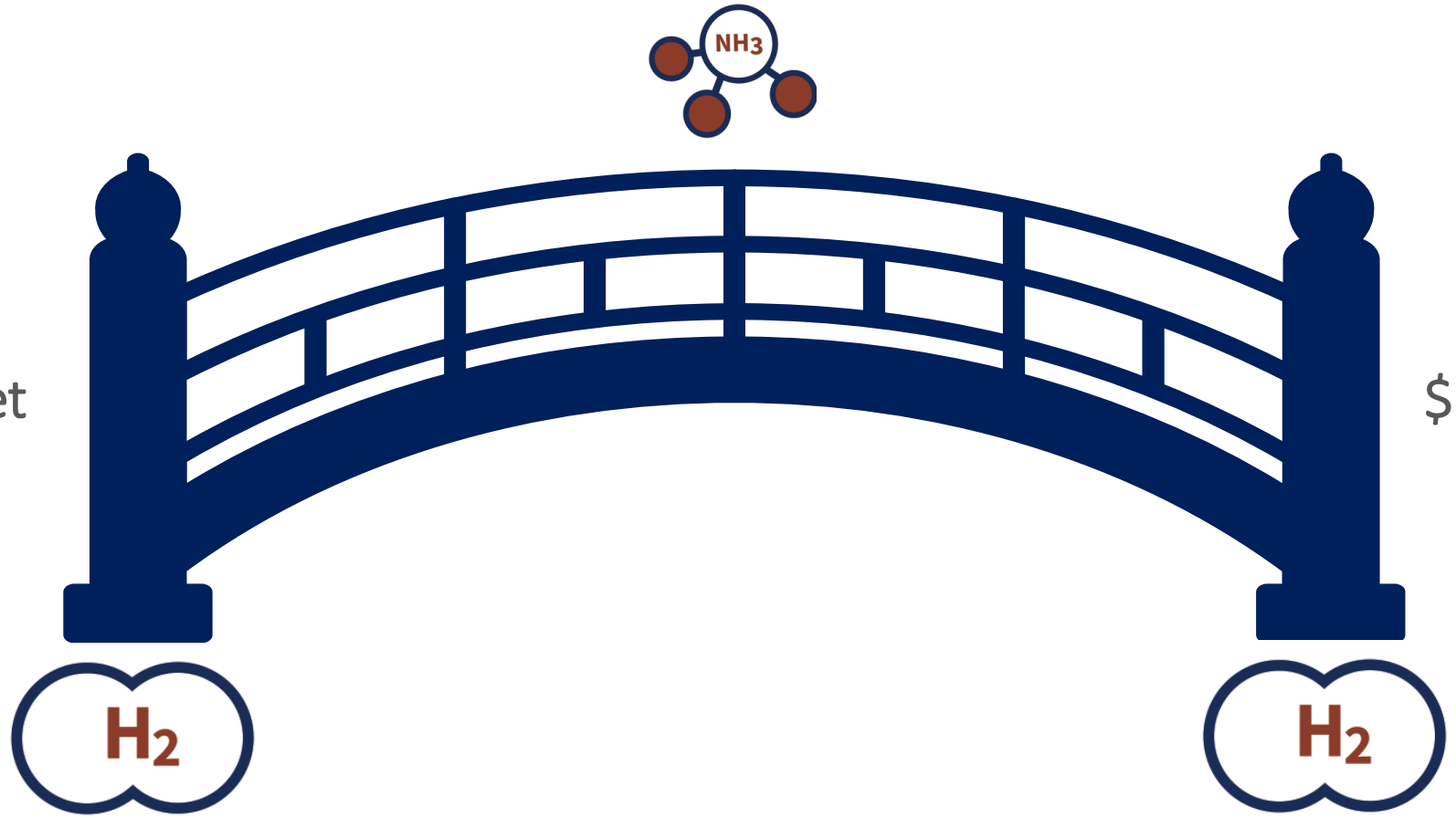
- Cap and trade system introduced
- Cap reduced over time
- Created competition that drove sulphur pollutions down where first movers profited from late movers
- So successful that very little evidence that this problem has any long term impact

