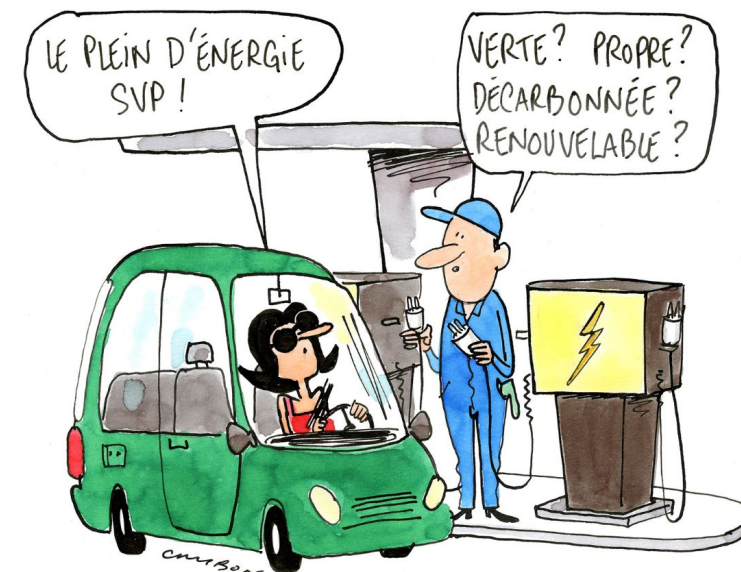


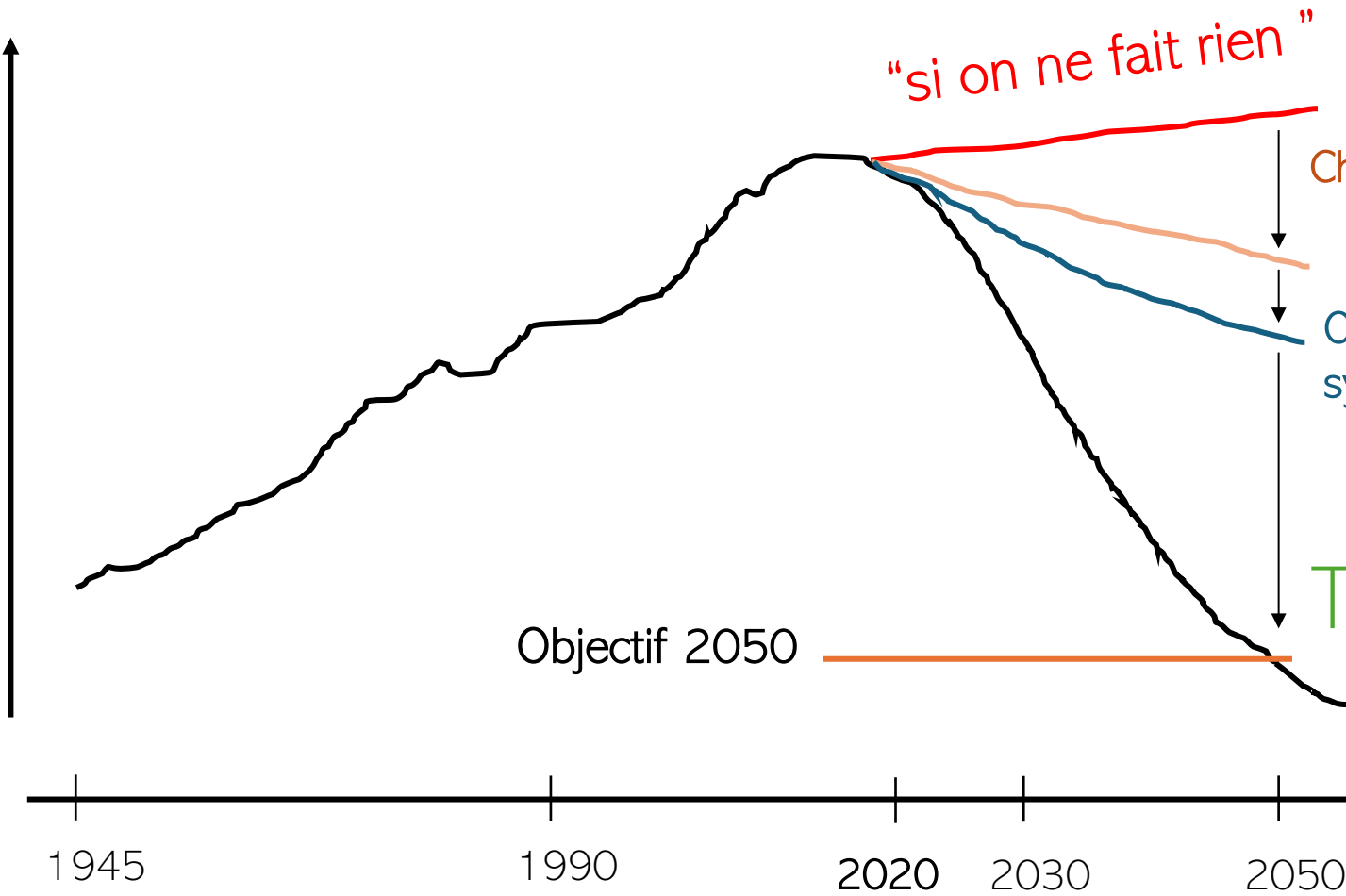
Ammoniac : vecteur énergétique et carburant

Christine ROUSSELLE



Grand challenge Energie - Climat

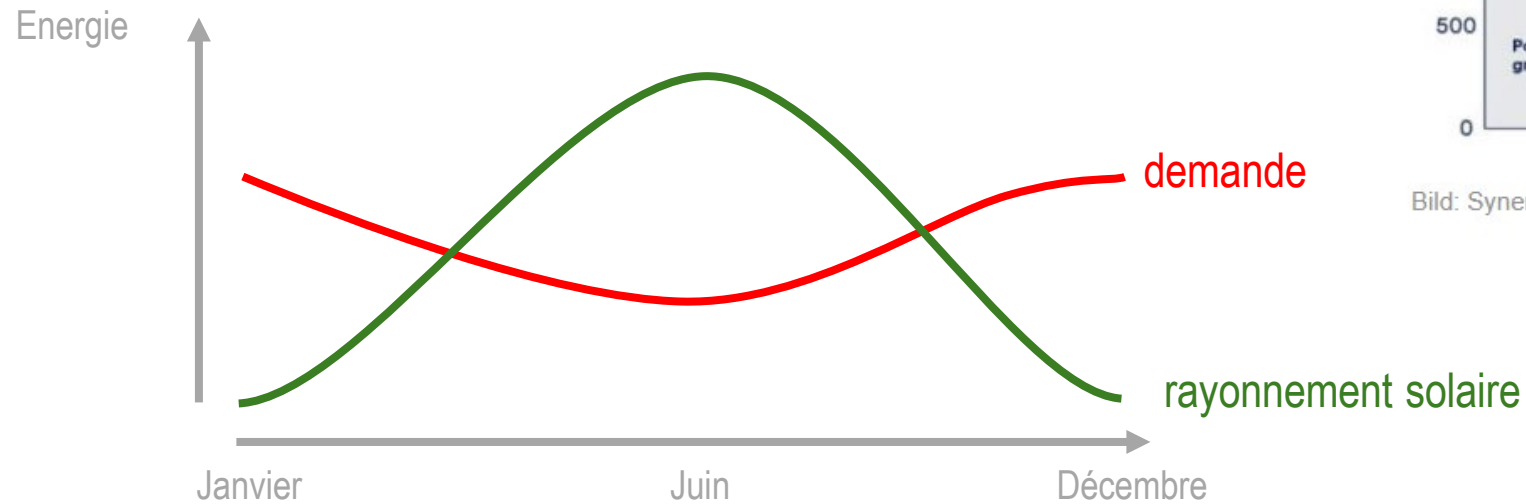
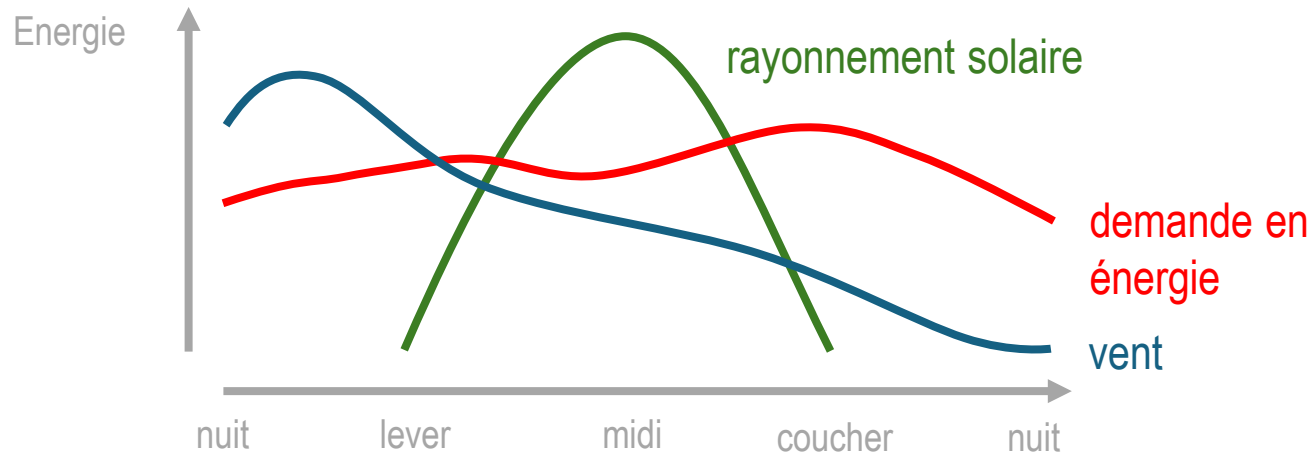
Emissions
CO₂



Transition énergétique



Scénario 2050 : 100% Energies Renouvelables



SFT 2016

Fameuse courbe de Canard

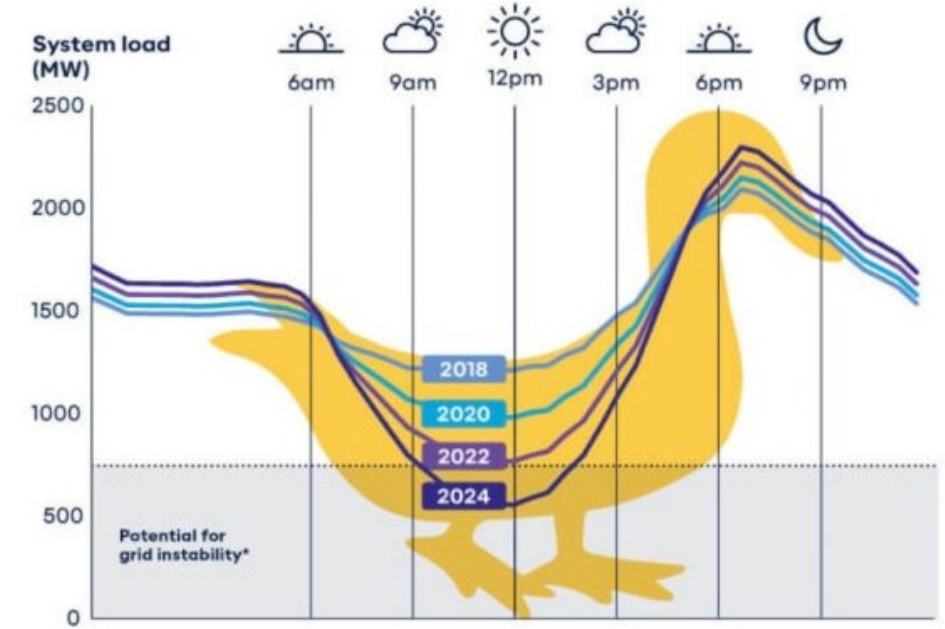
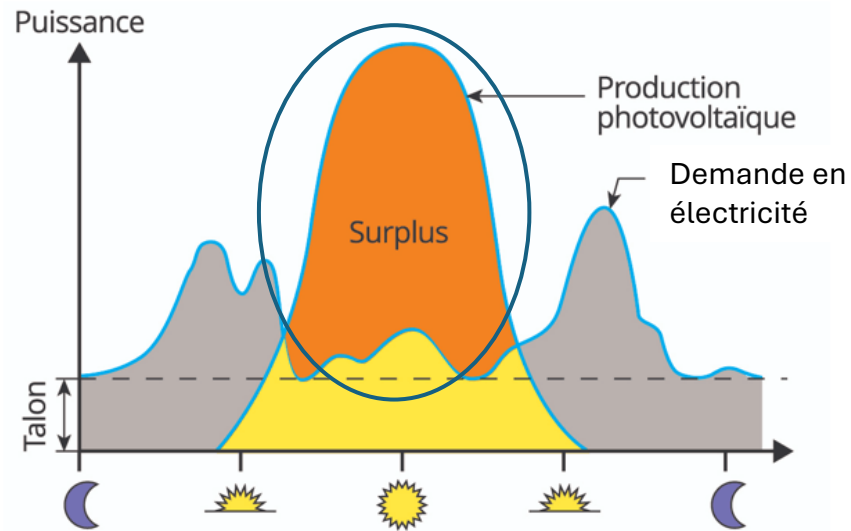


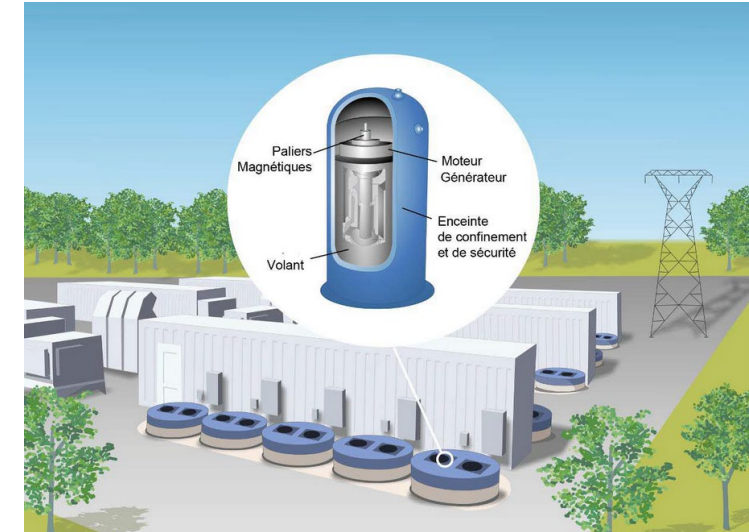
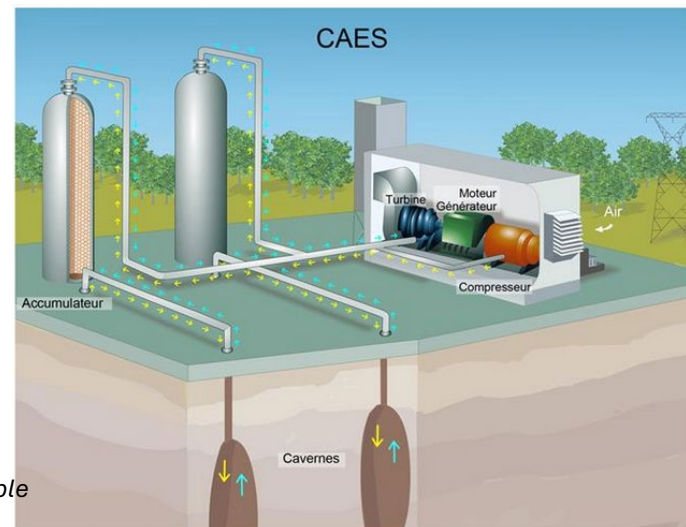
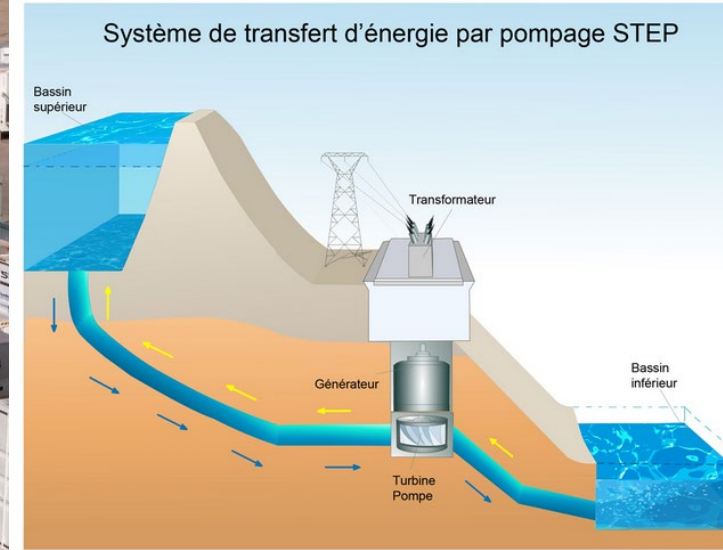
Bild: Synergy

Scénario 2050 : 100% Energies Renouvelables

Stocker le surplus d'énergie électrique, peut être sous une autre forme d'énergie!



