



**RÉPUBLIQUE
FRANÇAISE**

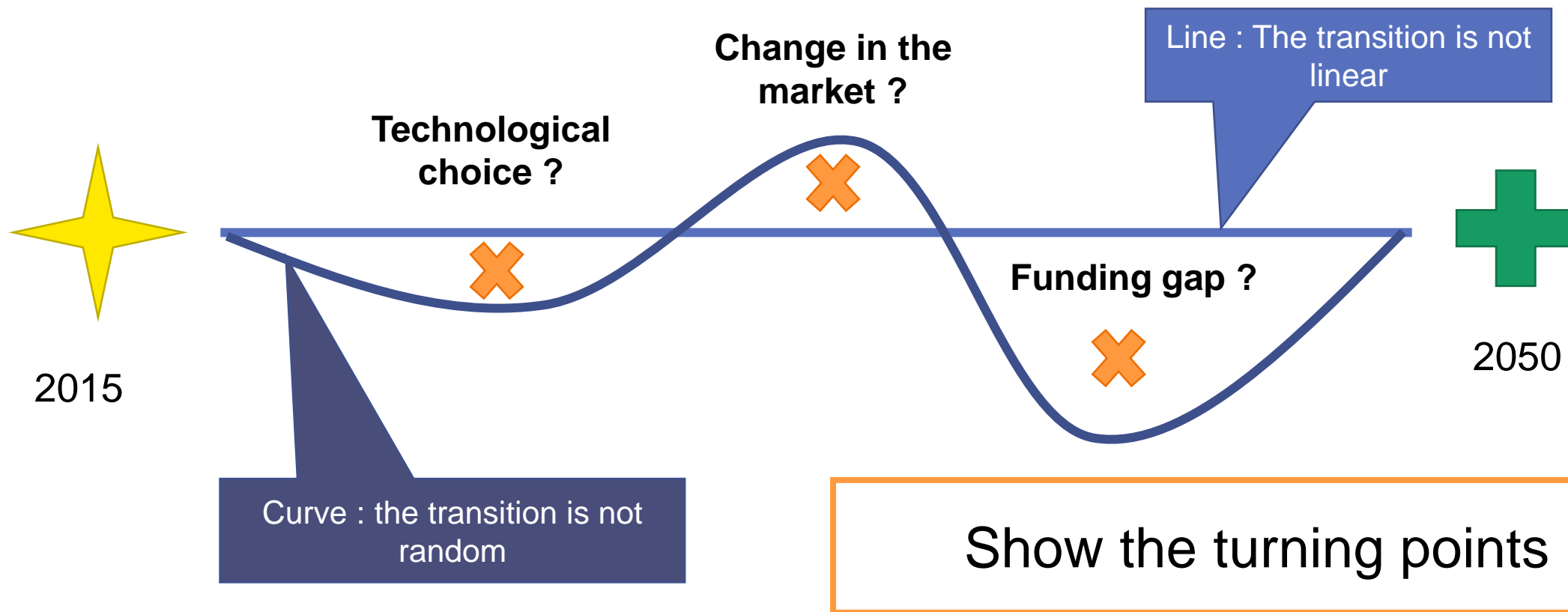
*Liberté
Égalité
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Transitions pathways for ammonia deep decarbonization: a case study of France



What is the purpose of an industrial net-zero pathway ?



What are the limits of industrial net-zero pathways ?

iea

**Ammonia Technology
Roadmap**
Towards more sustainable nitrogen
fertiliser production



International
Energy Agency



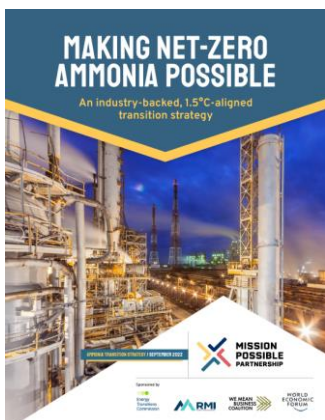
IRENA
International Renewable Energy Agency

INNOVATION
OUTLOOK
RENEWABLE
AMMONIA

in partnership with
AMMONIA ENERGY
ASSOCIATION

Compared to global and European net-zero pathways, France has :

- Not the same ammonia market
- Not the same industries
- Not the same energy resources and prices