Ammonia can Bridge the Gap

Change will happen—it's intrinsic and is already well underway

2020

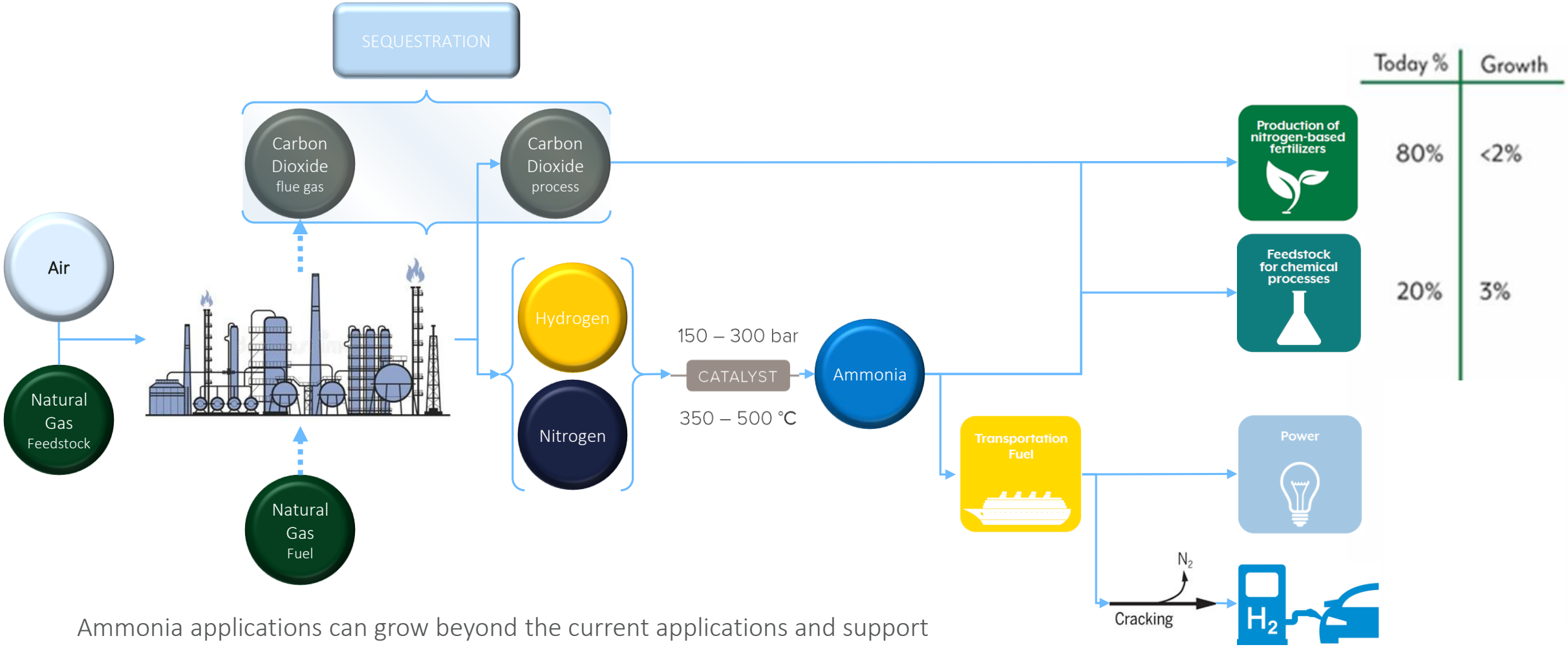
$130Bn Market



2050

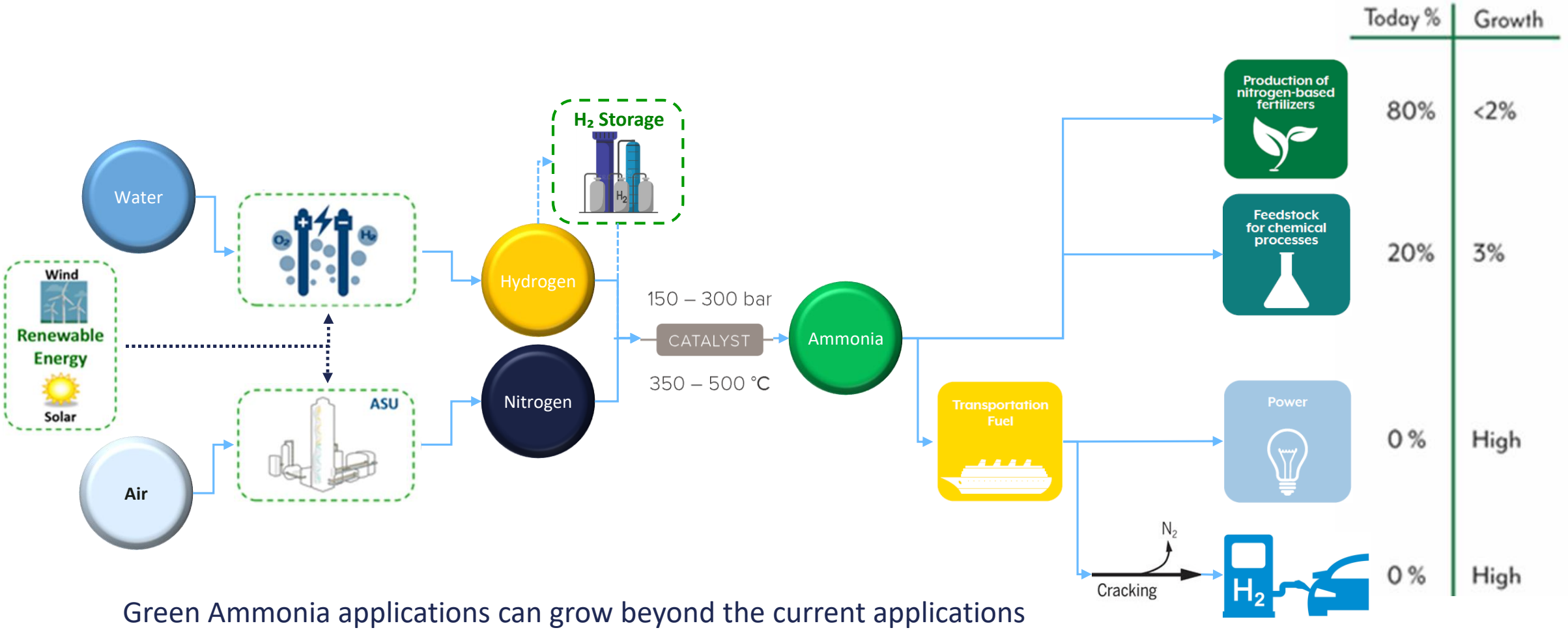
$2.5Tn + Market

Blue Ammonia: What is it?



Ammonia applications can grow beyond the current