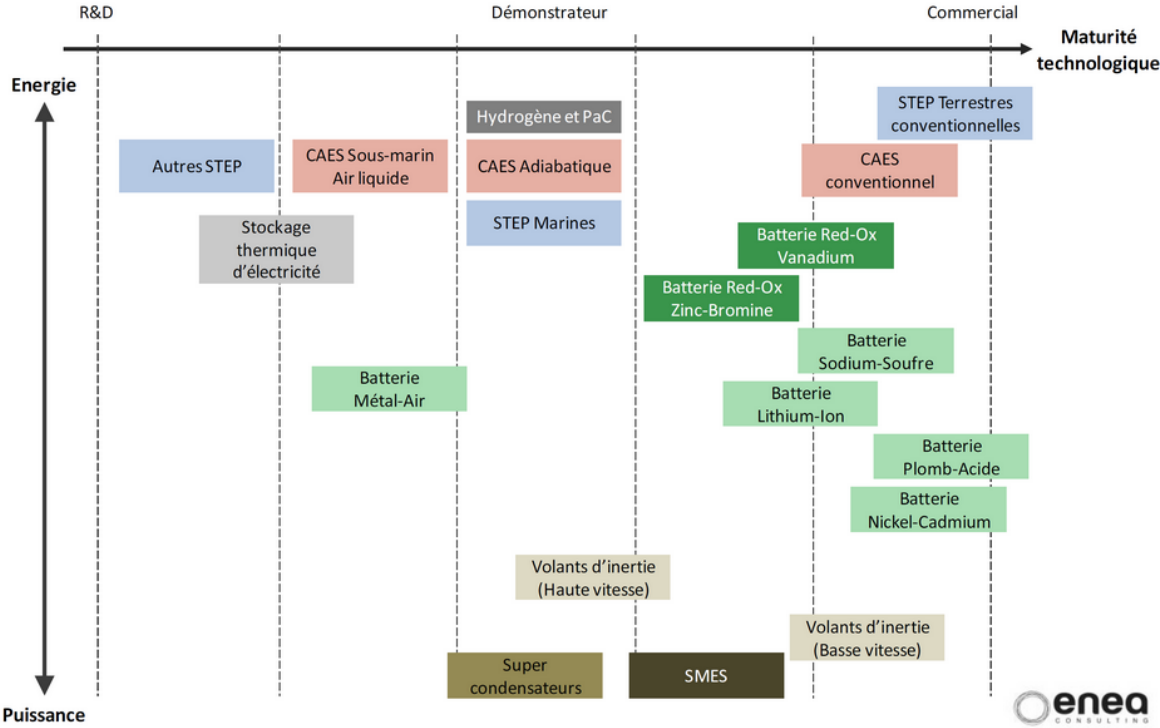
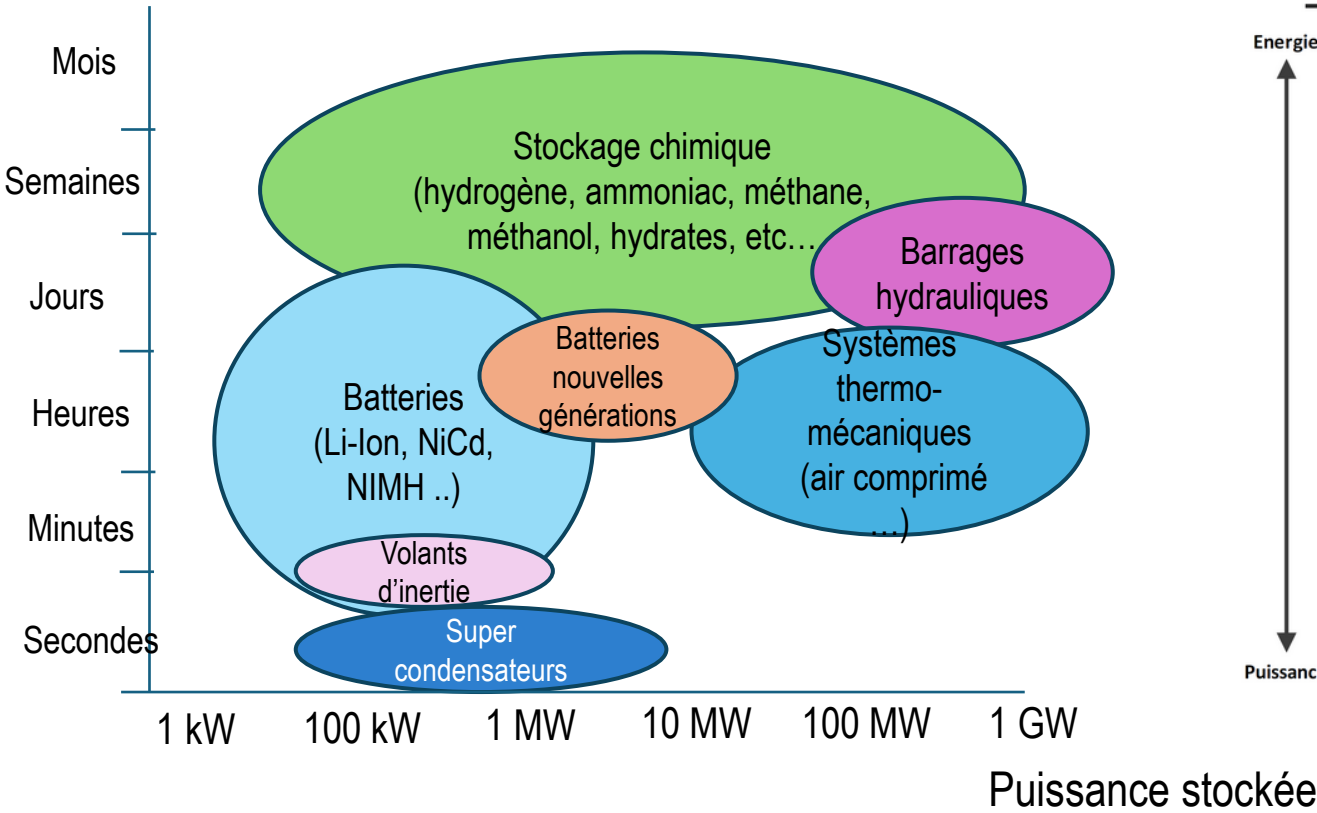
Les variations sont représentées par la courbe de charge en bleu. De base, elles ne sont pas très « en phase » avec la production d'électricité. Source : Ademe.



Scénario 2050 : 100% Energies Renouvelables

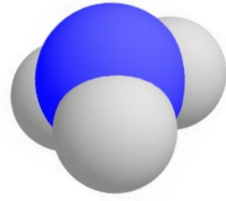
Durée de stockage

'Electro-fuels, e-fuels



SFT 2016

Et pourquoi l'ammoniac NH_3

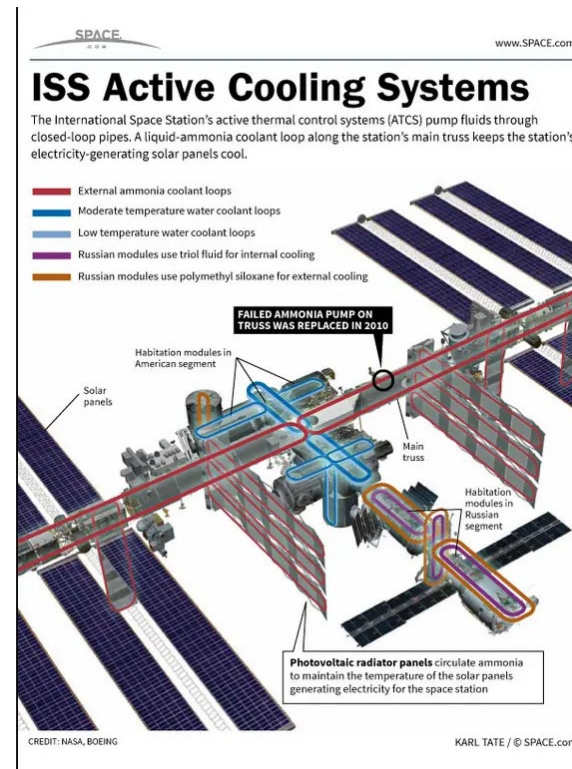


- 2ième produit chimique au monde (240Mt, <H₂SO₄)
- Fertilisant (80%)
- Industrie chimique (plastique, cosmétique, TNT)
- Conservation : froid, clim

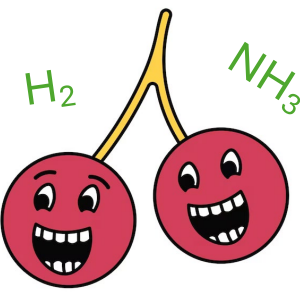


Gaz

Ammoniac Anhydre



Ammoniac = cet autre hydrogène



	NH ₃	Liquid H ₂
Tébullition (°C)	-33.4	-253
Pression Condensation à 25°C (atm)	9.9	N/A
Masse Molaire (g/mol)	17.00	2.02
H ₂ content (% by mass)	17.8	100
H ₂ densité (kgH ₂ /m ³)	121	70.8



- Le meilleur vecteur H₂ !

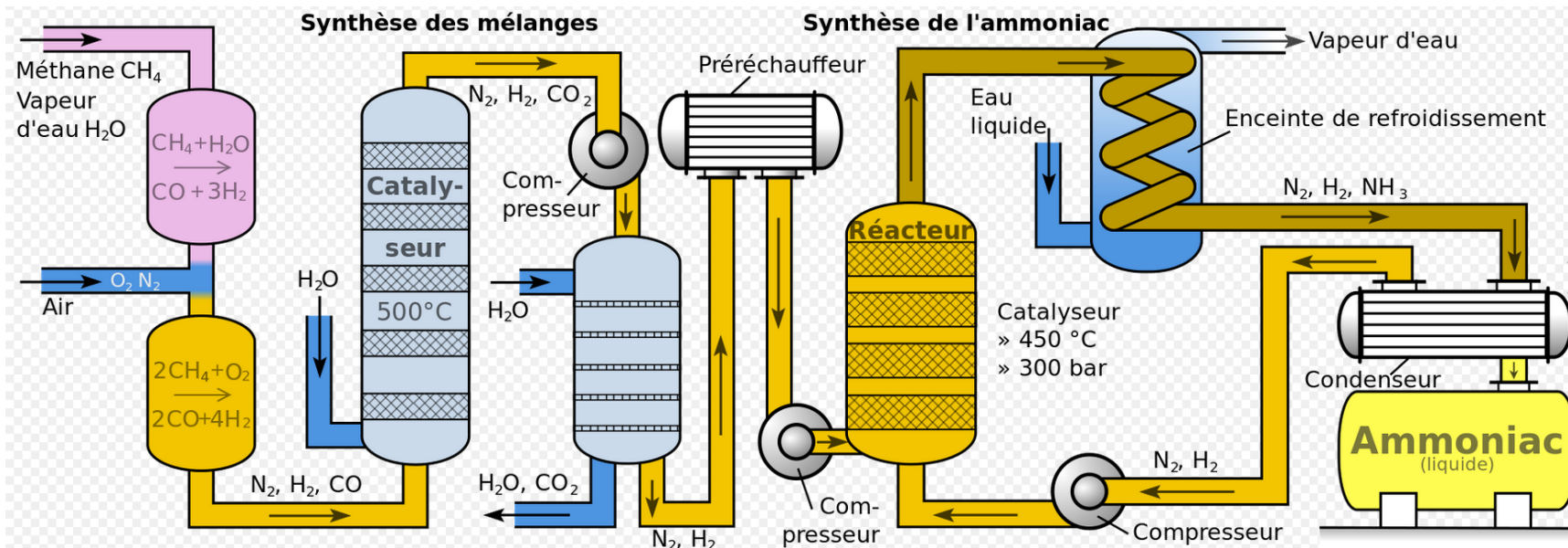
Production de l'ammoniac aujourd'hui

■ Voie Classique : Procédé Haber-Bosch (découvert en 1913)

- Synthèse à partir de : $\text{N}_2 (\text{g}) + 3 \text{H}_2 (\text{g}) \rightleftharpoons 2 \text{NH}_3 (\text{g})$
- Exothermique $\Delta H^\circ = -46 \text{ kJ/mol}$
- Réaction impossible à T ambiante

catalyseur : fer (Fe) ou nickel (Ni)

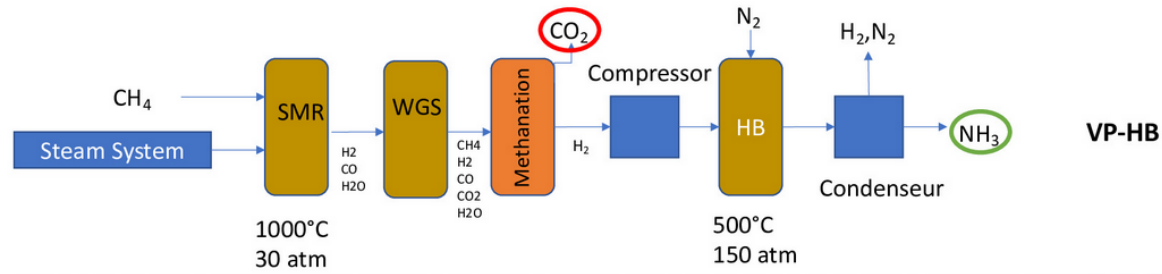
hte T pour la stabilité de la réaction ($>670 \text{ K}$) + hte P ($\sim 100\text{-}300 \text{ Bars}$)



Inconvénients majeurs :

- Produit à partir de H_2
- lui même produit à partir de CH_4 ou charbon

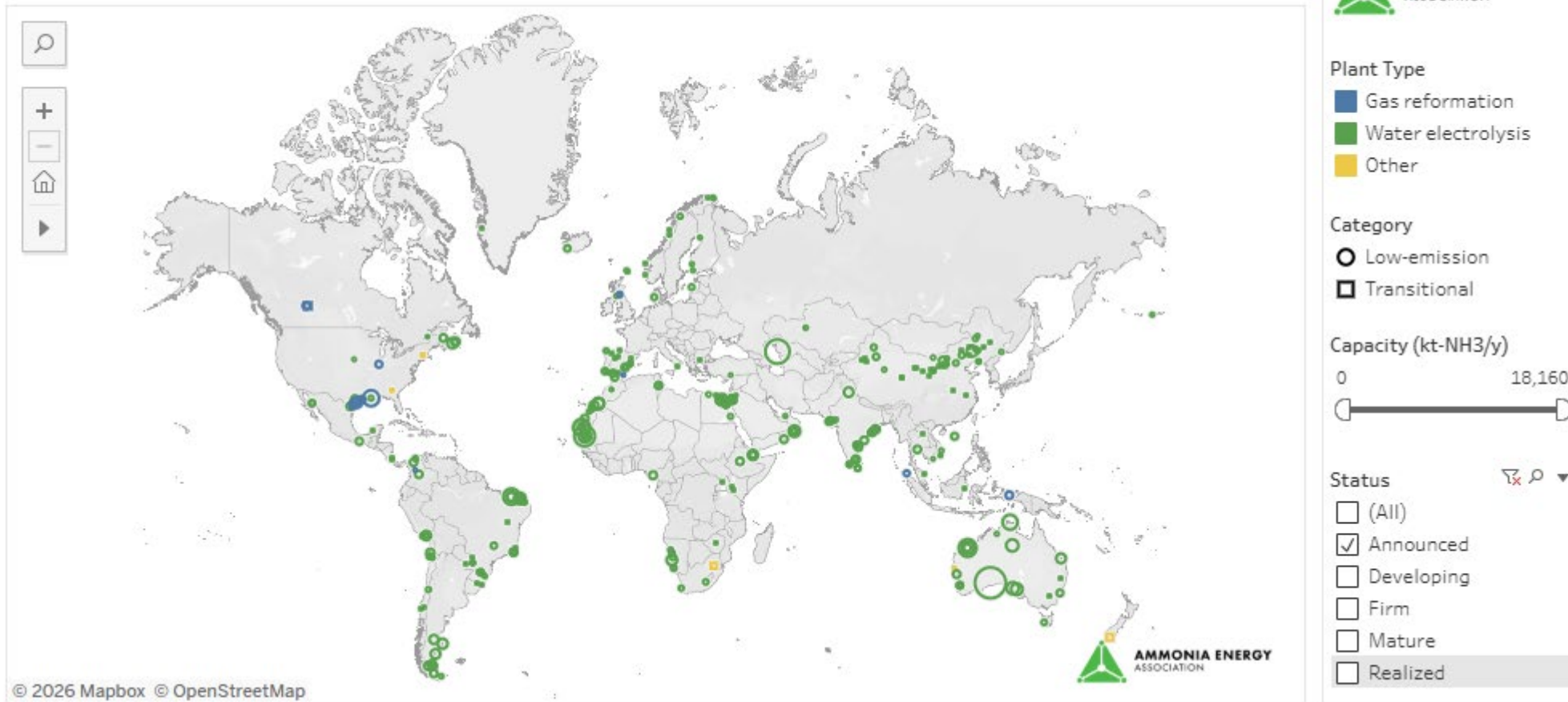
Comparaison en les différents procédés



FORCES	FAIBLESSES	OPPORTUNITES	MENACES/RISQUES
• Eprouvé • Fiable • Répond aux besoins	• Energivore • Empreinte C • Centralisé • Purification N_2 et H_2		• Réglementation C

Production

Low-emission Ammonia Plants



Actuellement : 240 Mt
2050 : 505 projets ! 400 Mt de NH₃
dont 44 Mt de NH₃ en 2030

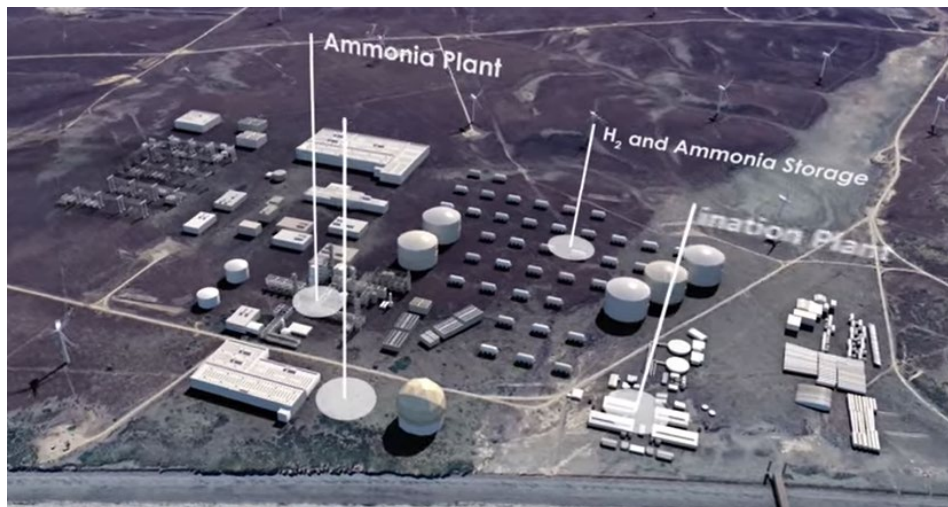
PROJETS DE PRODUCTION VERTE



Facts about the green ammonia plant in Denmark

- The plant is a demonstration project, which have received funding from the Danish Energy Technology Development and Demonstration Program (EUDP)
- Location: Ramme near Lemvig, Northwest Jutland, Denmark.
- Output: 5,000 tons of green ammonia annually from renewable power. This production will prevent 8,200 tons of CO₂ from being emitted into the atmosphere every year.
- Power supplied from renewable sources: 50 MW new solar panels and 12 MW existing V80-2.0 MW Vestas wind turbines.