**MAKING NET-ZERO
AMMONIA POSSIBLE**

An industry-backed, 1.5°C-aligned
transition strategy

MISSION
POSSIBLE
PARTNERSHIP



DEHEMA
Division of Energy Markets
and Technology

Perspective Europe 2030
Technology options for CO₂- emission
reduction of hydrogen feedstock
in ammonia production

Not adapted to the French situation

➤ Transcription needed

ADEME's pathways

Systemic

Transition Sectorial Plans

**TRANSITION(S)
2050**
DECIDE NOW
ACT 4 CLIMATE

<https://librairie.ademe.fr/recherche-et-innovation/5258-prospective-transitions-2050-synthesis.html>



S1 FRUGAL GENERATION



S2 REGIONAL COOPERATION



S3 GREEN TECHNOLOGIES



S4 RESTORATION GAMBLE

- Market efficiency/recycling
- Energy efficiency
- Energy mix
- CCS/CCU



Techno



Cost

- Abatement cost of technologies
- Cost structure (OPEX/CAPEX)
- Financing

Several scenarios

Market

- Demand evolution
- Employment/skills
- Risk analysis
- Business models



Public and private action plan

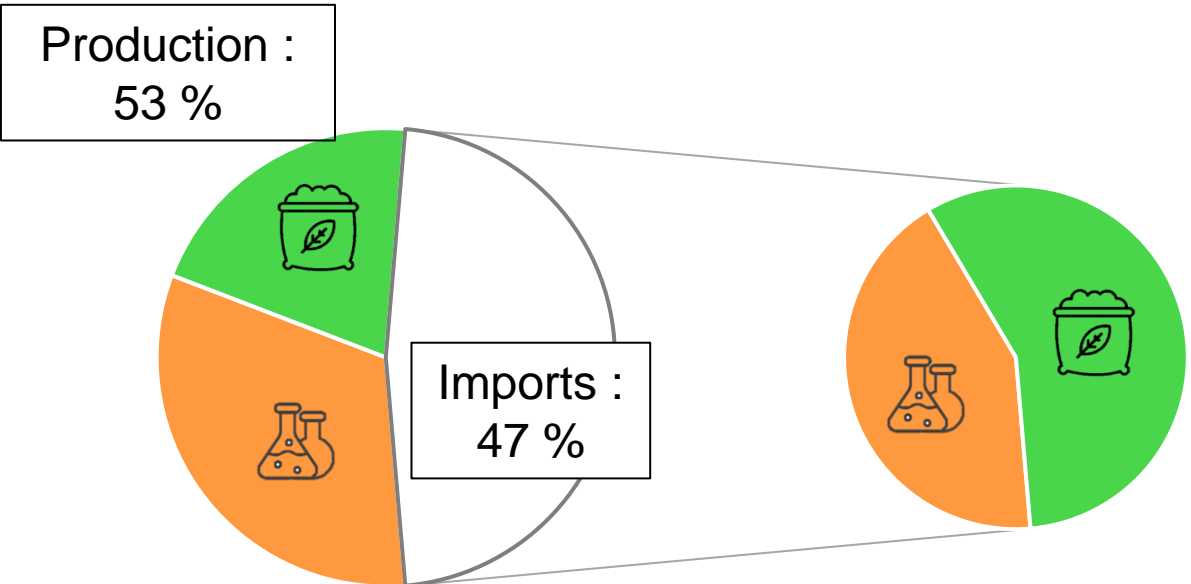
- Tax incentives, subsidies,...
- European policies
- Private funding