applications and support the **energy transition** towards lower/zero carbon fuels

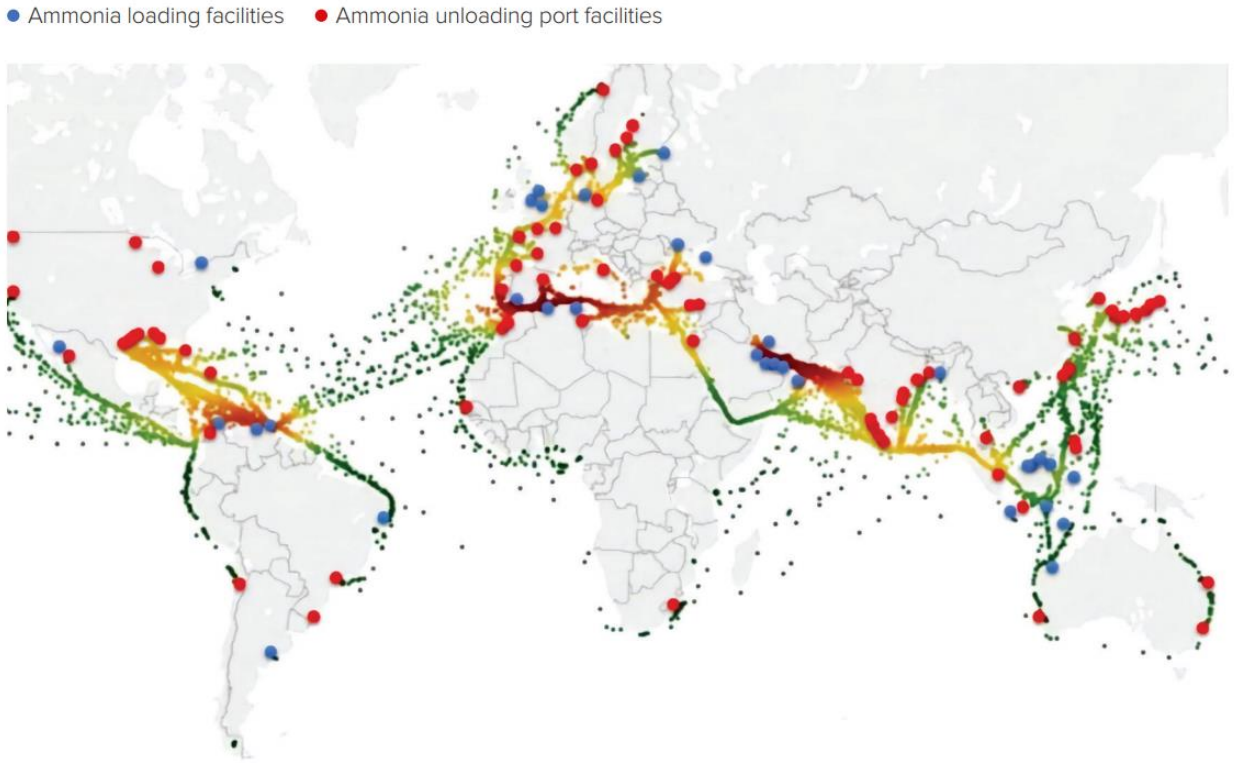
Green Ammonia: What is it?



Green Ammonia applications can grow beyond the current applications and support the **energy transition** towards lower/zero carbon fuels