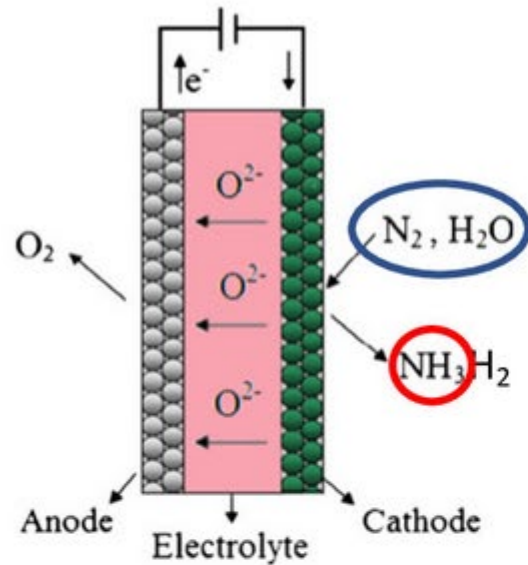
World's first of its kind green ammonia plant inaugurated by Skovgaard Energy, Vestas, and Topsoe



10 GW Eoliennes

- 8 GW d'électrolyseur
 - une usine désalination
 - une usine de production de NH₃
 - terminaux portuaires pour exportation
- A pleine capacité : 4.4 Mt de NH₃ vert / an

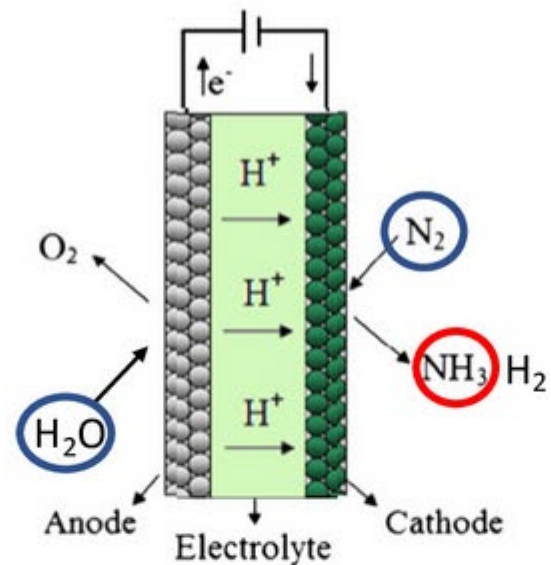
Nouveau procédé : électrolyse directe à haute température



Cathode:
 $3H_2O + N_2 + 6e^- \rightarrow 3O^{2-} + 2NH_3$
 Anode :
 $3O^{2-} \rightarrow 3/2 O_2 + 6e^-$

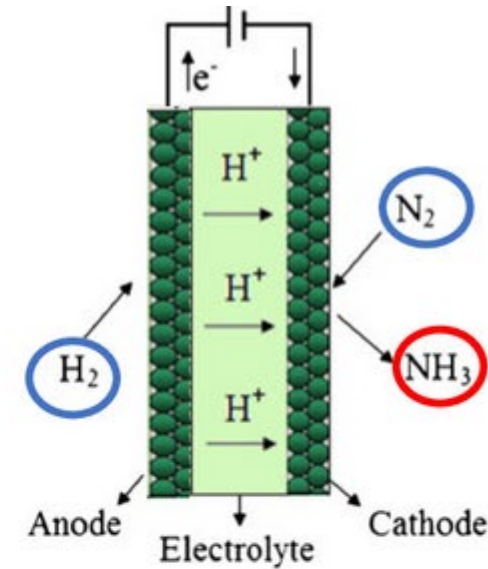


« SOEC »



Cathode
 $N_2 + 6H^+ + 6e^- \rightarrow 2NH_3$
 Anode
 $3H_2O \rightarrow 6H^+ + 3/2 O_2 + 6e^-$

« PEEC »



Cathode :
 $N_2 + 6H^+ + 6e^- \rightarrow 2NH_3$
 Anode :
 $H_2 \rightarrow 2H^+ + 2e^-$



« PH »

En pleine innovation

Angewandte
International Edition **Chemie**

GDCh

A Journal of the
German
Chemical Society

Research Article | Open Access | CC BY-NC-ND

Ammonia Synthesis at Room Temperature and Atmospheric Pressure from N₂: A Boron-Radical Approach

Dr. Soukaina Bennaamane, Barbara Rialland, Lhoussain Khrouz, Dr. Marie Fustier-Boutignon,
Dr. Christophe Bucher, Dr. Eric Clot, Dr. Nicolas Mézailles

In memory of Pascal Le Floch

First published: 27 October 2022 | <https://doi.org/10.1002/anie.202209102> | Citations: 1

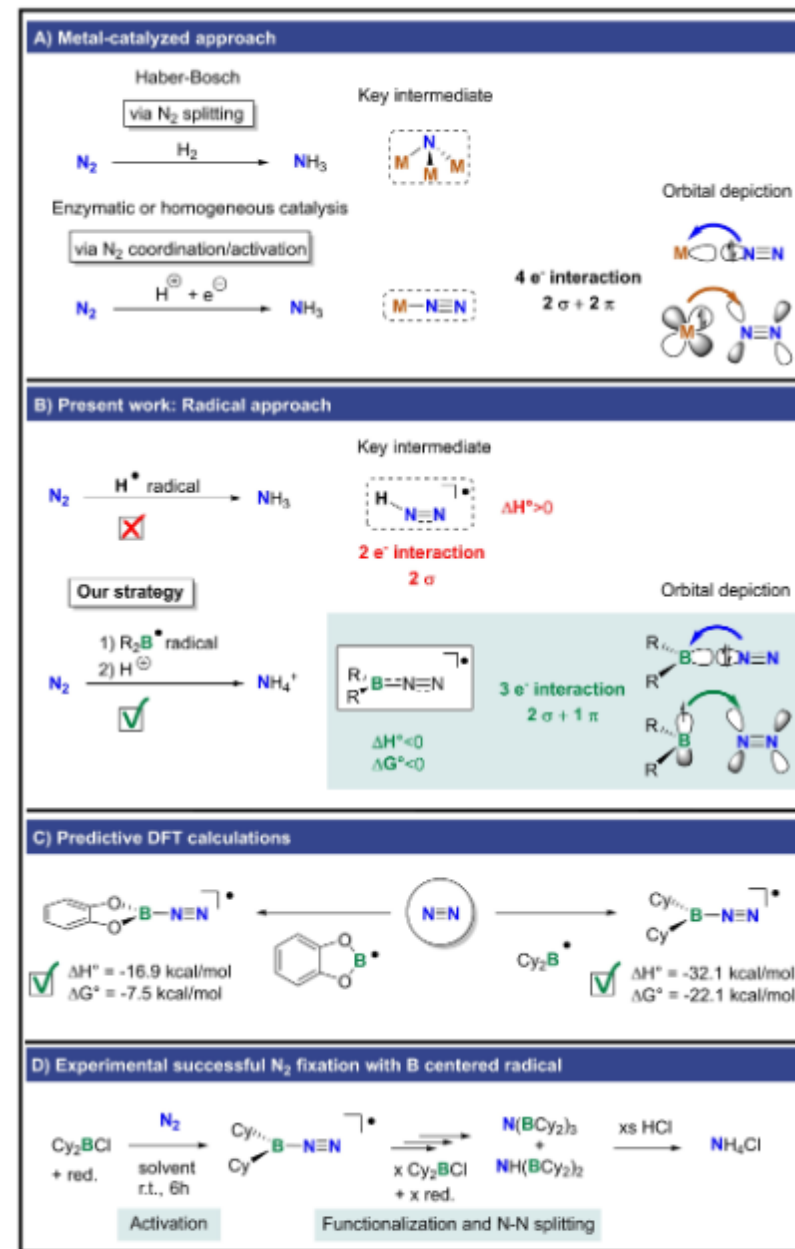


Figure 1. A: Known catalytic N₂ to NH₃ transformations. B: Radical approach to N₂-activation: our strategy. C: Computed additions of R₂B radicals on N₂. D: Successful N₂ to NH₄⁺ transformation via B-centered radicals.

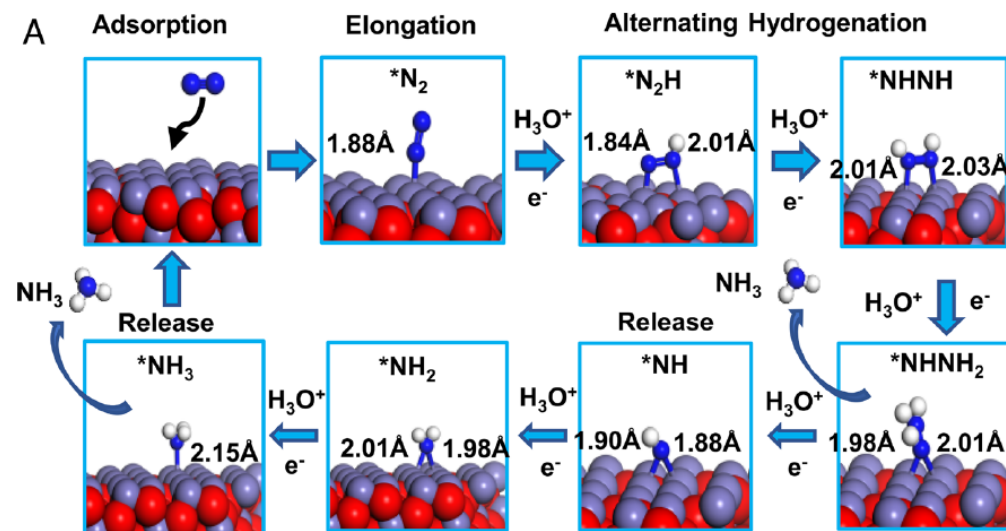
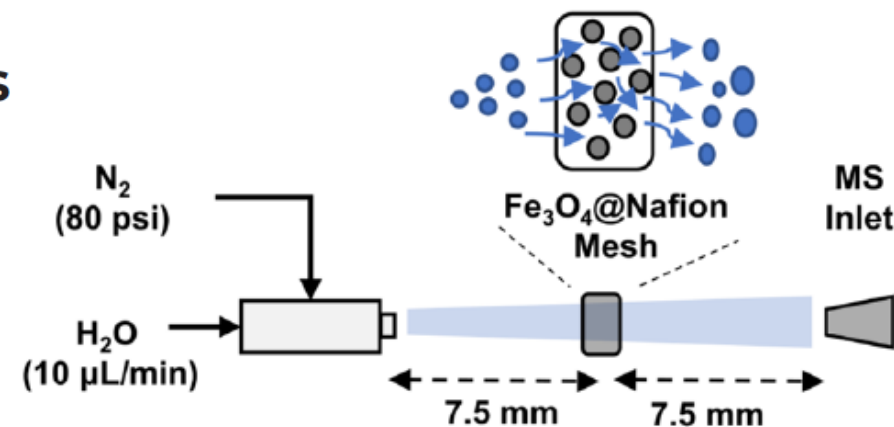
Making ammonia from nitrogen and water microdroplets

Xiaowei Song^a, Chanbasha Basheer^{b,1}, and Richard N. Zare^{a,1} 

Edited by Joseph Francisco, University of Pennsylvania, Philadelphia, PA; received January 20, 2023; accepted March 8, 2023

Water (H_2O) microdroplets are sprayed onto a magnetic iron oxide (Fe_3O_4) and Nafion-coated graphite mesh using compressed N_2 or air as the nebulizing gas. The resulting splash of microdroplets enters a mass spectrometer and is found to contain ammonia (NH_3). This gas–liquid–solid heterogeneous catalytic system synthesizes ammonia in 0.2 ms. The conversion rate reaches $32.9 \pm 1.38 \text{ nmol s}^{-1} \text{ cm}^{-2}$ at room temperature without application of an external electric potential and without irradiation. Water microdroplets are the hydrogen source for N_2 in contact with Fe_3O_4 . Hydrazine (H_2NNH_2) is also observed as a by-product and is suspected to be an intermediate in the formation of ammonia. This one-step nitrogen-fixation strategy to produce ammonia is eco-friendly and low cost, which converts widely available starting materials into a value-added product.

ammonia formation | water microdroplets | heterogeneous catalysis



Domaine en pleine innovation

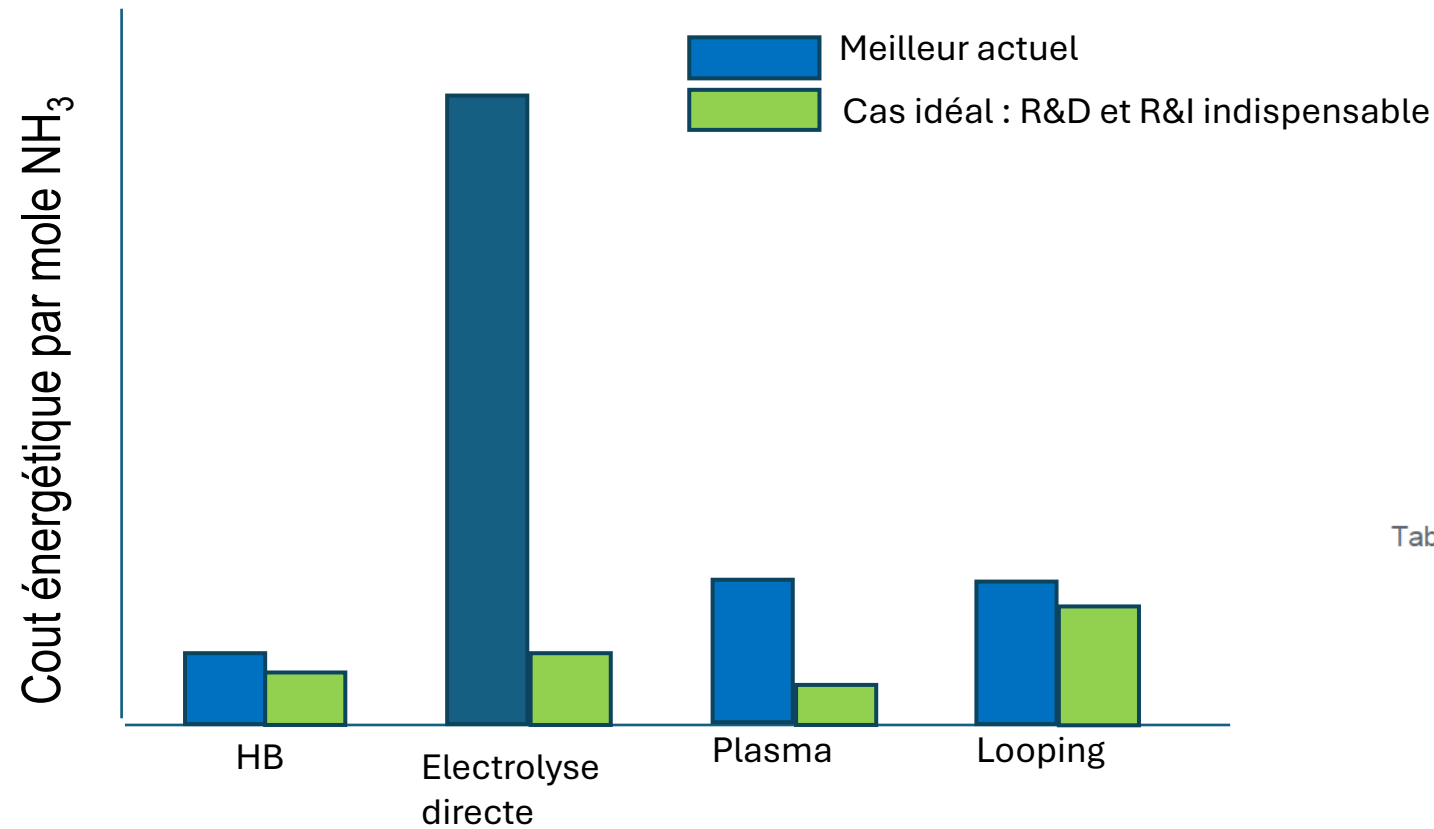


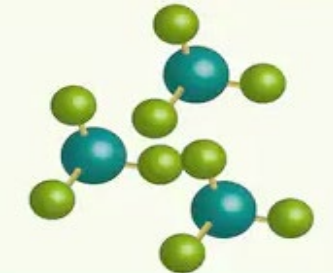
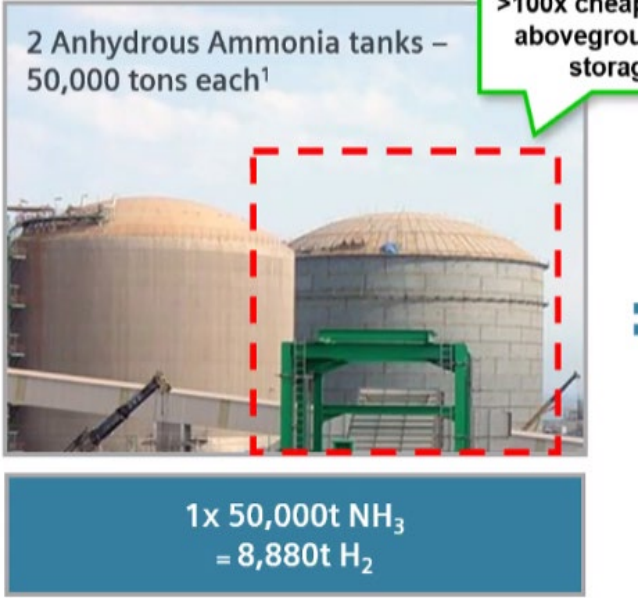
Table 5. Comparison of expected efficiency for different ammonia production pathways.

