



Ammonia Cracking

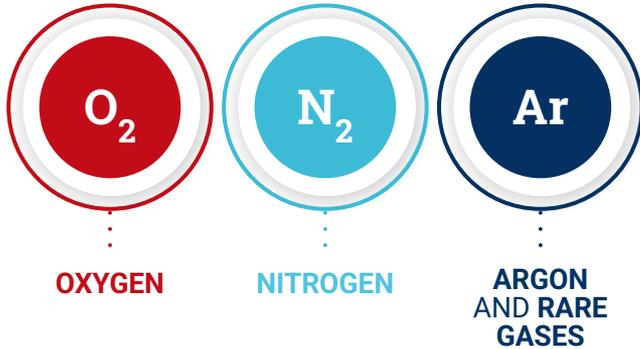
Hydrogen from Ammonia

Kenneth Kaiser
International Expert - Air Liquide R&D

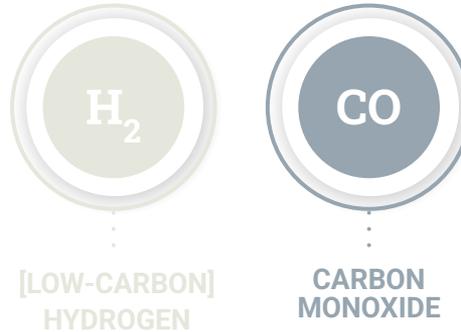
2026 - SwRI IPER Workshop

Supplying large volumes of *industrial gases and energy solutions*

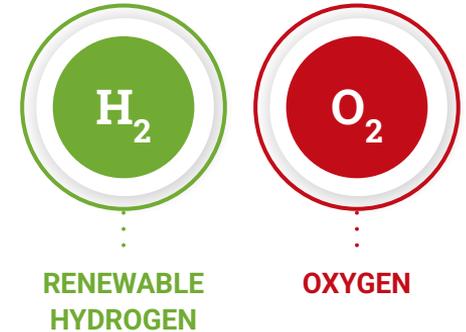
Cryogenic Air Separation Units (ASU)



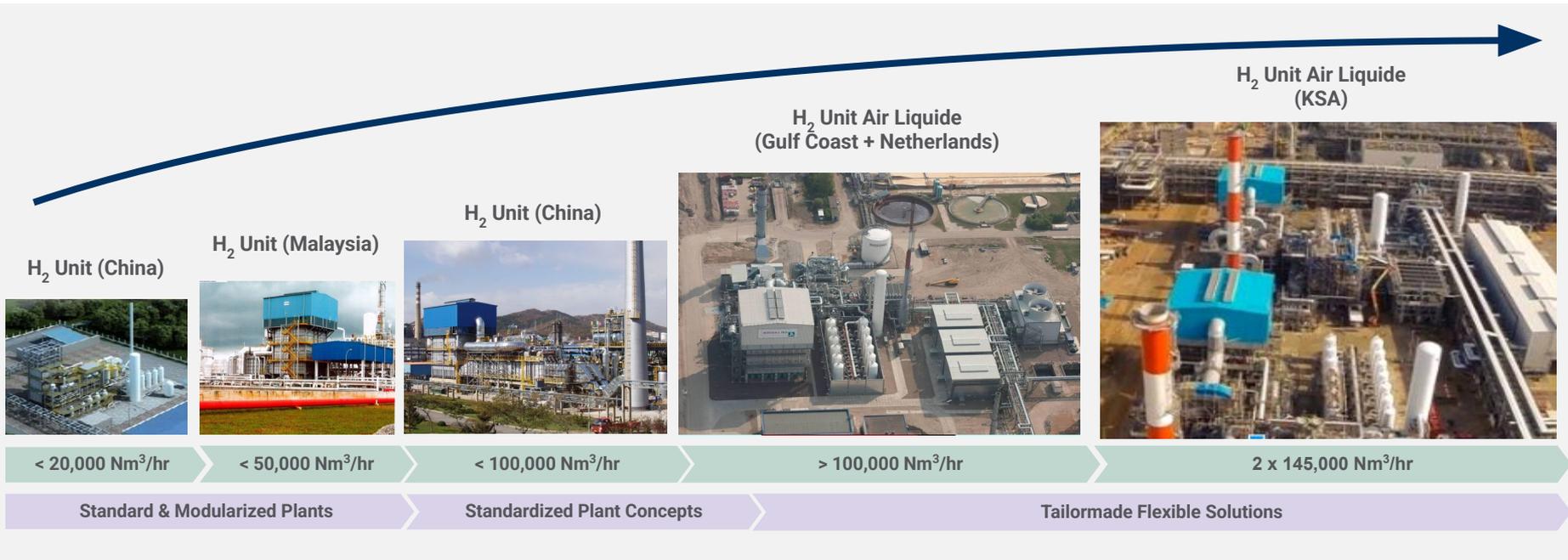
HyCO (including ATR/SMR/SMR-X)