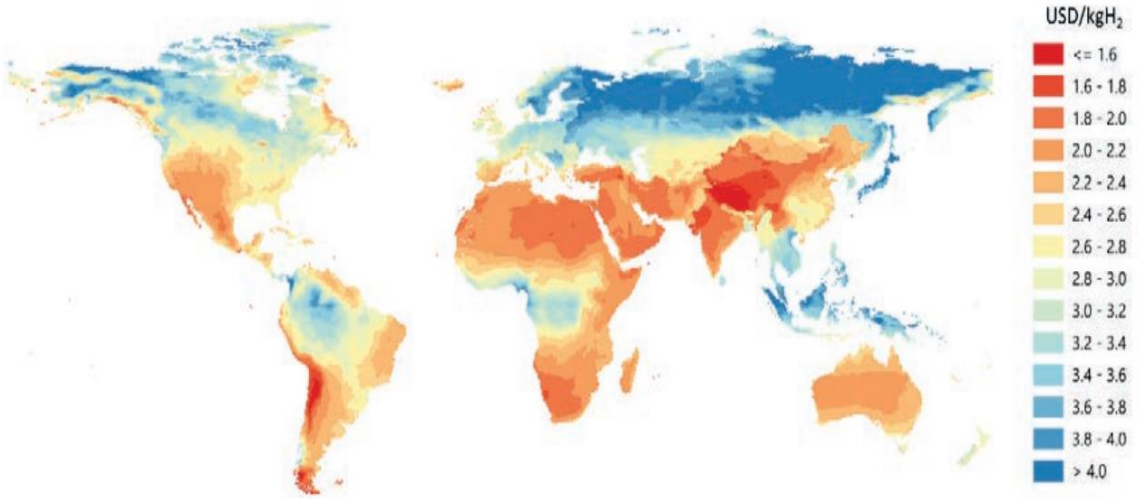
Green Ammonia: Why?

Green Ammonia: the new zero-carbon energy currency



Source: The Royal Society, 2020; IEA, 2020

Figure 14. Hydrogen costs from hybrid solar PV and onshore wind systems in the long term



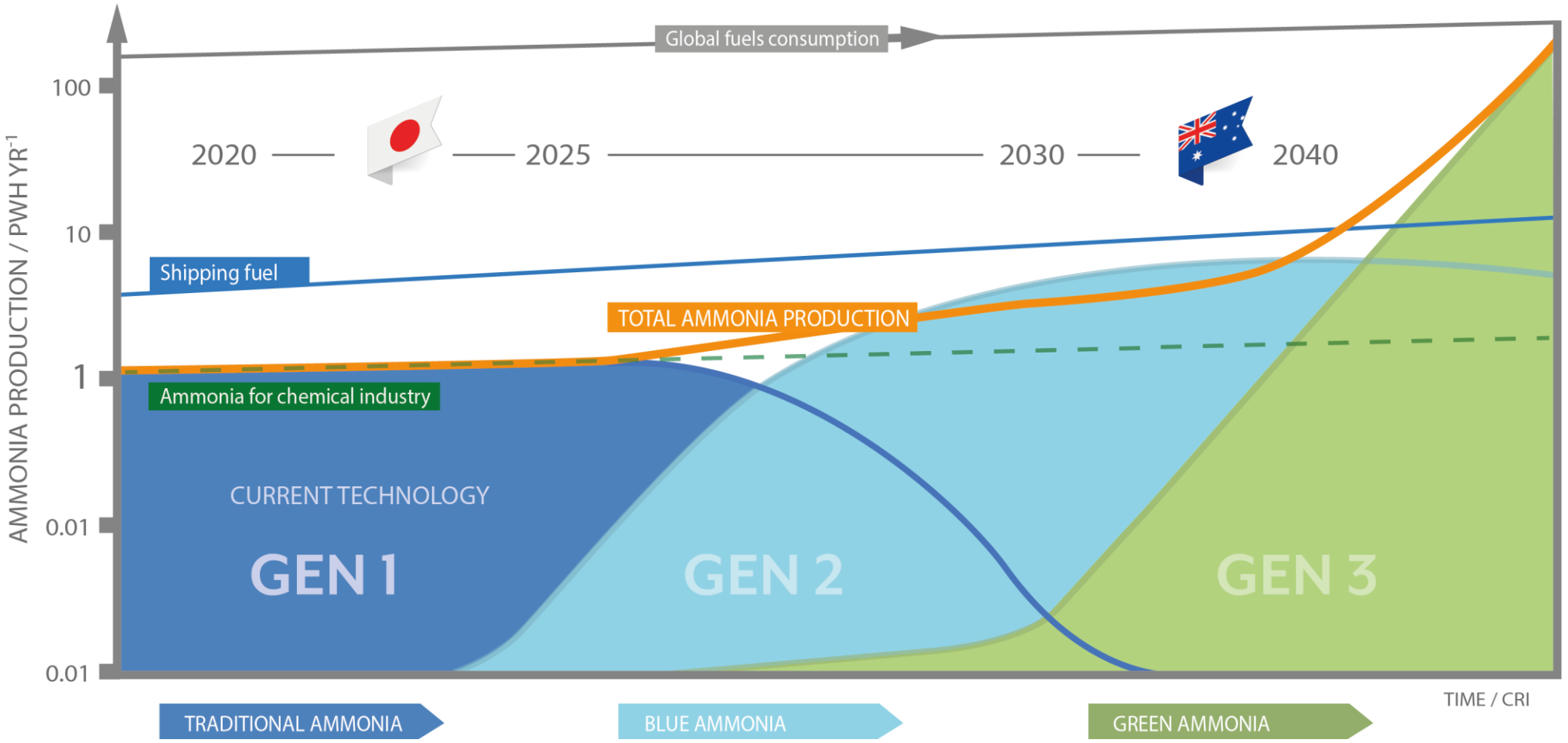
Notes: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area. Electrolyser CAPEX = USD 450/kW$_e$, efficiency (LHV) = 74%; solar PV CAPEX and onshore wind CAPEX = between USD 400–1 000/kW and USD 900–2 500/kW depending on the region; discount rate = 8%.