Ammonia French market

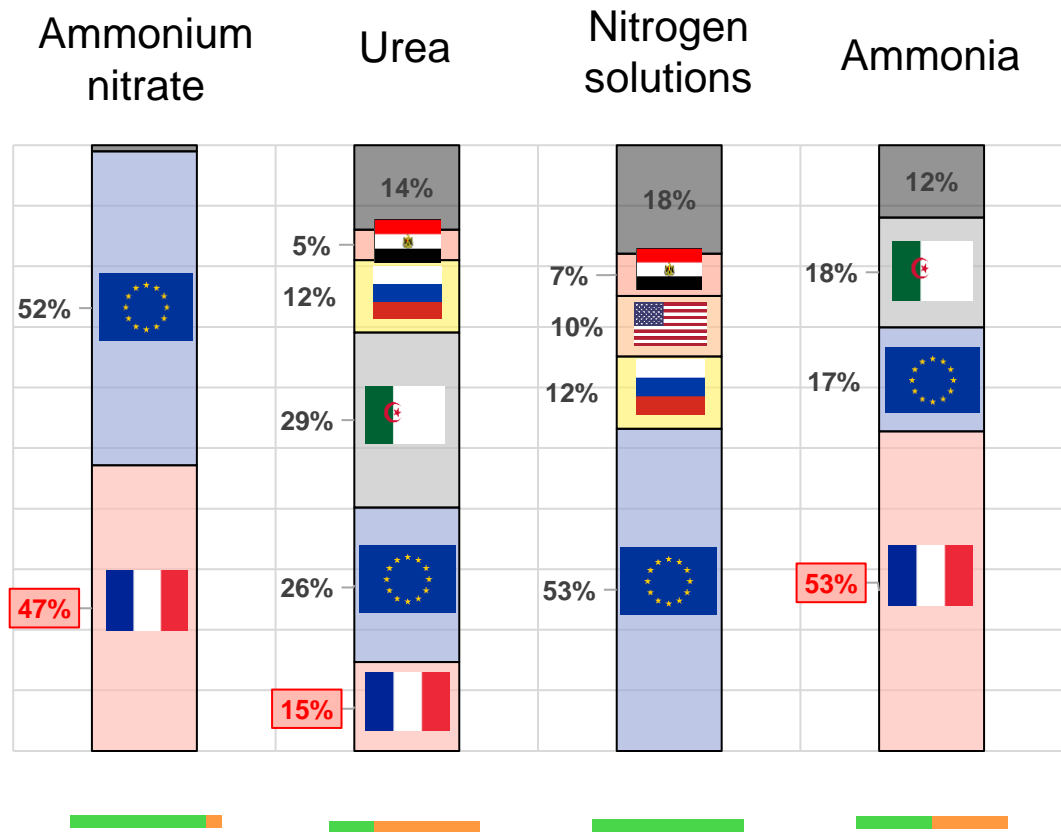
Large share of imports

Origin of nitrogen products consumed in France (2015)

Ammonia consumption in France (2015) : 1,7 Mt



Large share for chemistry



Specific fertilizer mix

Ammonia French industry

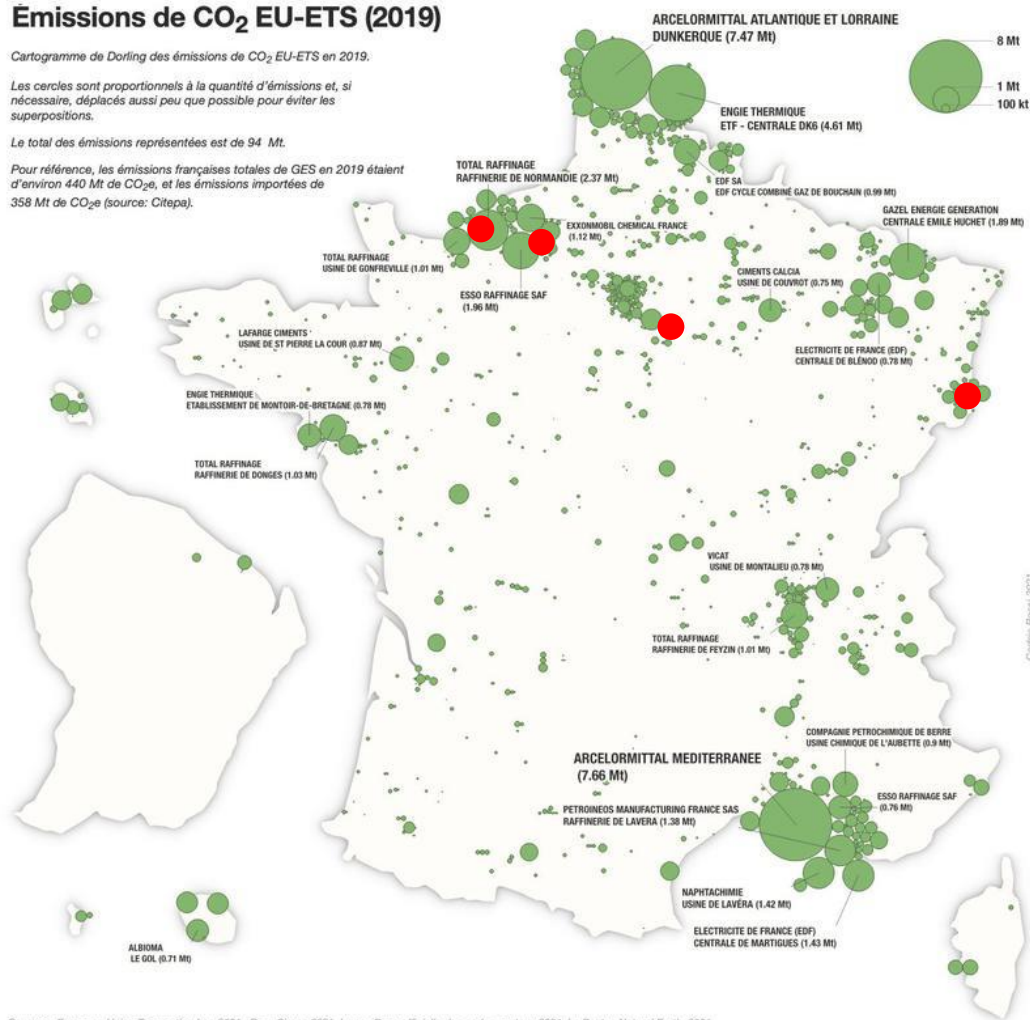
Emissions de CO₂ EU-ETS (2019)