Process Type	Expected Efficiency [up to]
Pathway 1 Electrolysis and Haber-Bosch synthesis	~72%
Pathway 2 Direct solar hydrogen production	9% [up 70%]
Pathway 3 Biogenic hydrogen production	~57%
Pathway 4 Non-thermal plasma synthesis	12-37% [up to 45%]
Pathway 5 Electrochemical ammonia synthesis	14-62% [up to 90%]

Solutions de stockage

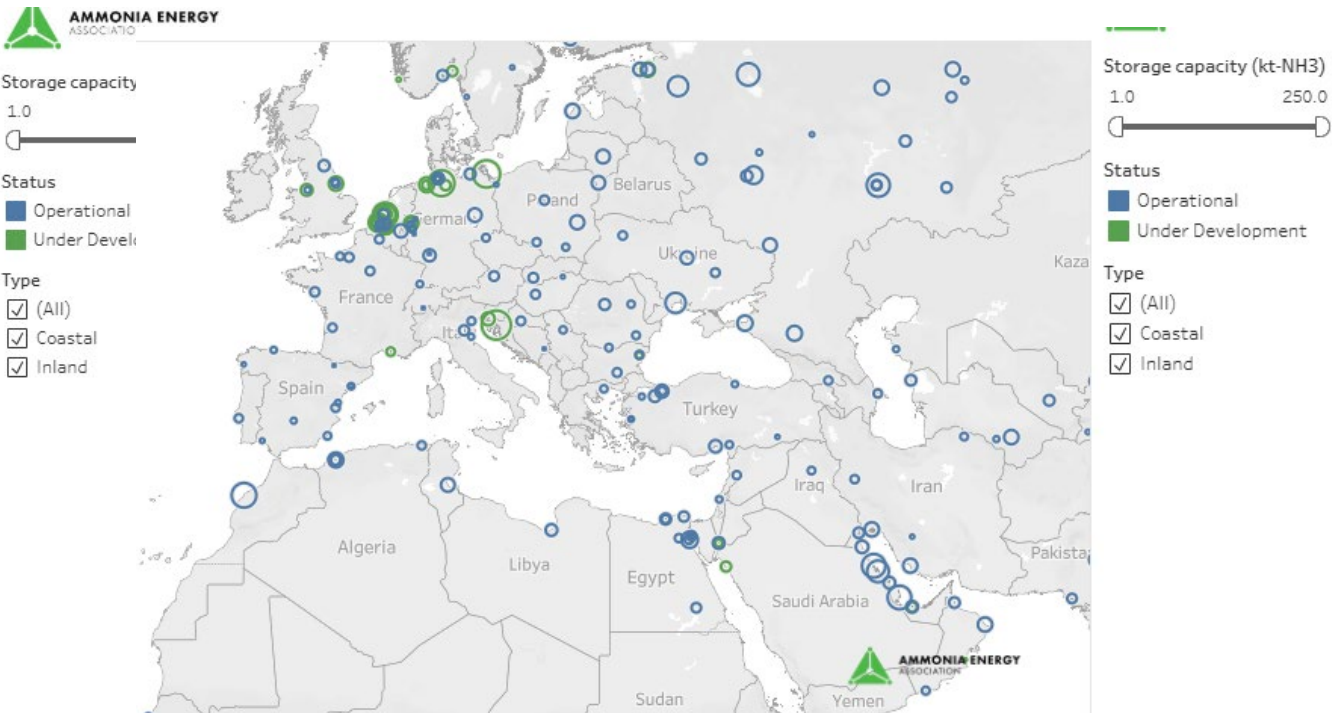
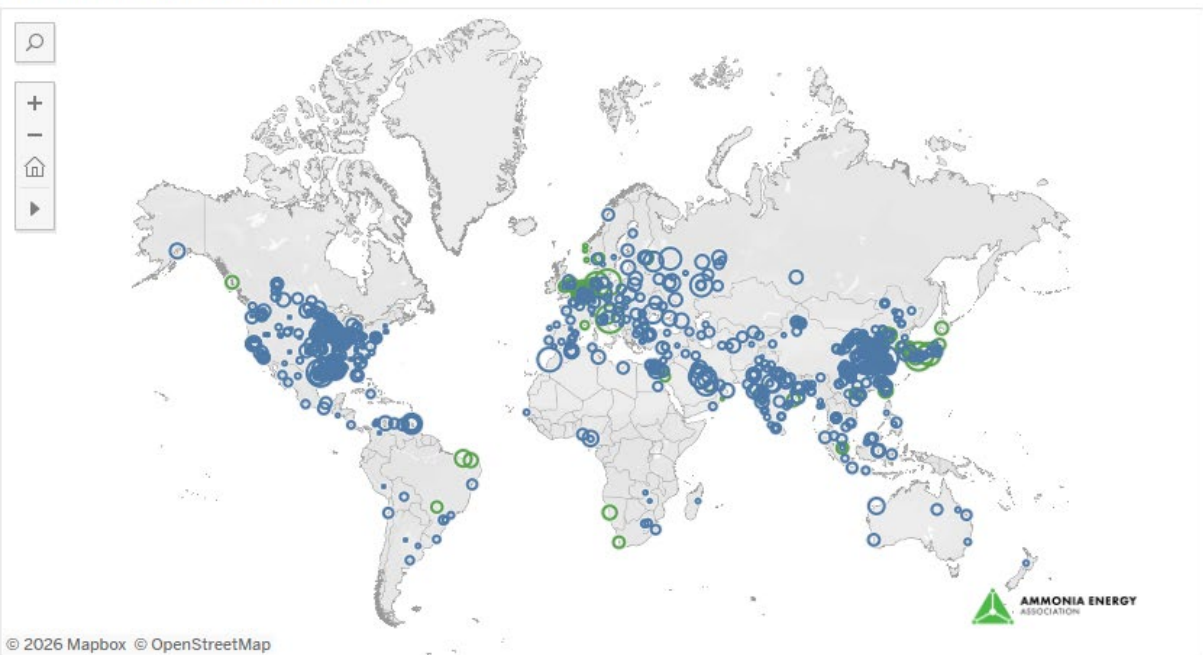
- Haute pression ou en réfrigération
- 1) Réservoirs pressurisés (17 bars) = 300 tonnes
 - maintenir en liquide malgré variation de Temp.
 - standard sécurité pour stockage et transport.
- 2) Réservoirs réfrigérés (-33°C)
 - = très haute capacité (jusqu'à 66.2 Millions de litres !)

50 mX40 m – simple mur en béton,
Réservoir en acier



Cesar Z, UK-India
Ammonia meeting,
2020

Ammonia Storage Terminals



Stockage et transport

Transport



Navires de 35 000 t, camions 20 t,
Wagons 50t
5000 km de pipeline aux US, 2000 en
Russie

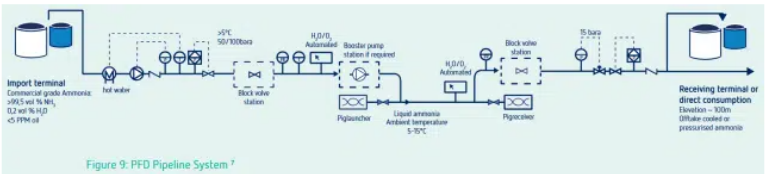
Ammonia pipeline in the Netherlands and Germany



Click to expand. The route for the Netherlands-Germany ammonia pipeline studied in ISPT's new report. Fig 7 from *Design and Safety Aspects for large-scale Clean Ammonia Pipelines* (May 2025).

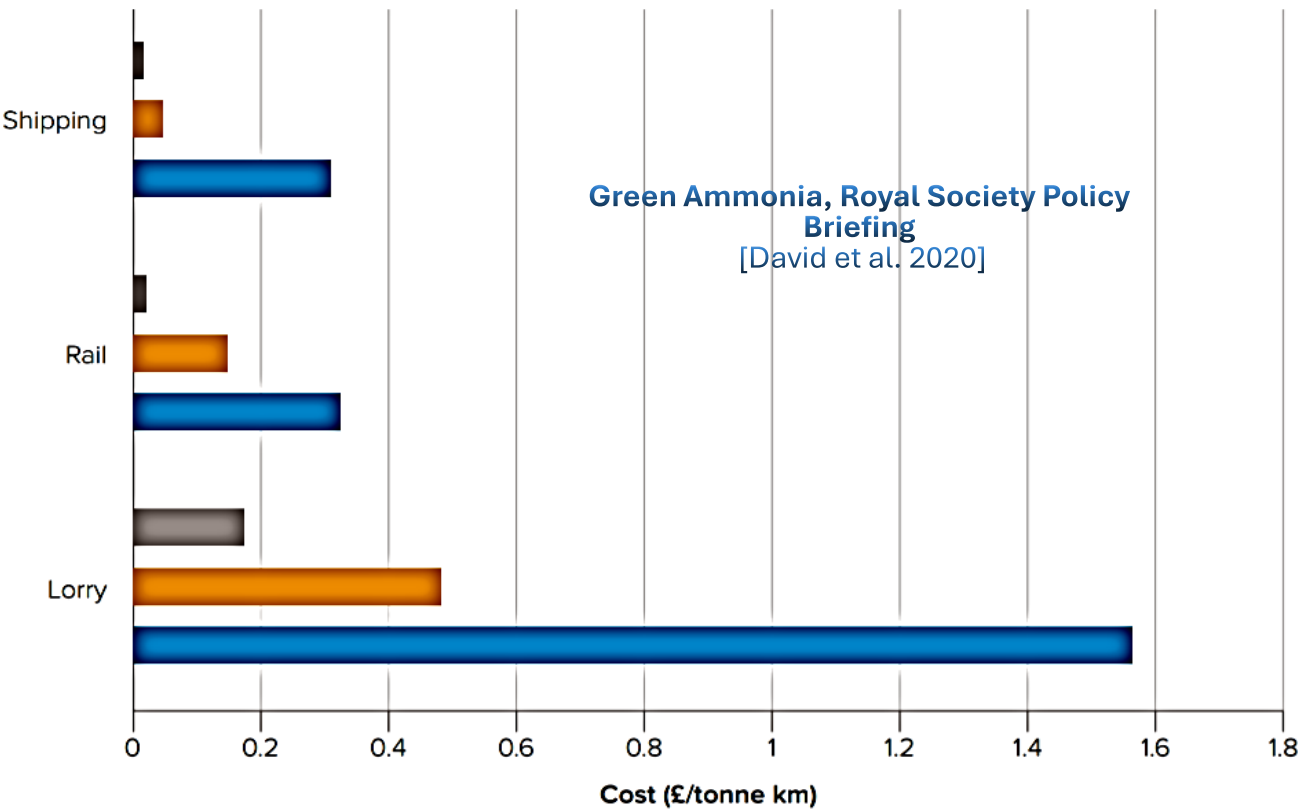
The ISPT report includes design aspects, technology choices, safety considerations, as well as an economic evaluation for a 550 km ammonia pipeline from the Port of Rotterdam to Venlo in the Netherlands, thereafter crossing via Cologne to Karlsruhe in Germany. This trajectory is comparable to the proposed Delta Rhine Corridor linking the Netherlands and Germany. The route covers rural areas, as well as densely populated areas. The pipeline in the study is designed for an annual flow capacity of 7 million tons of ammonia.

The scope comprises a system with a single pipeline, booster pump stations, valve stations and interfaces to import terminals in the Port of Rotterdam and receiving terminals inland. Various pipeline configurations have been considered, with the base scenario consisting of 20" pipes (15 mm wall thickness) with a design pressure of 50 barg and temperatures of 5-15°C, and three intermediate booster pump stations and 110 valve stations along the trajectory. The operating conditions align with well-recognized industrial best practices for ammonia transport via pipeline.



KEY

Ammonia Liquid hydrogen 350 bar hydrogen



Green Ammonia, Royal Society Policy Briefing
[David et al. 2020]

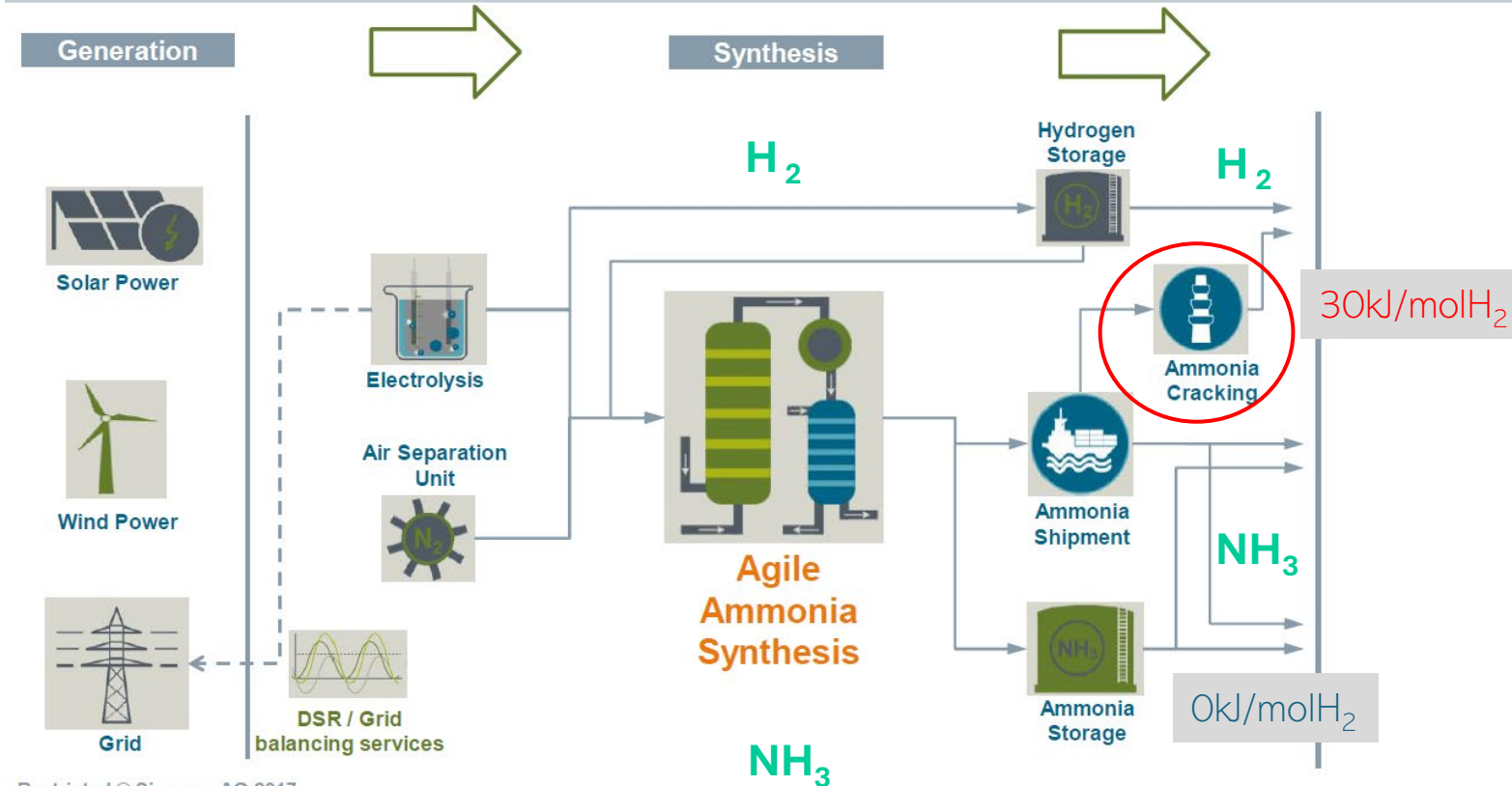
- Prix du transport : très 'peu' cher
- Quelque soit le mode de transport

2016

Ammoniac : un fertilisant ou un 'hydrogène' ?