Source: IEA analysis based on wind data from Rife et al. (2014), *NCAR Global Climate Four-Dimensional Data Assimilation (CFDDA) Hourly 40 km Reanalysis* and solar data from renewables.ninja (2019).

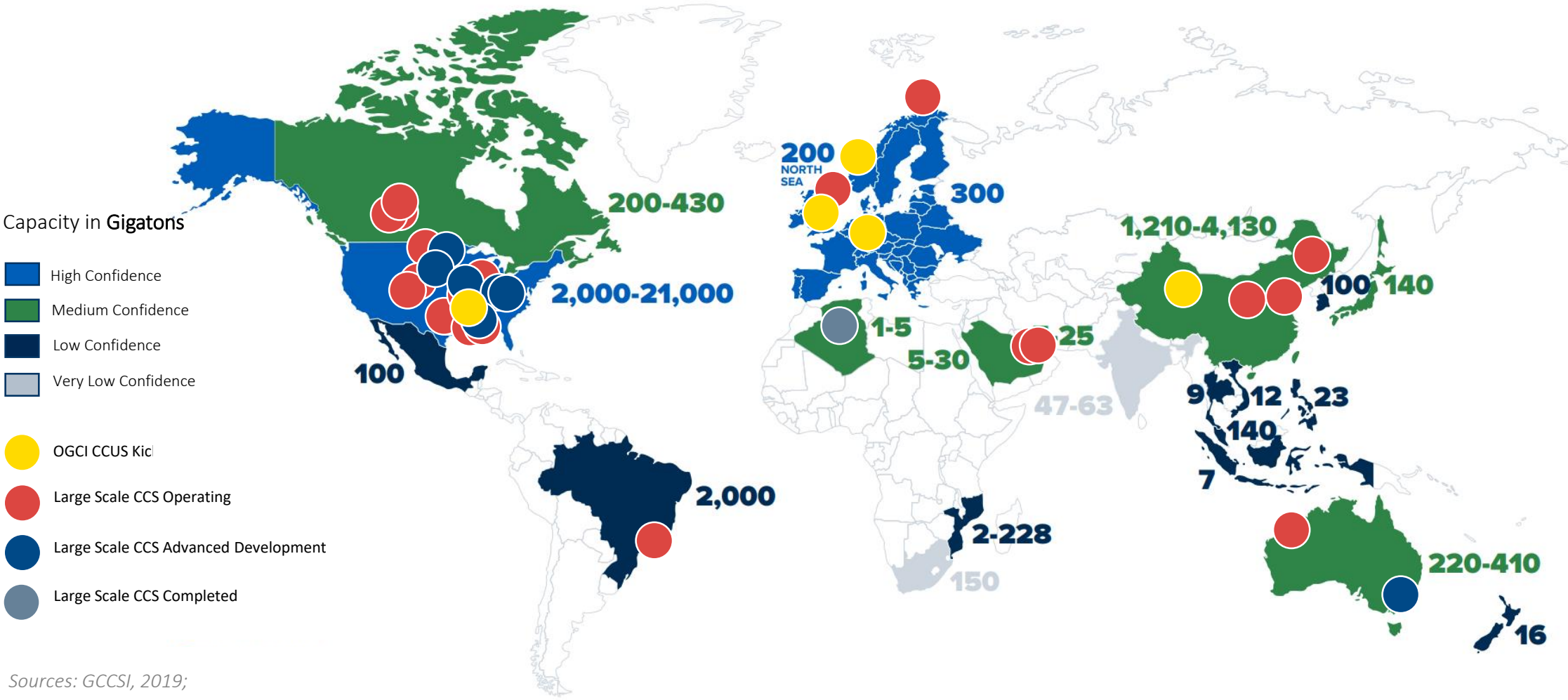
Source: IEA, the Future of Hydrogen, 2019