Cartogramme de Dorling des émissions de CO₂ EU-ETS en 2019.

Les cercles sont proportionnels à la quantité d'émissions et, si nécessaire, déplacés aussi peu que possible pour éviter les superpositions.

Le total des émissions représentées est de 94 Mt.

Pour référence, les émissions françaises totales de GES en 2019 étaient d'environ 440 Mt de CO₂e, et les émissions importées de 358 Mt de CO₂e (source: Citepa).



Sources : European Union Transaction Log 2021 ; Base Sirena 2021, Insee ; Base officielle des codes postaux 2021, La Poste ; Natural Earth, 2021

Small and medium sites

4 Sites

1,5 Mt Capacity

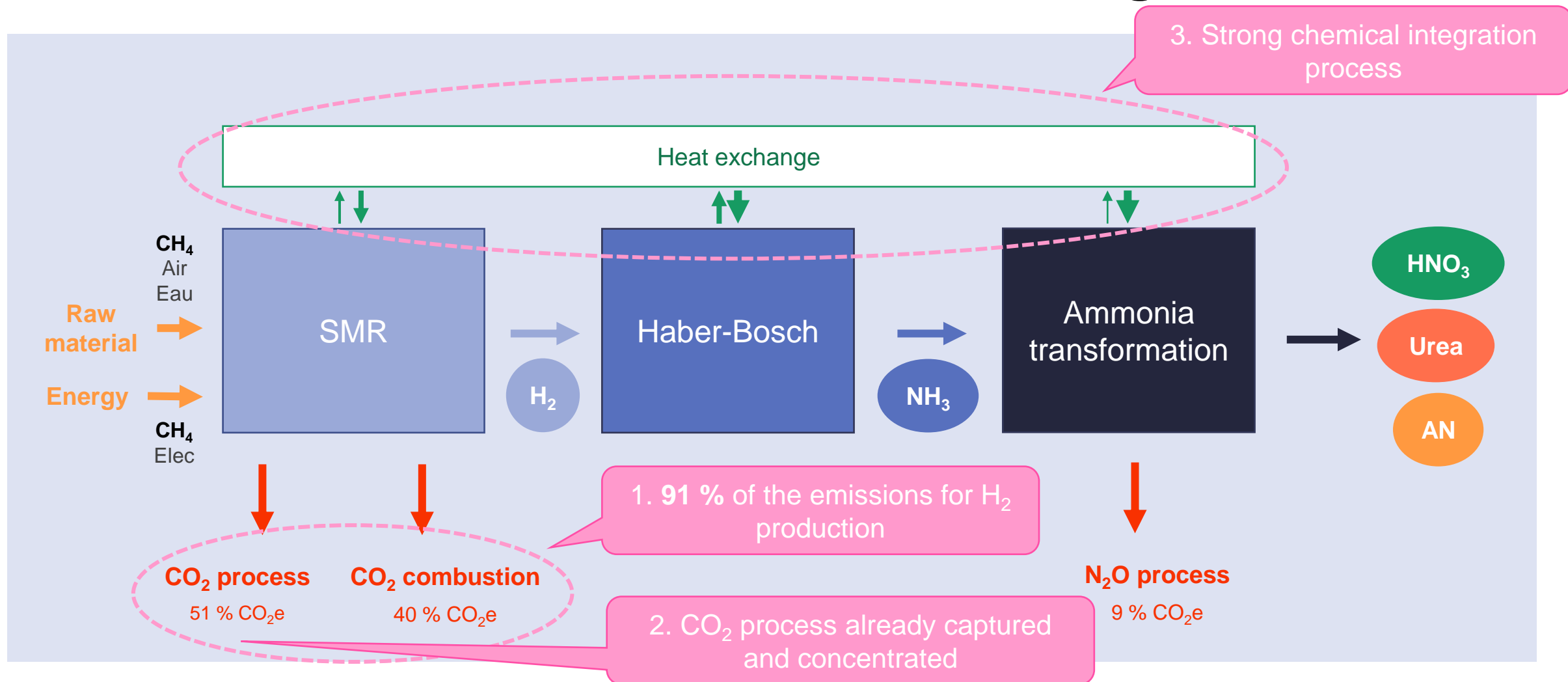
11 MWh/tNH₃
120 % BAT

Energy efficiency required

2,0 tCO₂e/tNH₃
EU-ETS benchmark 2015 : 1,62

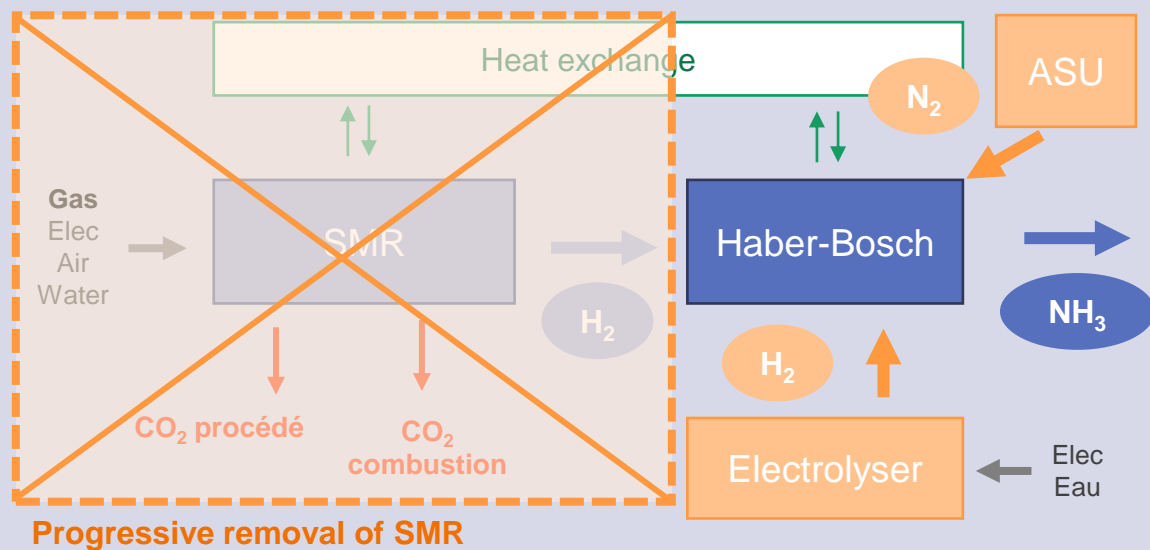
3 %
industrial emissions

SMR : 3 decarbonization challenges



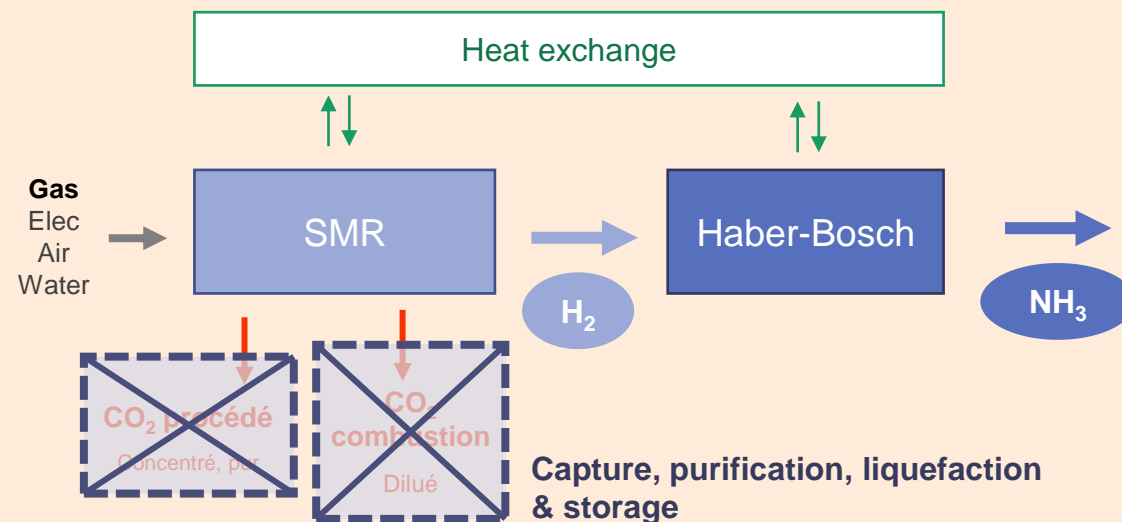
H₂ & CCS : 2 deep decarbonization levers...