Several potential markets exist for Green Ammonia:
it is a carbon-free flexible asset

SIEMENS



Restricted © Siemens AG 2017

Seite 13

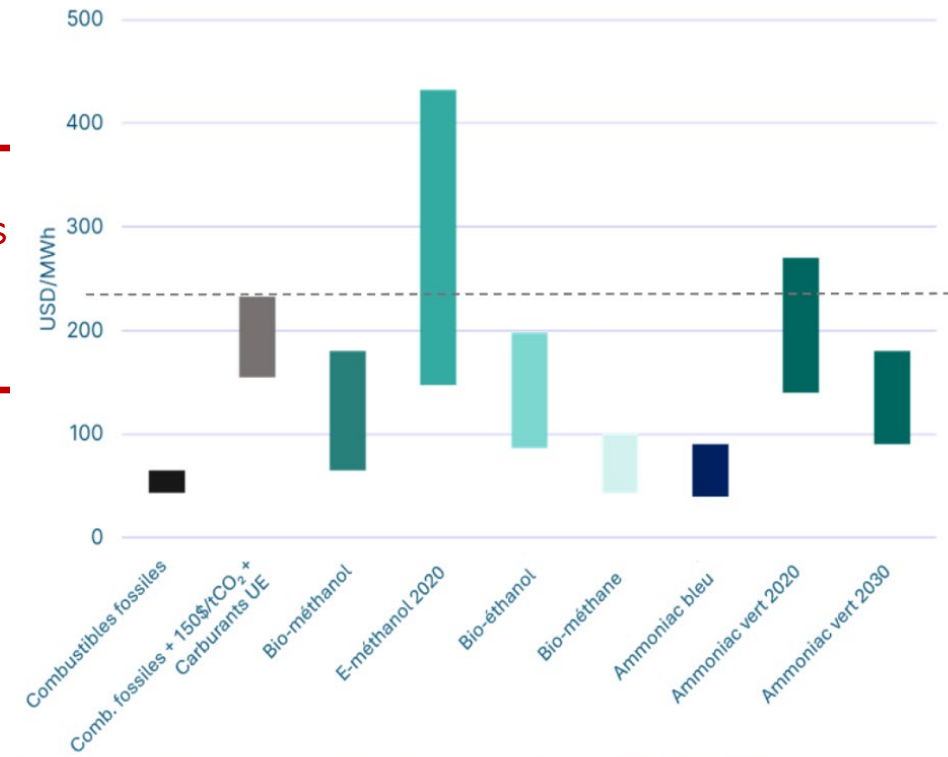
November 2017

SFT 2016

Optimisation des usages / nouveaux usages



SFT 2016



Power to Gas to Power

Produire de l'électricité : assurer une production d'énergie, propre et flexible



Comparison of ammonia with other chemicals in terms of efficiency for the production of electric power (from well to wheel).

[Dias et al. Energy and Economic Costs of Chemical Storage. Front. Mech. Eng. doi.org/10.3389/fmech.2020.00021]

SFI 2016



Ammonia on route to fuel ships and planes

Carbon-neutral ammonia could be a drop-in replacement for fossil fuels

by Alex Scott

AUGUST 12, 2020 | APPEARED IN VOLUME 98, ISSUE 31

Green ammonia for even cleaner electrical power

GenCell is also working on a technology to economically produce "green ammonia"—ammonia that is made without emitting CO₂ sources. Once this technology is perfected, it will become possible to manufacture green ammonia independently of the grid, which in turn will supply the hydrogen that powers fuel cells—creating a totally green electrical power solution.



GenCell

Who We Are

What We Do

Industries We Serve

Market Insights

Event

Home

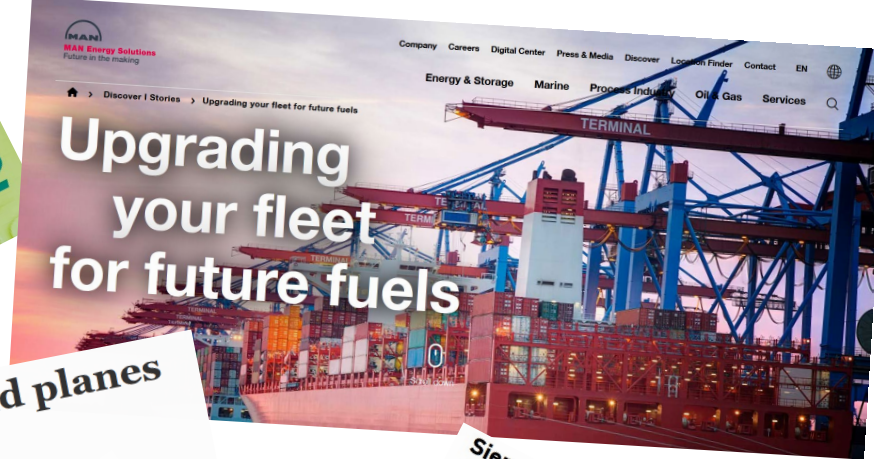
What role will ammonia play in global hydrogen trade?

OPINION

What role will ammonia play in global hydrogen trade?

Low-carbon ammonia is emerging as a carrier of choice for hydrogen exports, but it's not without its challenges

10 January 2022 | 1 minute read



Siemens Tests Ammonia as a Form of Energy Storage for Renewables

The company has opened a novel new facility to study the efficiency of converting electricity to hydrogen, and then to ammonia, and back.

JASON BROWN | JUNE 27, 2018



Where large-scale storage of surplus renewable energy is a goal, the German industrial giant Siemens is investigating the use of ammonia as a way to store and transport hydrogen in energy systems with high penetration of renewables.

Les Grands d'Olivet
Renewable Energy & Fuel Cells
Global ammonia storage pilot

TOP ARTICLES
MOST POPULAR
MOST COMMENTS



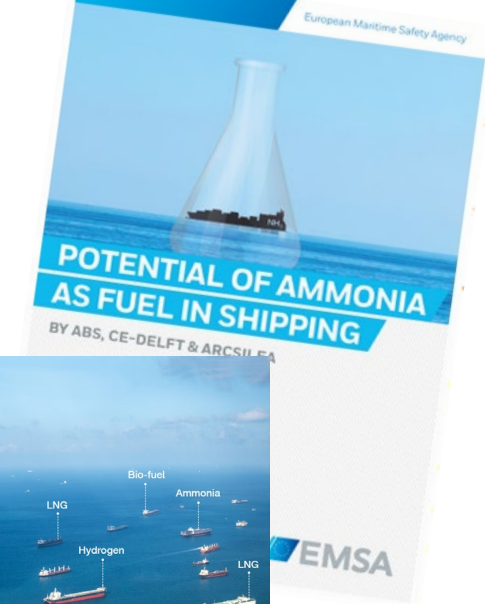
Ammonia: hydrogen's green soulmate?



The fertilizer industry produces and consumes up to 50% of the hydrogen produced every year in Europe. [Source: EC, Hydrogen 2020]

A chemical traditionally used in the fertilizer industry, ammonia is now also entering the realm of energy as a way to store and transport hydrogen, or as an alternative transport fuel in its own right.

Ammoniac comme carburant, comme combustible



Is ammonia the fuel of the future?

Industry sees the agricultural chemical as a convenient means to transport
by **Alexander H. Tullo**
March 8, 2021 | A version of this story appeared in **Volume 99, Issue 8**



By Rex Isaacs, Todd Grubb, Chris Montgomery, Zeeco, Inc. with Alok Sarkar, William McLaughlin, ExxonMobil on November 24, 2025



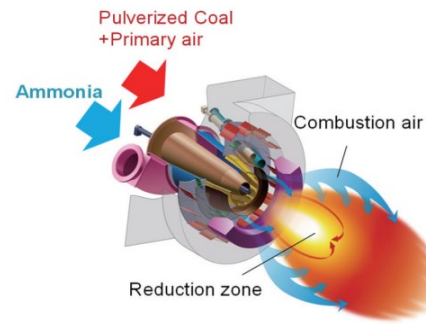
ABSTRACT

Ammonia as a fuel for industrial heating and steam generation is being considered as an option to help reduce industrial greenhouse gas emissions, especially in regions without indigenous natural gas or pore space for CO₂ sequestration. Ammonia is attractive as a low-carbon fuel because of its



Green ammonia for even cleaner electrical power

GenCell is also working on a technology to economically produce "green ammonia"—ammonia that is made without emitting CO₂ during the synthesis process by leveraging renewable energy sources. Once this technology is perfected, it will become possible to manufacture green ammonia independently of the grid, which in turn will supply the hydrogen that powers fuel cells—creating a totally green electrical power solution.



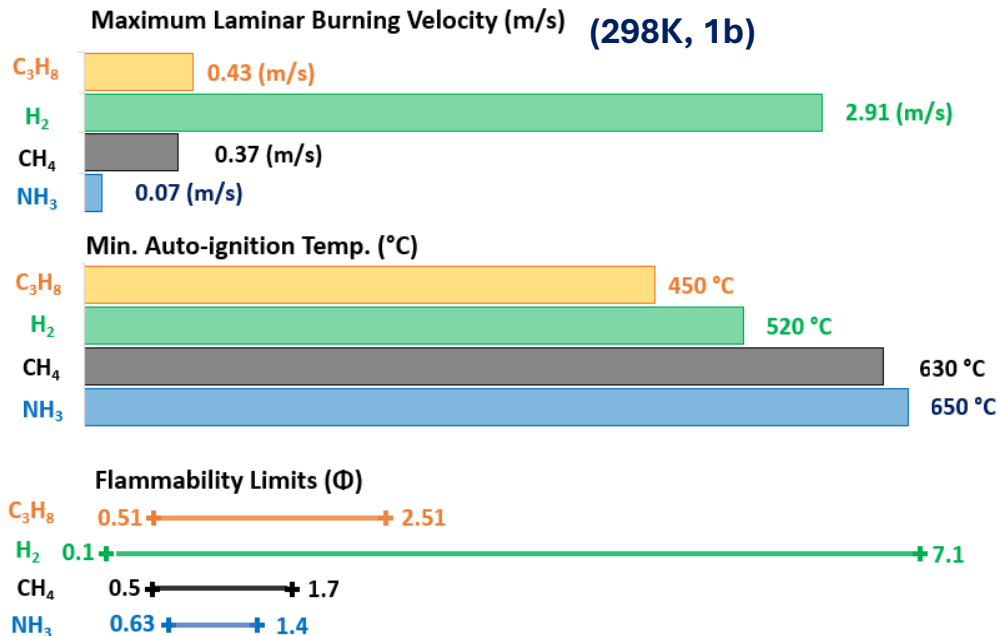
From fertilizer to marine fuel



Ammoniac comme combustible : un challenge

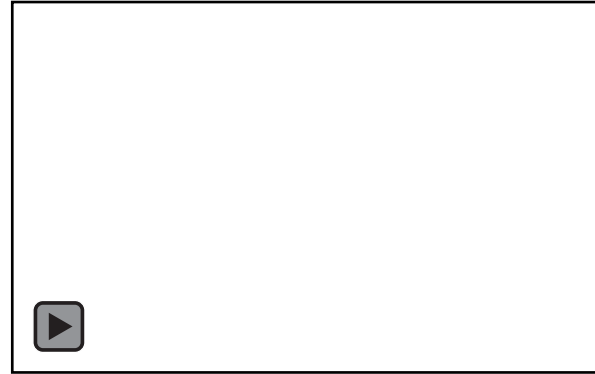
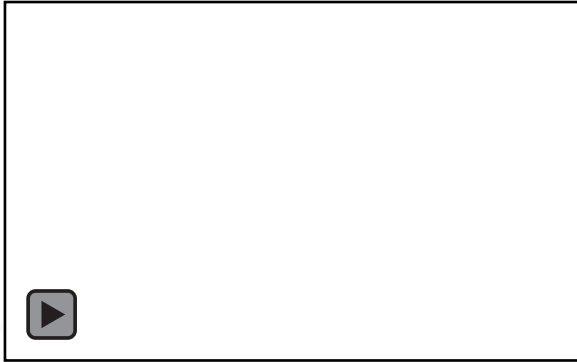
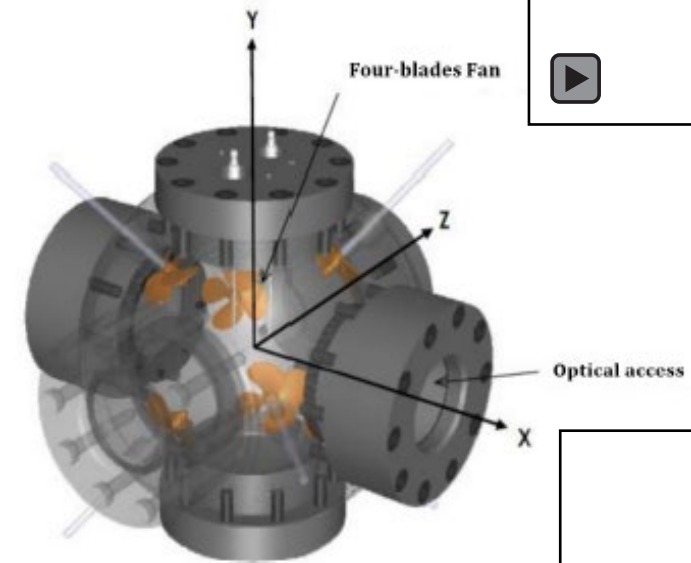


- Pas de CO_2 😊
- Parfait, simple ?



- 🔗 Stabilisation de la combustion
- 🔗 Interaction flame-turbulence
- 🔗 Emissions indésirables (NO_x) (+ autres ?)

Ammonia as fuel = a challenge



Ammoniac comme combustible : un challenge

- Corrosif (cuivre, laiton, nickel, zinc...) (selon concentration, HT)
- Réaction avec les acides, les halogènes, les agents oxydants
- Mais aussi avec le caoutchouc naturel, le nitrile, polyurethane, viton (FKM) ou silicone (BT)

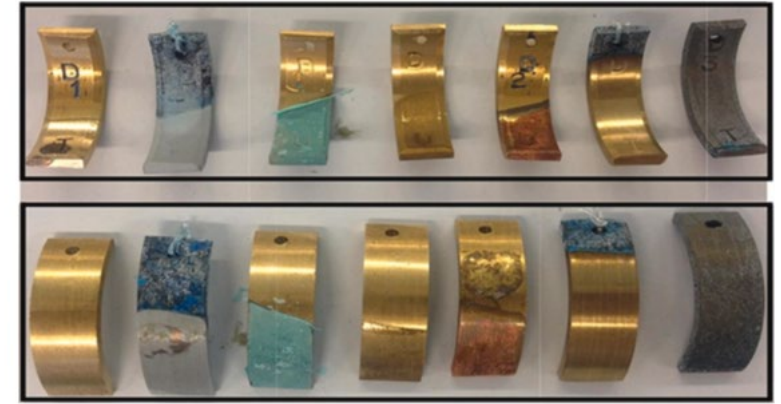


Fig. 25. Brass samples exposed to different levels (pH) of ammonia concentration [294].

Effets de diverses teneurs en NH_3

Teneurs en ammoniac
(exprimé en ppm)

■ Toxique



100 à 500

► Les concentrations sont dangereusement élevées, l'irritation s'intensifie. L'exposition prolongée, à de fortes concentrations, peut provoquer la mort

50 à 100

► Paupières gonflées, conjonctivites, vomissements, gorge irritée

25

► Limite exposition admissible LEA, [PEL (NIOSH)]

0 à 25

► Irritation mineure des yeux et des voies respiratoires

Ammoniac comme combustible : un challenge

- Corrosif (cuivre, laiton, nickel, zinc...)
- Certains plastiques etc...
- Toxique



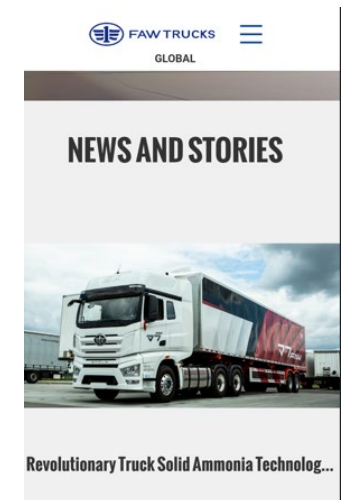
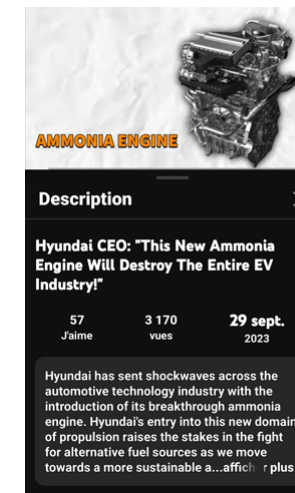
Et pourtant les applications se développent

1) Dans le transport terrestre

- Bcp de recherches sur les moteurs à l'Ammoniac
 - Seul ou avec un promoteur de combustion :
 - H_2 , bio-carburant (essence, diesel, bio-carburants, DME, méthanol, éthanol, ...)



Toyota CEO: "Our New Ammonia Engine Will Bankrupt The Entire EV Industry!"



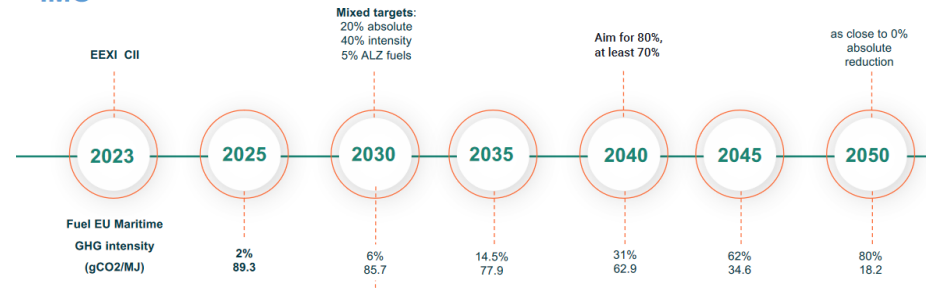
49 tons of traction truck with ammonia engine

Et pourtant les applications se développent

2) Dans le transport maritime

Fuel EU Maritime / IMO targets

IMO



RIGHTSHIP



2020-2025
Wärtsilä
Ammonia 2-4
project &
Conversion
project with
Eidesvik Offshore



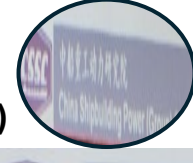
2021-2025
WinGD
methanol &
ammonia



2020-2025
MAN
2-stroke NH₃
engine



2021-2024
IHI Power Systems
Diesel/Ammonia (80%)



2023-2026 ?
CSSC
Ammonia > 95%



Dalian COSCO Shipping Heavy Industry has kicked off construction of China's first ammonia/diesel dual-fuel-powered 5500HP azimuth-stern drive (ASD) tug as part of COSCO Shipping Heavy Industry's project "R&D and Demonstration Application of Ammonia-powered Dual-fuel Engine and Supply System".