Future Trade Flows – H2 and Products

Ammonia Economy Roadmap

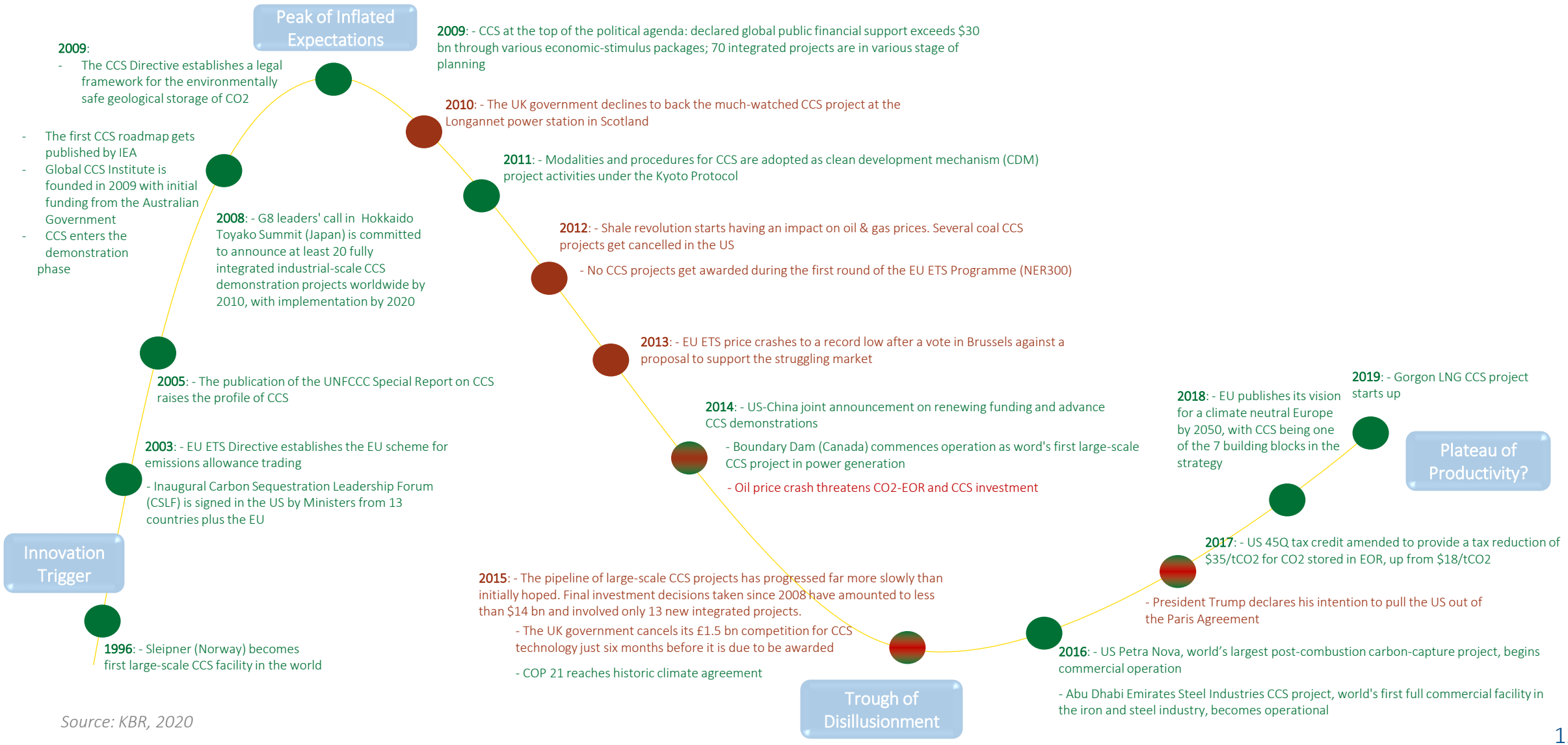


CCS Capacity



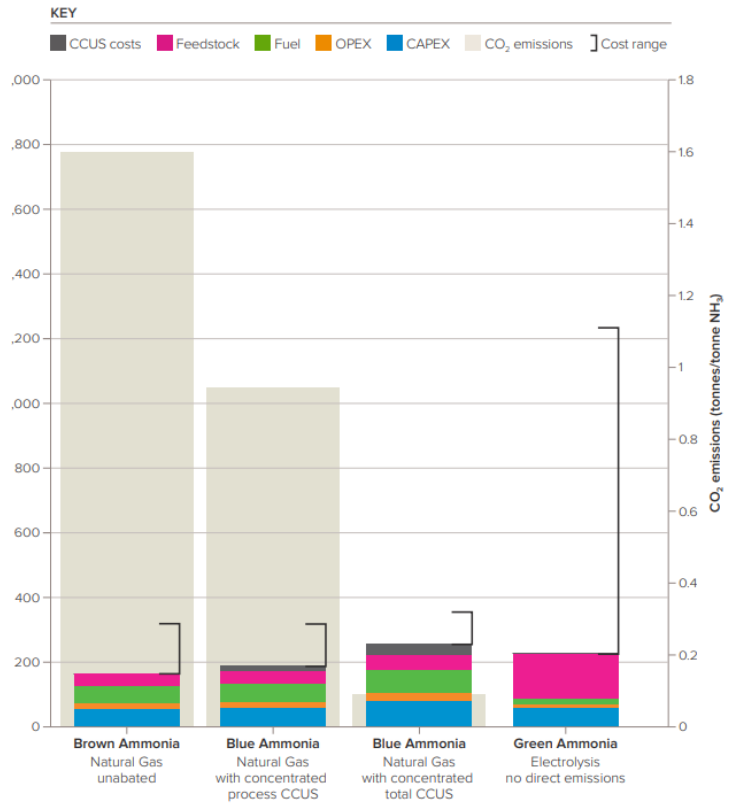
Sources: GCCSI, 2019;

Policy Support Driving a Plateau of Productivity?