H₂ : a new process is mandatory



- Progressive activation (< 15 %) with energy penalties ...
- ...then new process mandatory : retrofit
- 90 % of emissions avoided

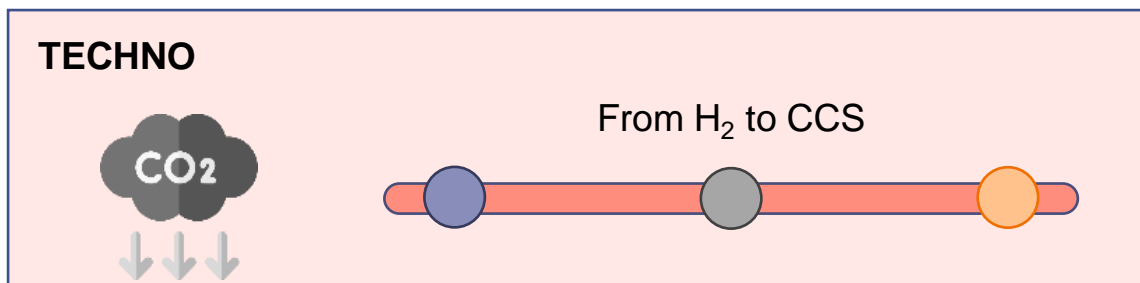
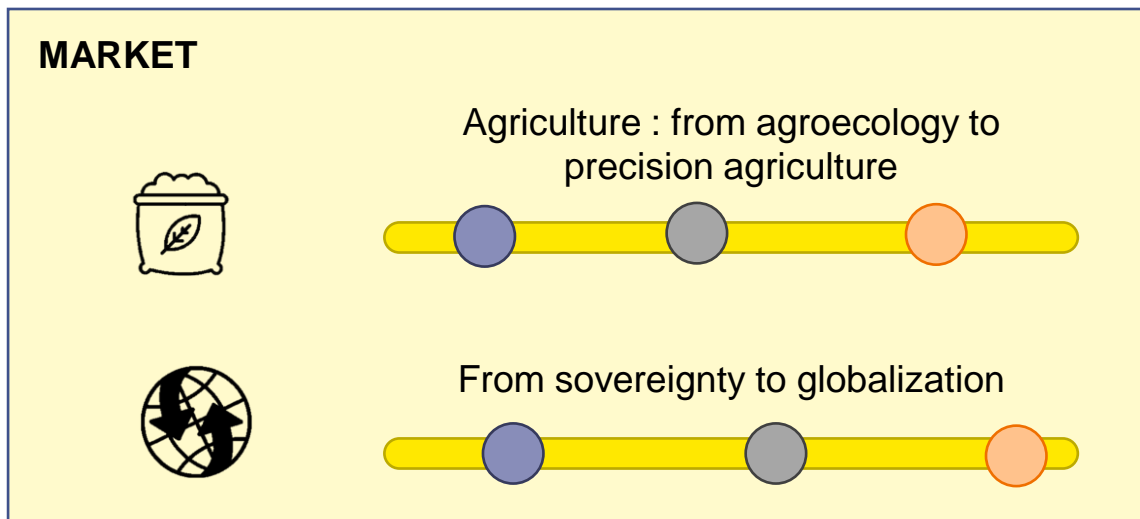
CCS : 2 CO₂ sources to consider



- Identical process + new capture equipment
- 90 % of emissions captured
- Need of CO₂ infrastructures : likely not everywhere