Electrolysis & NH₃ cracking



Building on experience: Steam Methane Reforming (SMR) Engineering and Operations



Air Liquide E&C has designed or built **>145** Steam Reforming Plants

Air Liquide operates **>80** Hydrogen, Syngas and CO Production Plants



Systematic improvement of

- Process Safety
- Reliability
- Operability
- Maintainability

by operational feedback

Building on experience: SMR-X™

SMR-X



SMR-X™ technology

Enabling energy savings and zero steam export



97%
Thermal
Efficiency

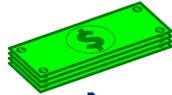
FOIK based on SMR-X™ technology

In operation since 2020

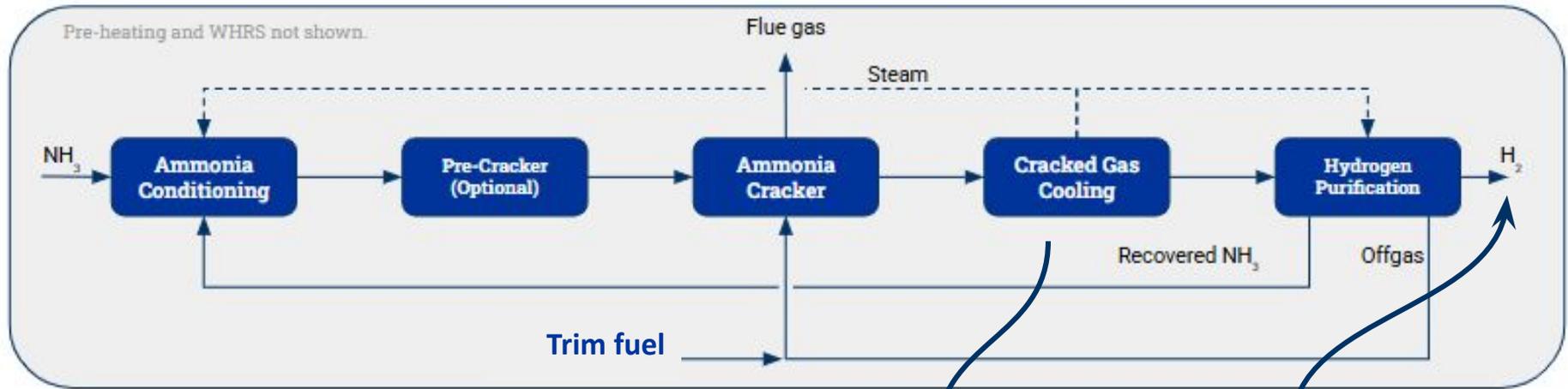
Flexibility of the technology

7.2
kg_{NH3} /
kg_{H2}

Total Cost of
Ownership



Without external fuel



External, e.g. Natural
Gas, Hydrogen, ...



Cracked gas from
the cracker itself



Product carbon
footprint

ARCAS & Ammonia Cracking

Air Liquide - From the labs to the field

Catalyst screening & kinetic measurements (lab scale, crushed catalyst)

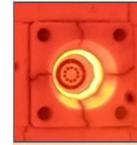


Catalyst benchmarking and long-term testing (technical scale, full shaped catalyst)

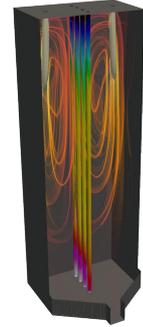


In-house 1D & 3D firebox modeling (NH₃ combustion & NH₃ cracking reaction)

Combustion



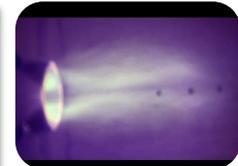
Reaction



Process gas purification (studied separately, not in the scope of Arcas)



Testing of industrial burners with H₂, N₂ & NH₃ fuels



95 % NH₃ fuel

Metallic materials testing



The Air Liquide industrial scale ammonia cracking pilot plant

The first reference for de-risking the technology



ARCAS Industrial-Scale Demonstration Plant



Technology Readiness Levels: A selection of technology bricks

After the industrial scale ammonia cracking pilot plant (ARCAS)

Catalysts



Q1 2026
TRL 8

Metallic Materials



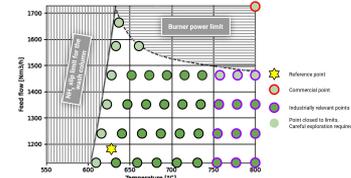
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Combustion



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TRL 8

Reactor design



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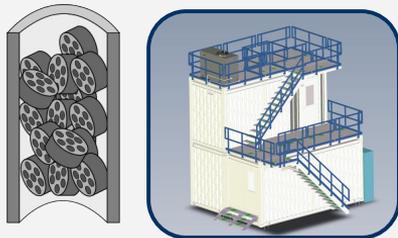




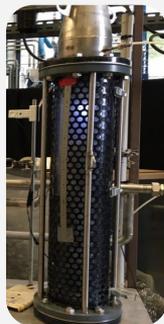
Thank you

R&D Test benches in Air Liquide

NH₃ Catalysts Process Development Unit



Catalysts Pressure Drop



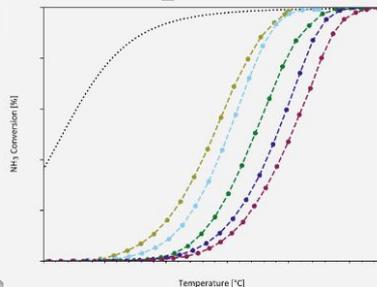
Metallic Materials



NH₃ combustion



Laboratory Catalyst tests



PSA Adsorbents