Source: KBR, 2020

Producing Green Ammonia Today: Challenges/Opportunities



(1) Ammonia: zero-carbon fertiliser, fuel and energy store, Issued: February 2020, The Royal Society

Cost comparison of Ammonia production(1)

- 'Cost range' refers to the range of total levelised costs across regions
- The lower end of the cost range is disaggregated into cost categories
- Electrolysis assumptions:
  - Powered by 100% renewable electricity
  - 'Feedstock cost' is the electricity for the electrolyzer
  - 'Fuel cost' is additional electricity for the air separation unit, synthesis loop, etc.

Producing Green Ammonia Today: Challenges/Opportunities

Power Supply
- Price per kWh
- Understanding in Renewables
- Capacity factor
- Scale – experience of developer

Supply Chain
- Electrolyser capacity to build
- Modularization & offshore build
- Vested interests of other developers

Logistics
- Mobilization
- Labour costs
- Mega project delivery

Off-take
- Midstream H2 production
- Downstream NH3 production
- Demand centres

Schedule
- Ability to deploy / upstream to mid and downstream
- Integration with demand requirements

Finances
- ECA / sovereign wealth
- G2G collaboration

World Leader in Ammonia Technology

- Licensed 244 grassroots ammonia plants since 1950
- More than 50% of world's ammonia produced using KBR's ammonia process
- Since 2000, KBR has licensed 38 new grass root ammonia plants (24 based on Purifier™ technology)

★★★

2019 Records

World's Largest Single Train Plant
2,890 tpd (2,982 tpd achieved)
Eurochem, Russia

World's Most Efficient Plant
6.27 gcal/ton, Chambal, India

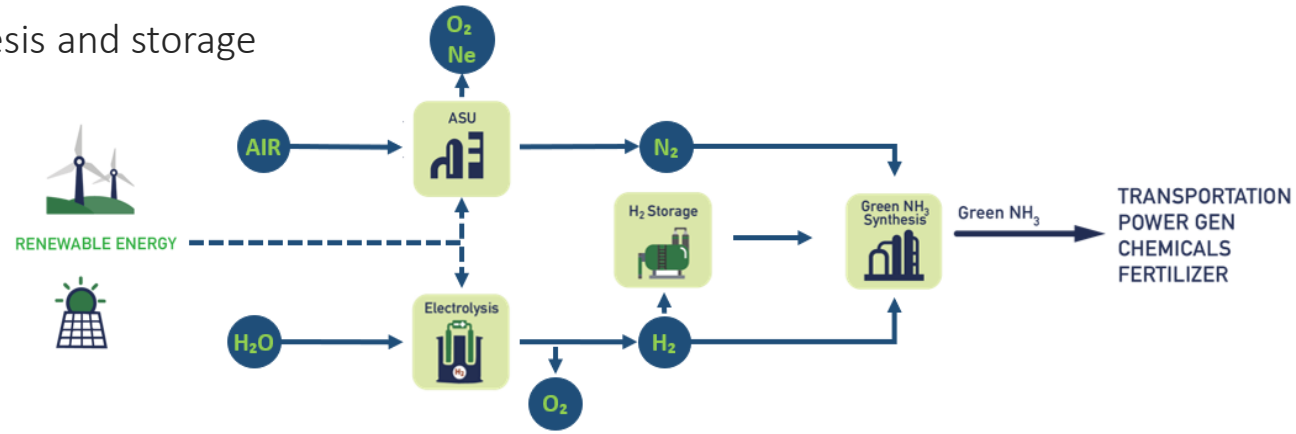
World's Most Reliable Plant
Over 5 years continuous operation at Yara, Netherland

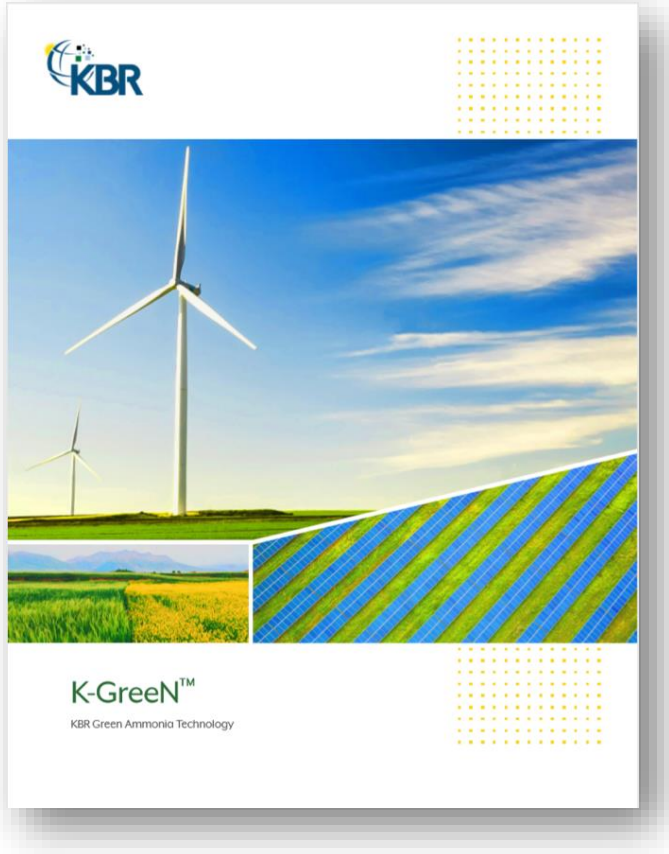
K-GreeN™

KBR is the leading ammonia process licensor. We offer the most reliable and energy-efficient ammonia technology at lower capital cost, with more than 75 years of experience and 242 ammonia plants worldwide.