Et pourtant les applications se développent

3) Autres



Fortescue & Deutsche Bahn to develop ammonia-powered trains in Germany

By [Julian Atchison](#) on October 10, 2022

Deutsche Bahn (DB) and Fortescue Future Industries (FFI) will collaborate to **modify existing diesel engines** to run on hydrogen & ammonia fuel. Targeting locomotive & other traction vehicle applications, the pair will utilise Ammonia's ammonia cracking technology in their design. We reported on **Ammonia's "Ammonia Fuel Refinement"** unit earlier this year, and how it had been installed and tested in a converted speedboat to simulate the operation of an inland cargo barge. DB reports that a prototype, bench-top system (converted diesel engine plus cracking unit) is currently being tested (including "endurance" and NOx emission testing), with results expected next year.



Click to learn more. A Deutsche Bahn Class V90 diesel locomotive, used for shunting and freight haulage. Source: Wikimedia Commons/Steffen Mokosch.



FLXdrive locomotive similar to those acquired by Vale. Credit: Wabtec

Wabtec will build the FLXdrive locomotives at its plant in Contagem (state of Minas Gerais). The locomotives' delivery is forecast for 2026.

Initially, we are maximizing energy efficiency, replacing the diesel locomotives in the dynamic helper with battery ones, but the idea is that, in the future, the other locomotives on the train can be fueled by ammonia. This way, we would have a clean operation at EFC. This agreement is the first of many that we are seeking in order to accelerate the decarbonization of our railway operation.

—Vale's Director of Energy, Ludmila Nascimento

The CRRC has mastered the production of medium-speed ammonia-diesel engines

12.12.2023

At the Dalian plant, a stand featuring the first dual-fuel twelve-cylinder Q engine, 12V240H-DFA, was showcased, this is reported by the railway transport news portal **Railway Supply**.



It claims to generate up to 208 kW of energy from a single cylinder, with 85% of power coming from ammonia, reducing CO2 emissions by 80%.

The production of railway wagons in Kazakhstan



Autre application : 'Off-road'
(Groupe électrogène, engins de construction, mine, grues...)

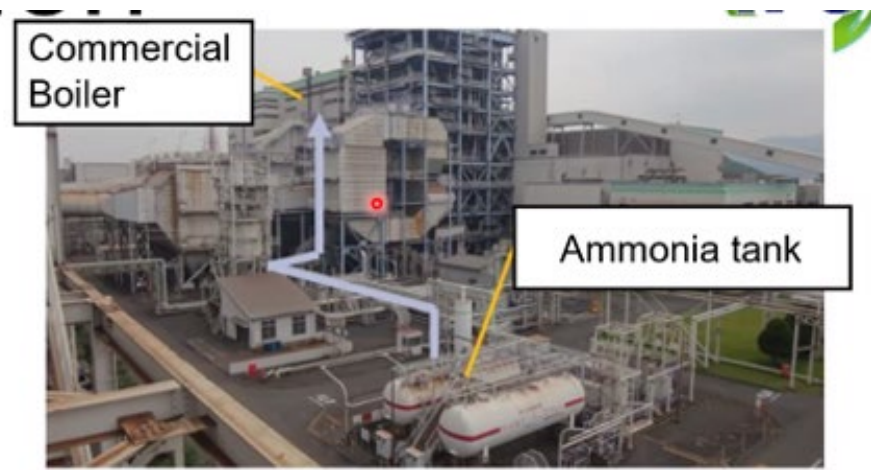
Et pourtant de nombreuses utilisations...

4) Pourquoi pas l'aéronautique



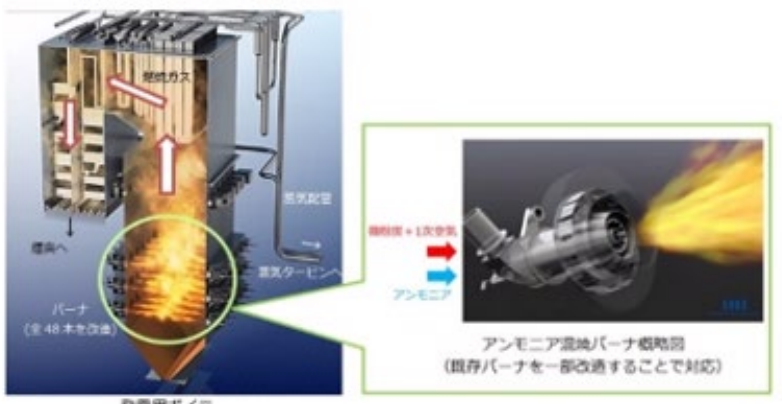
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La génération d'énergie électrique

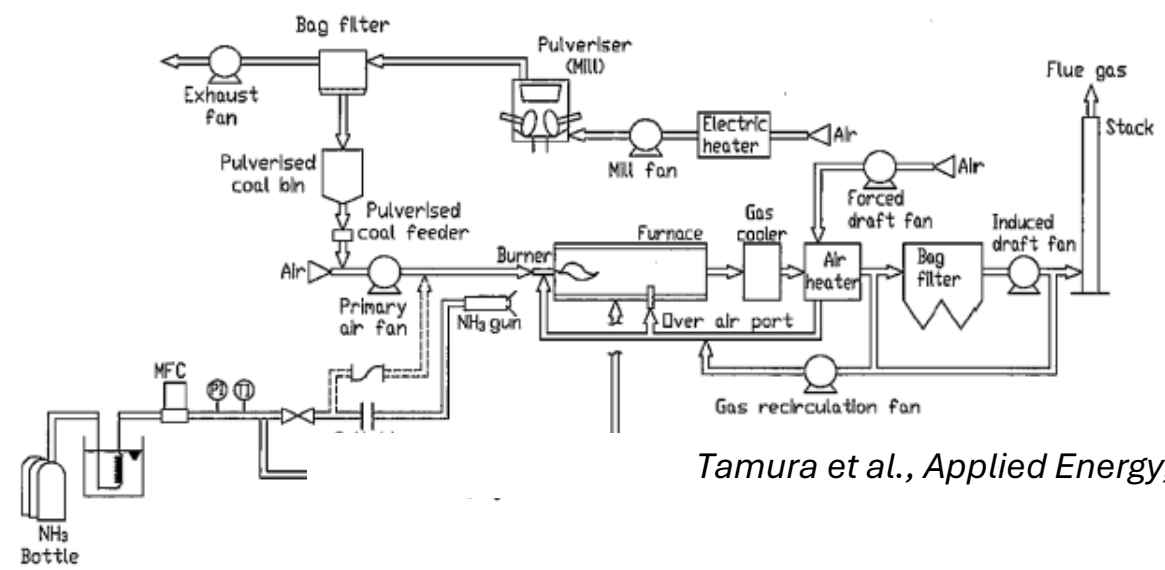


Test of the co-firing of ammonia and coal (2017)
Chugoku electric. co., Mizushima Power Station @ Okayama

Yoshizaki, J. CSJ,
<https://www.jst.go.jp/sip/dl/k04/end/team6-10.pdf>

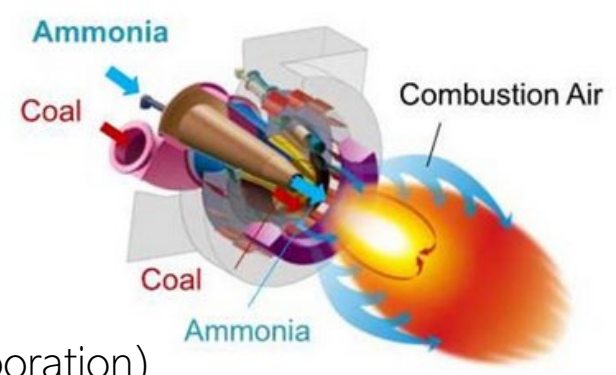


Co-firing test (in preparation)
@ Hekinan power station, JERA



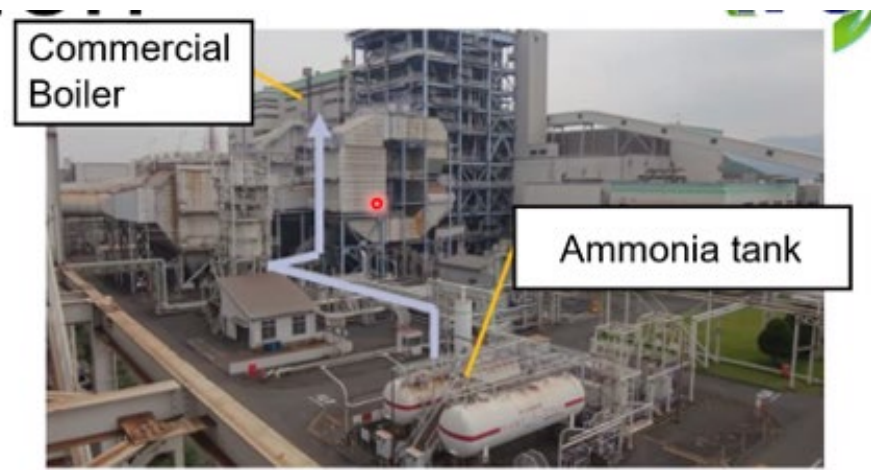
Tamura et al., Applied Energy, 2020

- 50 kg/ h ammoniac = 35% NH3 en Energie total
- Différents sites et technologie d'injection

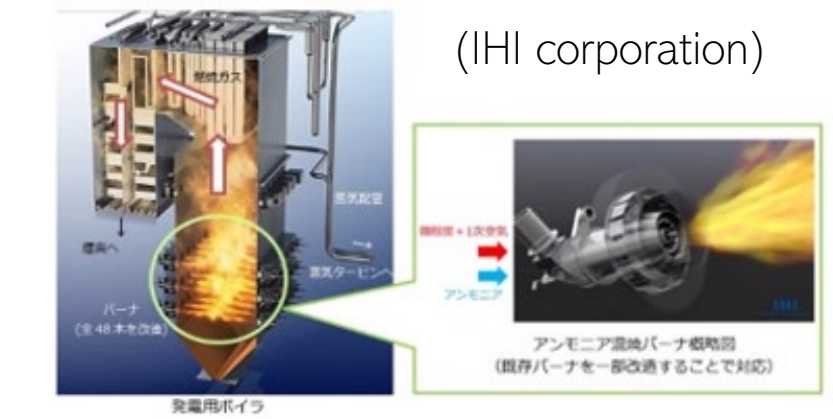


2016 (IHI corporation)

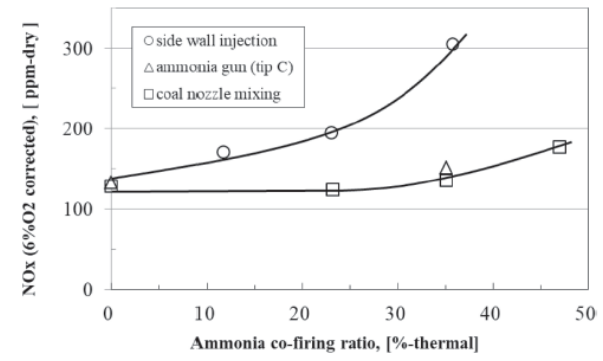
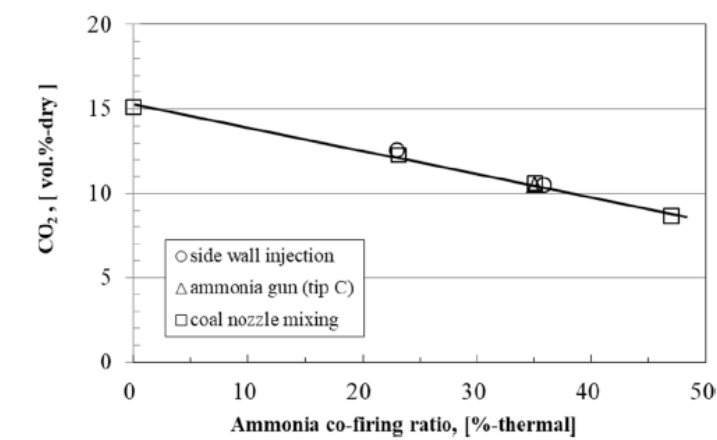
La génération d'énergie électrique



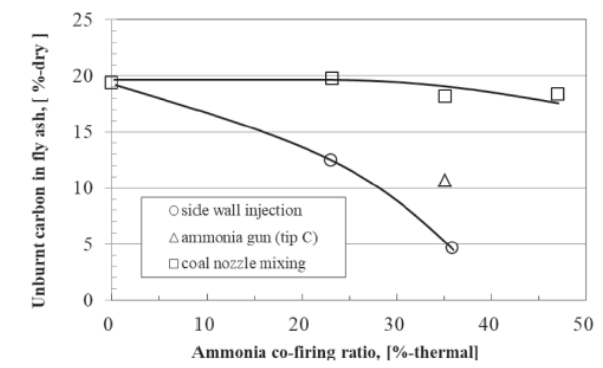
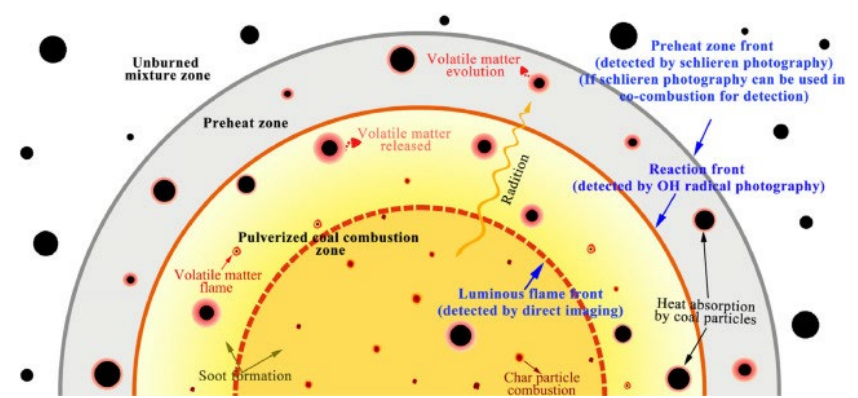
Test of the co-firing of ammonia and coal (2017)
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<https://www.jst.go.jp/sip/dl/k04/end/team6-10.pdf>



Co-firing test (in preparation)
@ Hekinan power station, JERA



(a) NO_x emission at furnace exit vs. ammonia co-firing ratio



(b) Unburnt carbon in fly ash at furnace exit vs. ammonia co-firing ratio

Impact sur les émissions :

- Fonction du lieu d'injection,
- Du temps de résidence, de la richesse locale

2016

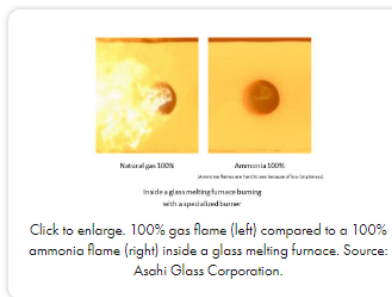
Dans l'industrie :

Ammonia fuel for glass production de Japan

By Julian Atchison on September 19, 2023

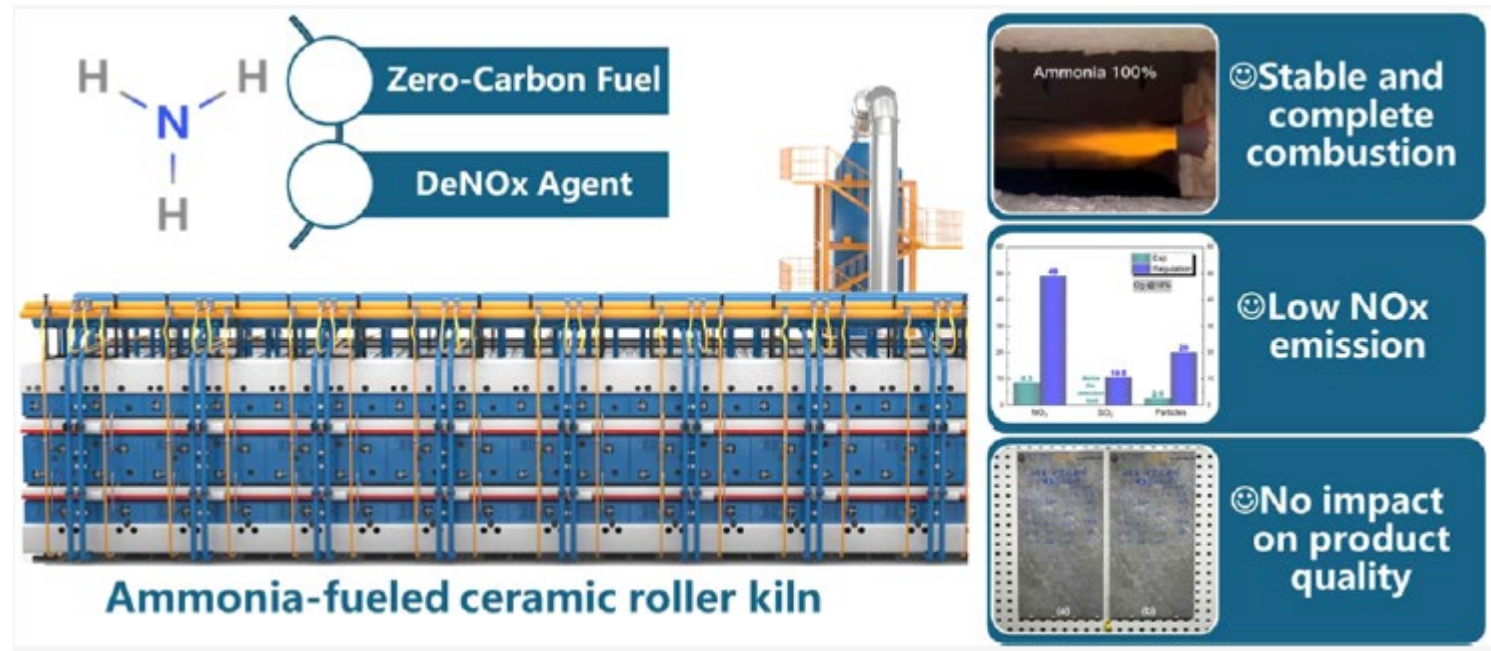
Asahi Glass Corporation

Earlier this June, AGC announced it had successfully used 100% ammonia fuel to produce architectural glass over two days of testing at its Yokohama Technical Center. The project is an ongoing joint effort, with technical contributions from Taiyo Nippon Sanso Corporation, the National Institute of Advanced Industrial Science and Technology & Tohoku University, and support from government body the New Energy and Industrial Technology Development Organization (NEDO). AGC confirmed that effects on glass quality and furnace materials, control of flame temperature, furnace temperature, and nitrogen oxide (NOx) emissions were all within acceptable limits.



Pure Ammonia-Fueled Roller Kiln for the Production of Ceramic Tiles: A First Demonstration

Jiwei Zhou, Zhou Yu,* Liuhao Ma, Xuren Zhu, Shiping Jin, Jianguo Du,* Xiru Cheng, Shanjun Ke, Guoqing Xie, Yi-Bing Cheng, and Yu Wang

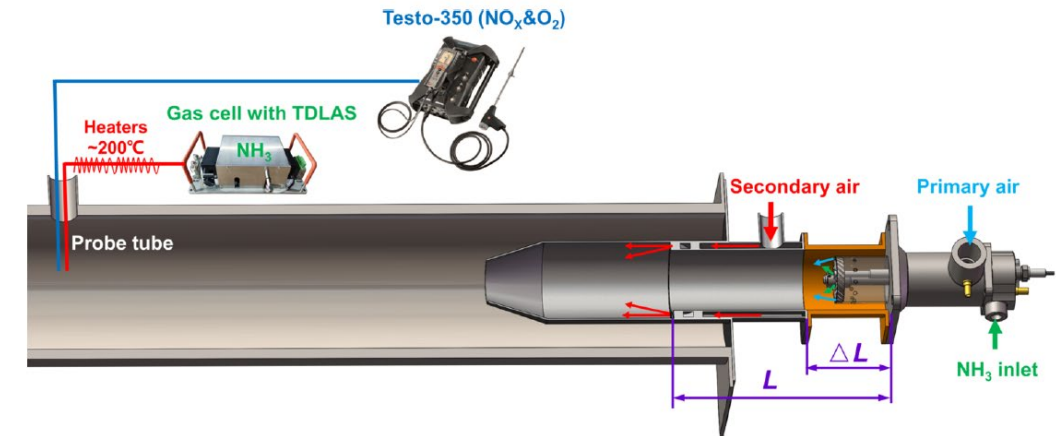
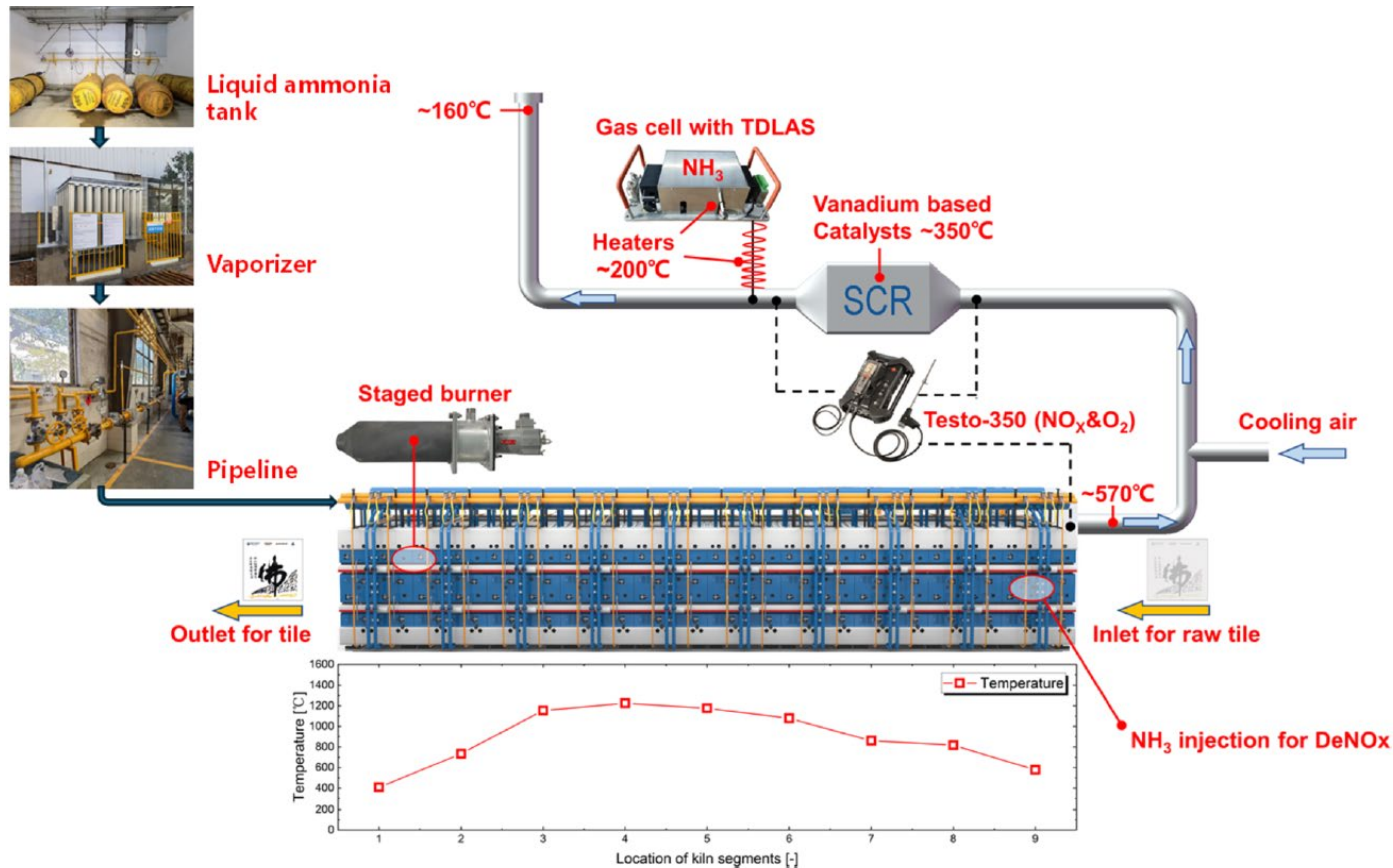


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Dans l'industrie :

Pure Ammonia-Fueled Roller Kiln for the Production of Ceramic Tiles: A First Demonstration

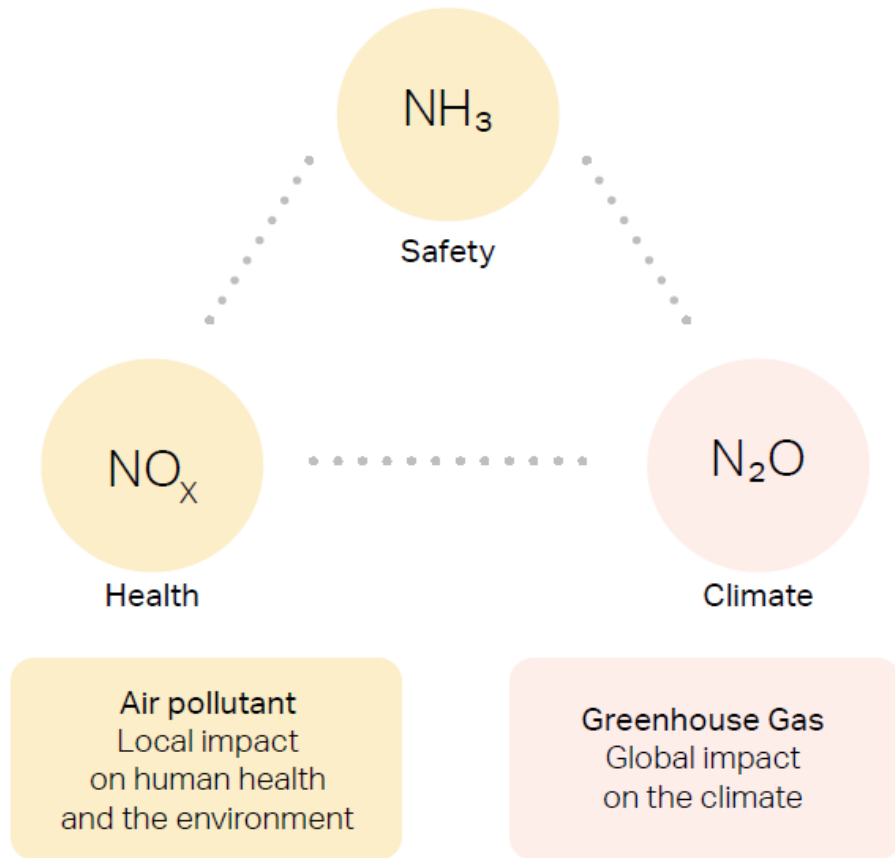
Jiwei Zhou, Zhou Yu,* Liuhao Ma, Xuren Zhu, Shiping Jin, Jianguo Du,* Xiru Cheng, Shanjun Ke, Guoqing Xie, Yi-Bing Cheng, and Yu Wang



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Question majeure : émissions polluantes ?

Ammonia combustion emission risk triangle

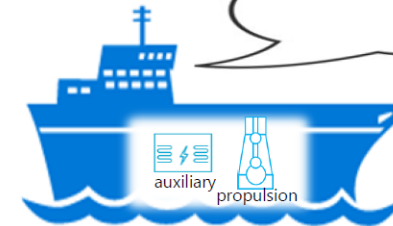


Combustion exhaust gases from ammonia fueled engine will include ...

NH₃ : Strong pungent smell, highly toxic to human body

NO_x : Photochemical smog, acid rain, air pollution

N₂O : GHG about 300 times more potent than CO₂, ozone depleting gas



Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

T 2016

Predictions via mécanismes cinétiques

- 2 sources of NO_x : thermal + Fuel-Nox
- Quelle stratégie de mélange locale ?

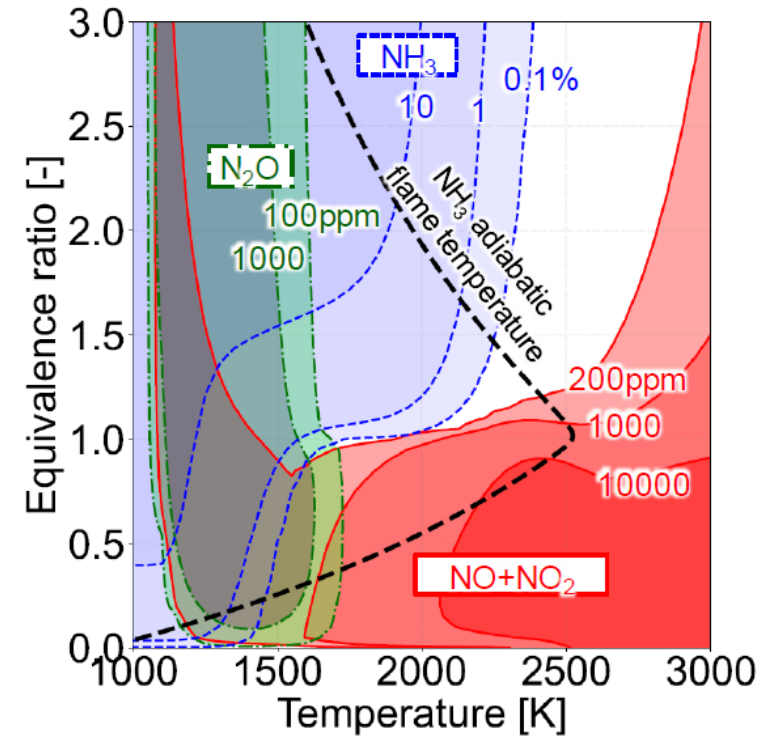
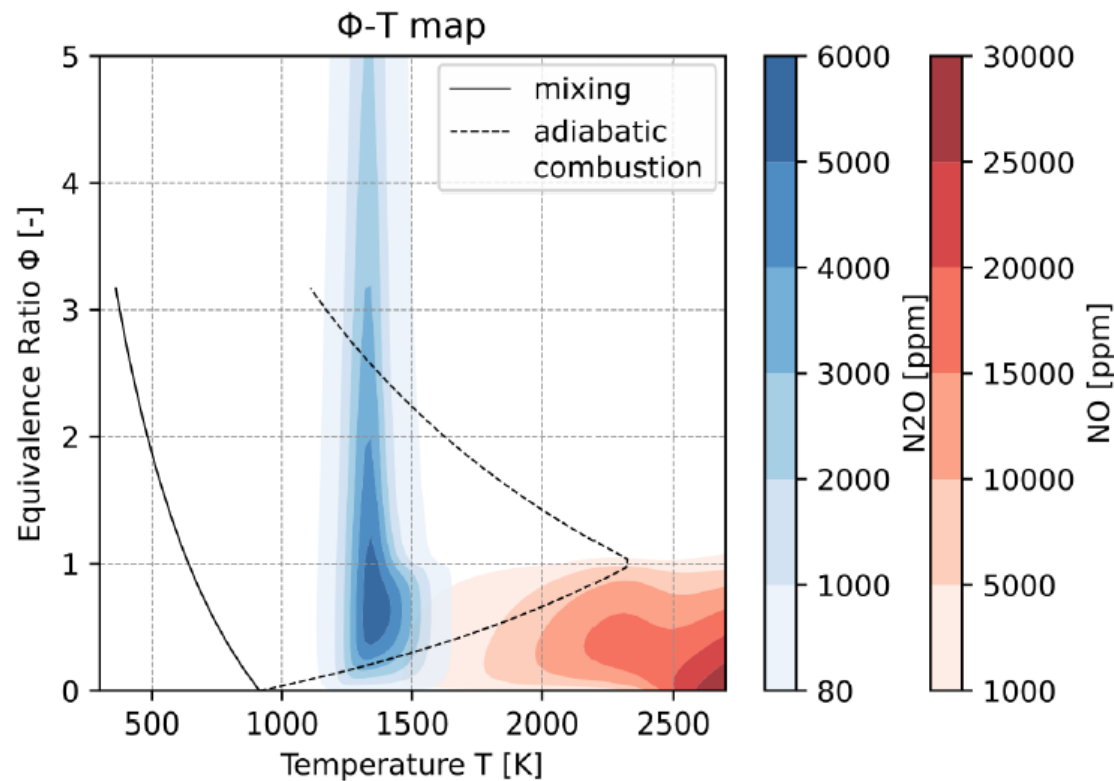
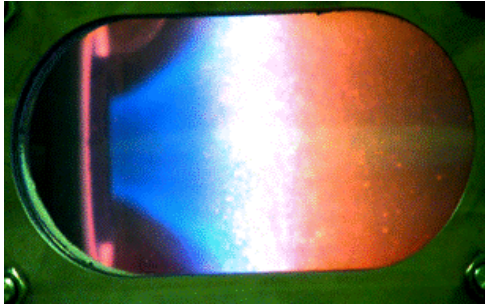
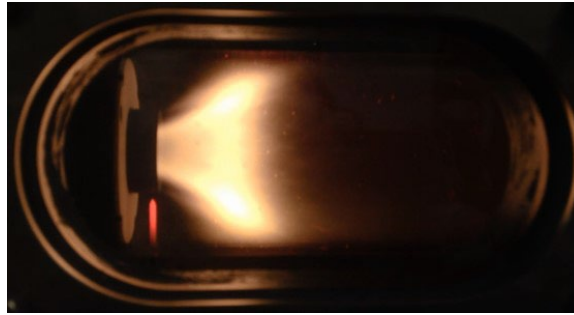


Figure 5 NO+NO₂, unburned NH₃, N₂O emission characteristic of NH₃/air mixture with NH₃/air adiabatic temperature at each equivalence ratio, pressure of 6.0MPa and initial temperature of 900K.