The green ammonia process aims at high efficiency synthesis of CO_2 free ammonia. It includes:

- Nitrogen generation and storage
- Synthesis of gas compression
- Hydrogen generation and storage
- Ammonia synthesis and storage





Think Green Ammonia, think KBR.

Conclusions

- Reimagining assets globally key to maintaining value and relevance
- Delays in cutting emissions increase the possibility for existential risks to a business
- Collaboration is fundamental within this ammonia community but also externally
  - Ammonia part of a whole economy transition (System of Solutions)
  - Climate related financial reporting (TCFD)
  - Certification bodies established to bring confidence to investors
  - Project financers
- As we are moving from invention to innovation, bankability is king

Contact Us

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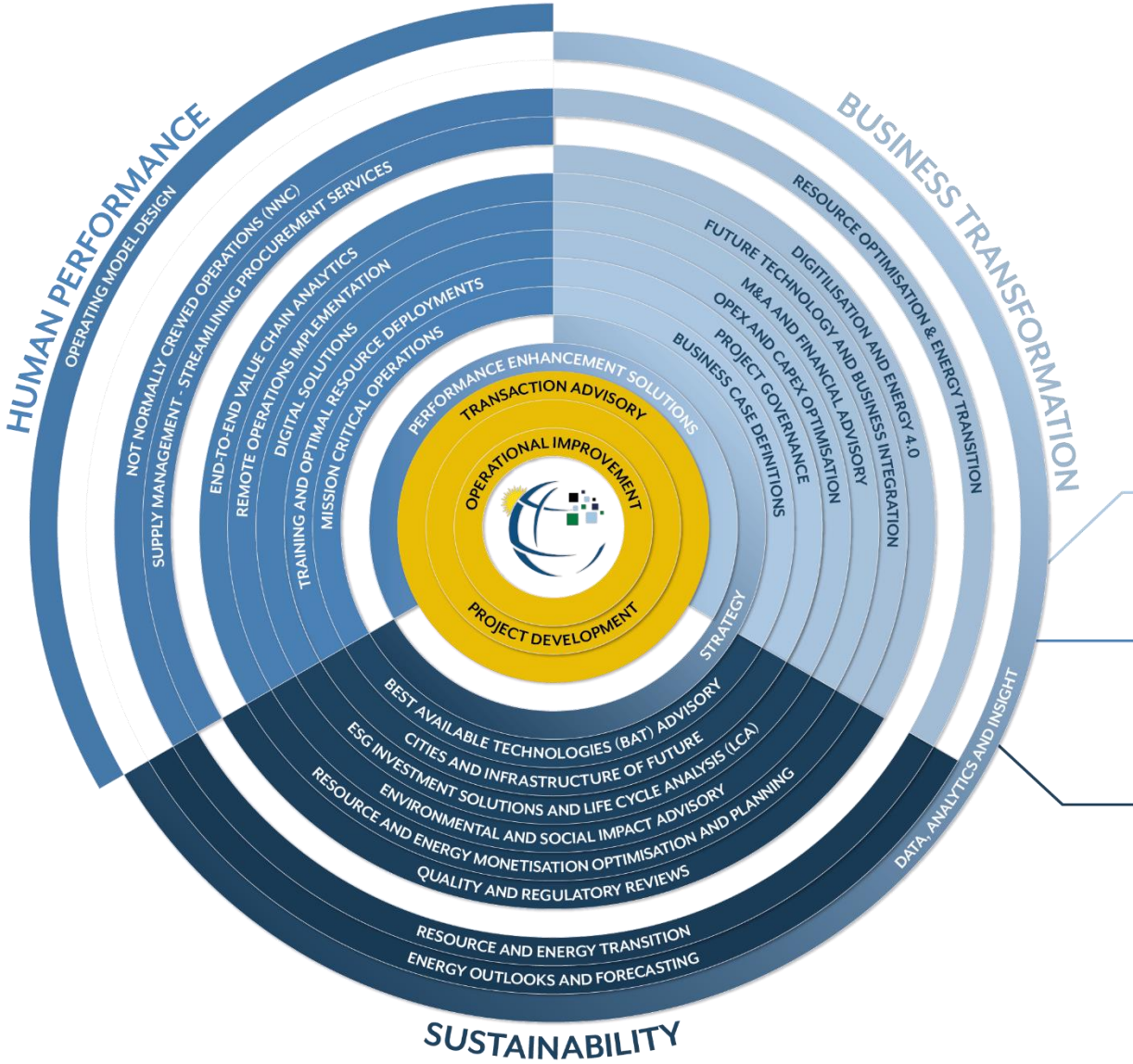

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