Exemple de développement de 'swirler' NH_3/H_2 or CH_4

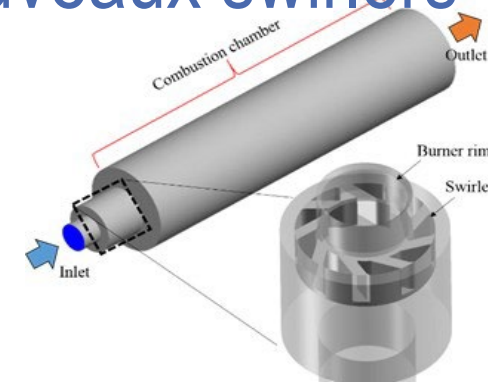


66%_{vol} NH_3 33%_{vol} CH_4

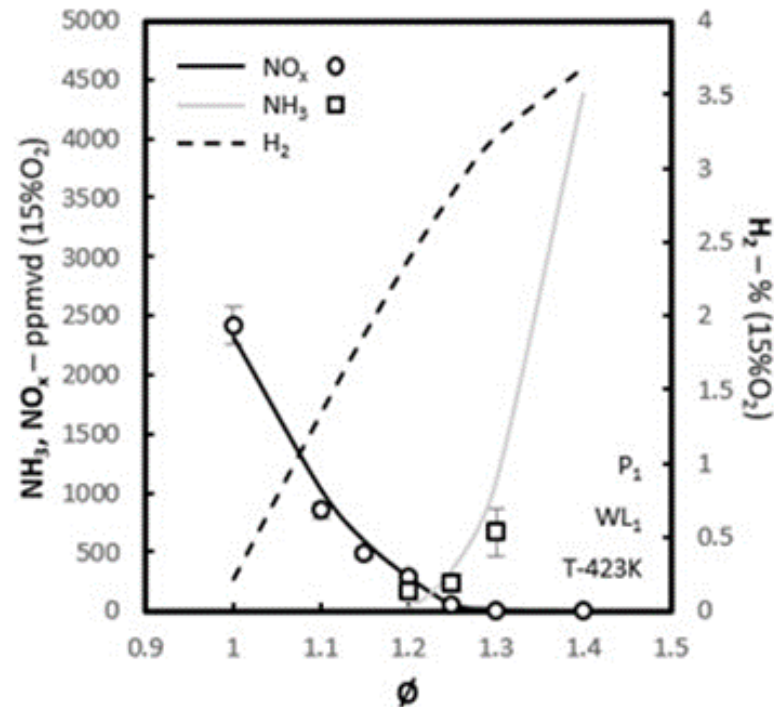


70%_{vol} NH_3 30%_{vol} H_2

Nouveaux swirlers



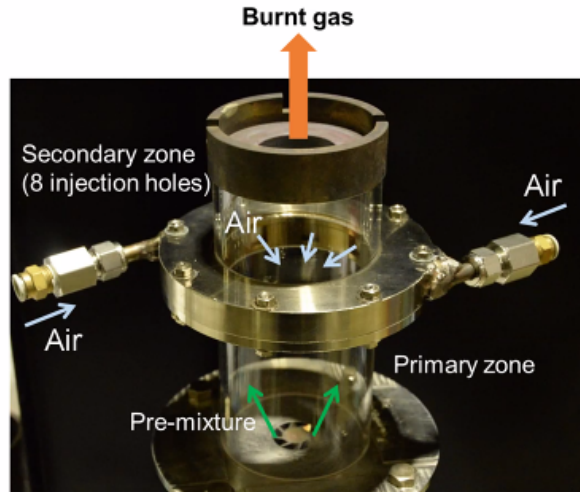
Mashruk et al., Applied Energy, 2022



- clear reduction of NO_x at high E.R
- but higher unburnt fuel (NH₃ and H₂)

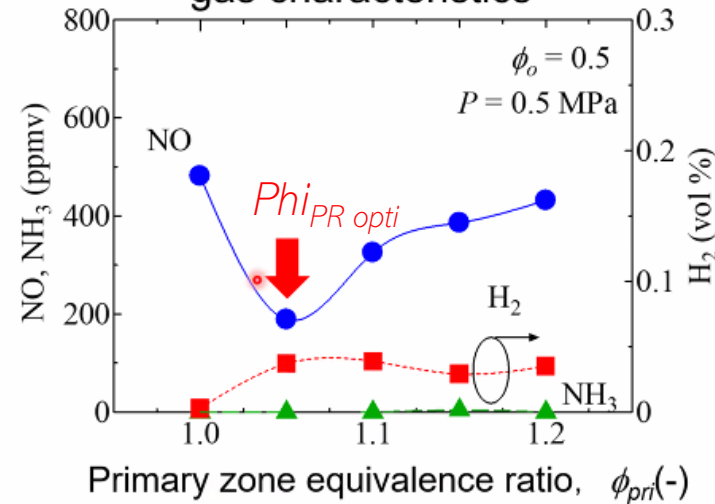
2016

Brûleur à 2 étages

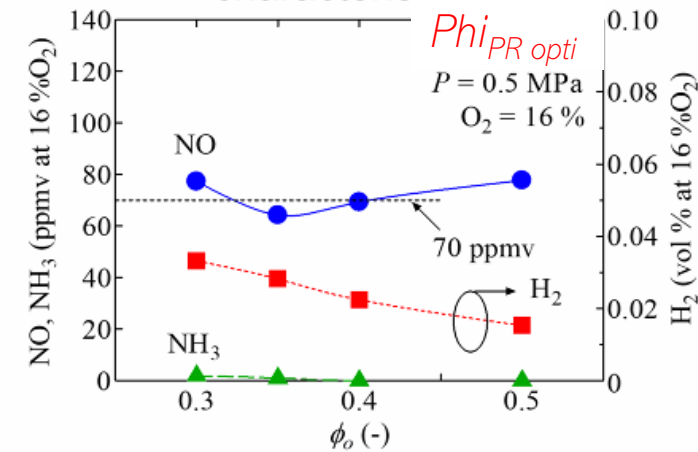


Model combustor

Effects of primary zone equivalence ratio on product gas characteristics



Effect of overall equivalence ratio on product gas characteristics

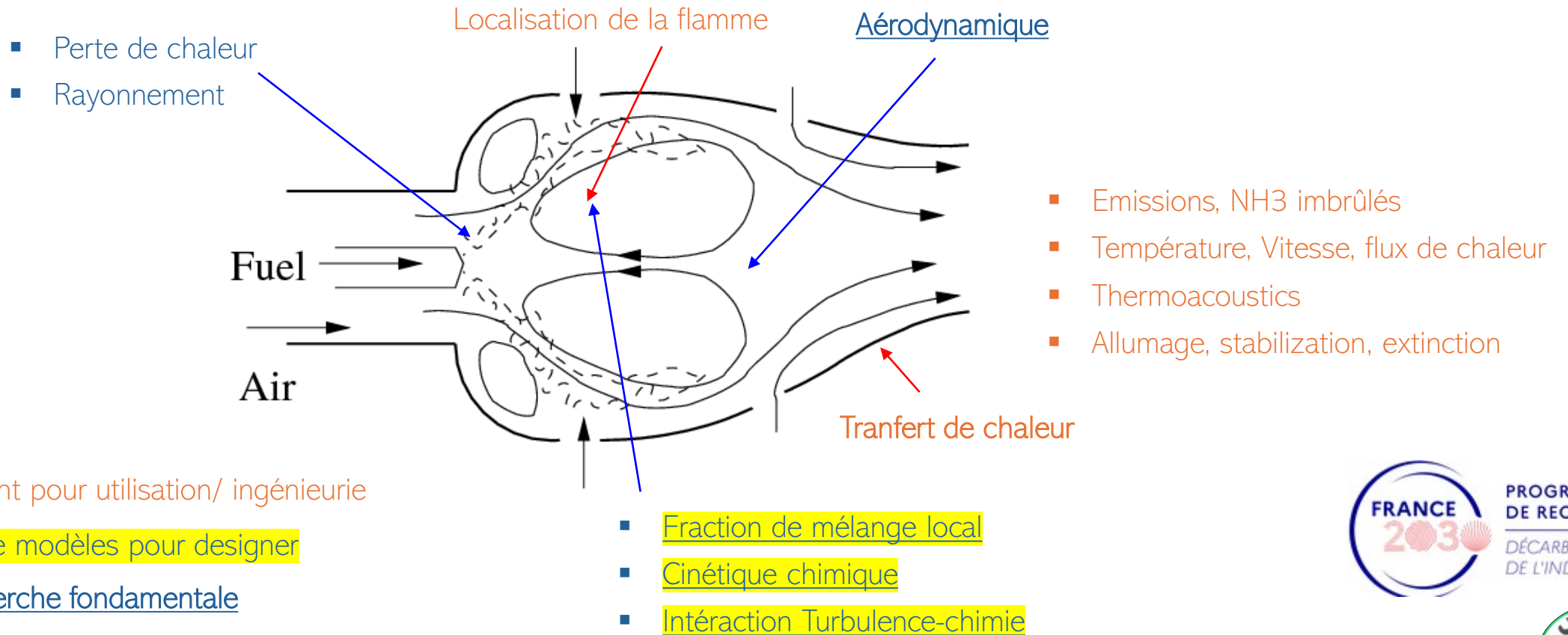


- Contrôle de la zone primaire
- Réduction simultanée de NO, NH₃

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Comment shifter de combustible

- Comment concevoir un brûleur flexible, optimisé
- Flamme de prémélange, de diffusion, partiellement prémélangée



Rouge: important pour utilisation/ ingénierie

Bleu : besoin de modèles pour designer

Souligné : recherche fondamentale

Ammoniac comme carburant/combustible : les Challenges

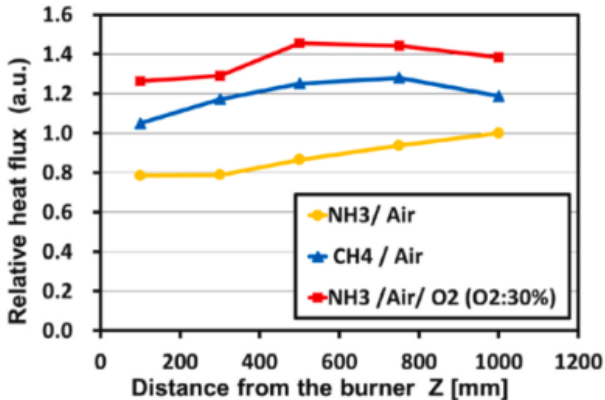
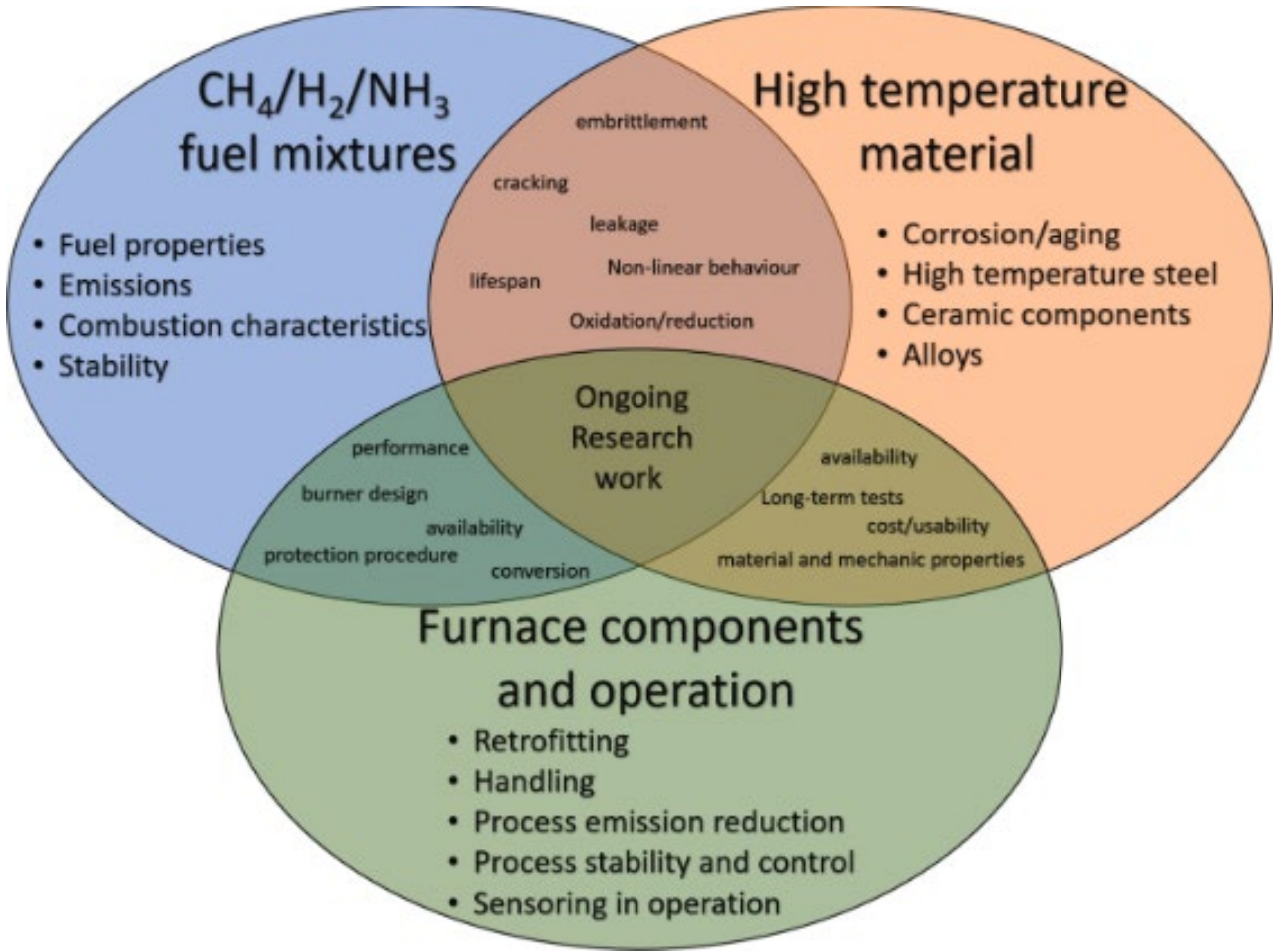


Fig. 23. Radiative heat flux distribution in an experimental furnace fired with a non-premixed flame (10kW), from [261]

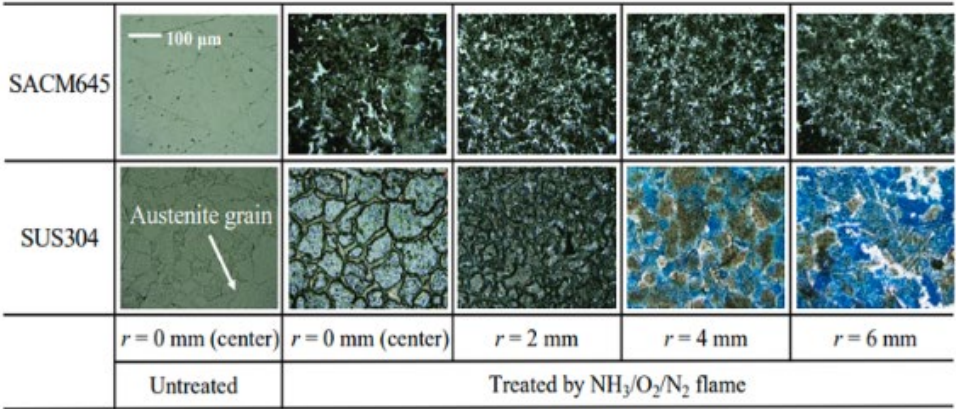


Fig. 5. Optical micrographs of the SACM645 and SUS304 test plate surfaces after being exposed to the NH₃/O₂/N₂ flame at 550 °C for 5h [8]

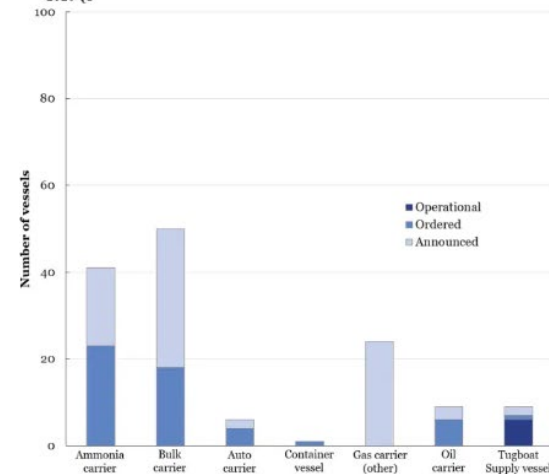
Conclusion : aujourd'hui (AEA)

- 2024 : 45 Mt NH₃ (22% de la production) = transporté
- Avril 2026 : 31 installations pour craquer du NH₃ suite à l'importation de H₂
- Ammoniac combustible
 - Pour la production d'énergie :
 - 2023 : 53 Projets en développement
 - Central thermique en 'Co-firing', haut TRL 2024
 - TaG à l'ammoniac 100% : des brûleurs proches du 'commercial'
 - Mais comment passer du Gas Nat au NH₃ : système flexible en carburant ?
- Pour la production de chaleur HT
 - 'Démonstrateur' : ciment, céramique, rouleau d'al
- Pour le transport : maritime (3 bateaux tests)

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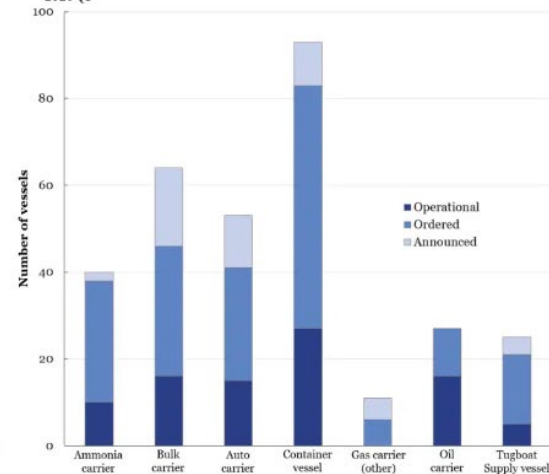
Ammonia-fueled vessels

By vessel type and status
2026 Q1



Ammonia-ready vessels

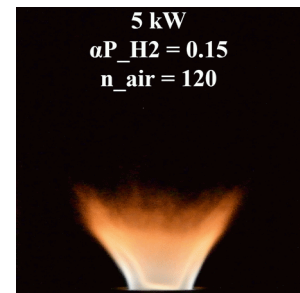
By vessel type and status
2026 Q1



Conclusion

- L'économie de l'Ammoniac et celle de l'Hydrogène = même combat !
- L'Ammoniac peut être utilisé pour décarboner tous les secteurs !
- L'Ammoniac seul ou partiellement craqué sera possible pour certaines applications
- Les émissions, la toxicité, sont des points qui méritent plus de recherche
- Mais l'acceptabilité par la société, les politiques et les citoyens est nécessaire :
 - Comment changer la perception du public ?

🧊 C'est un sujet fascinant !



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PROGRAMME
DE RECHERCHE
DÉCARBONATION
DE L'INDUSTRIE