3 pathways for ammonia industry decarbonization

Context transition



Pathways

“Resilience and renewable ammonia”

Based on organic agriculture, strong EU, autonomy, electrification, H₂ infrastructures development

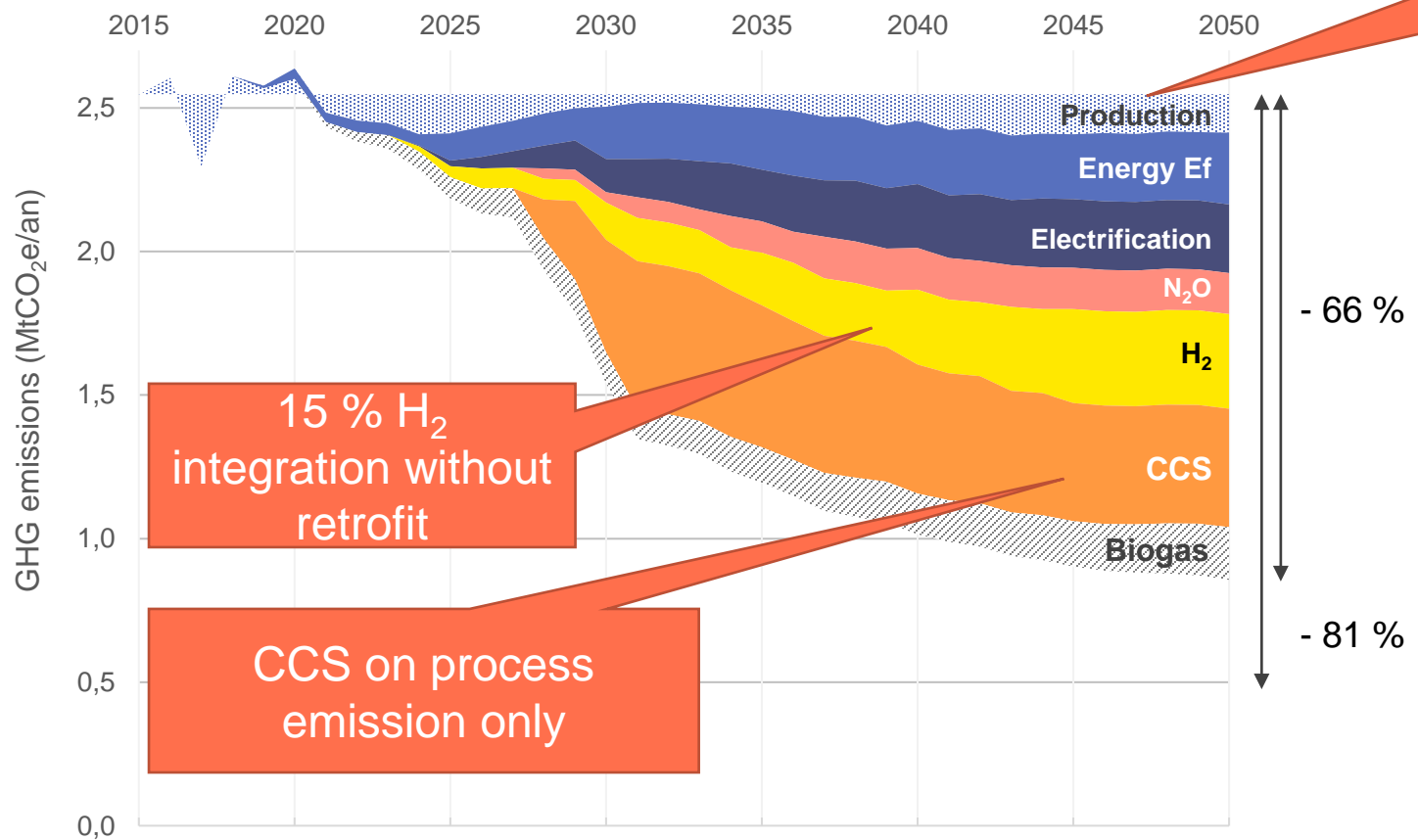
“Reference”

Based on trends for agriculture, international exchanges, industrial decarbonization announcements, stated policies, extrapolation

“Low-carbon ammonia and globalization”

Based on specialized agriculture, intensive exchanges, lack of competitiveness, CCS development

Reference : emissions lock-in



Small decrease in fertilizer consumption

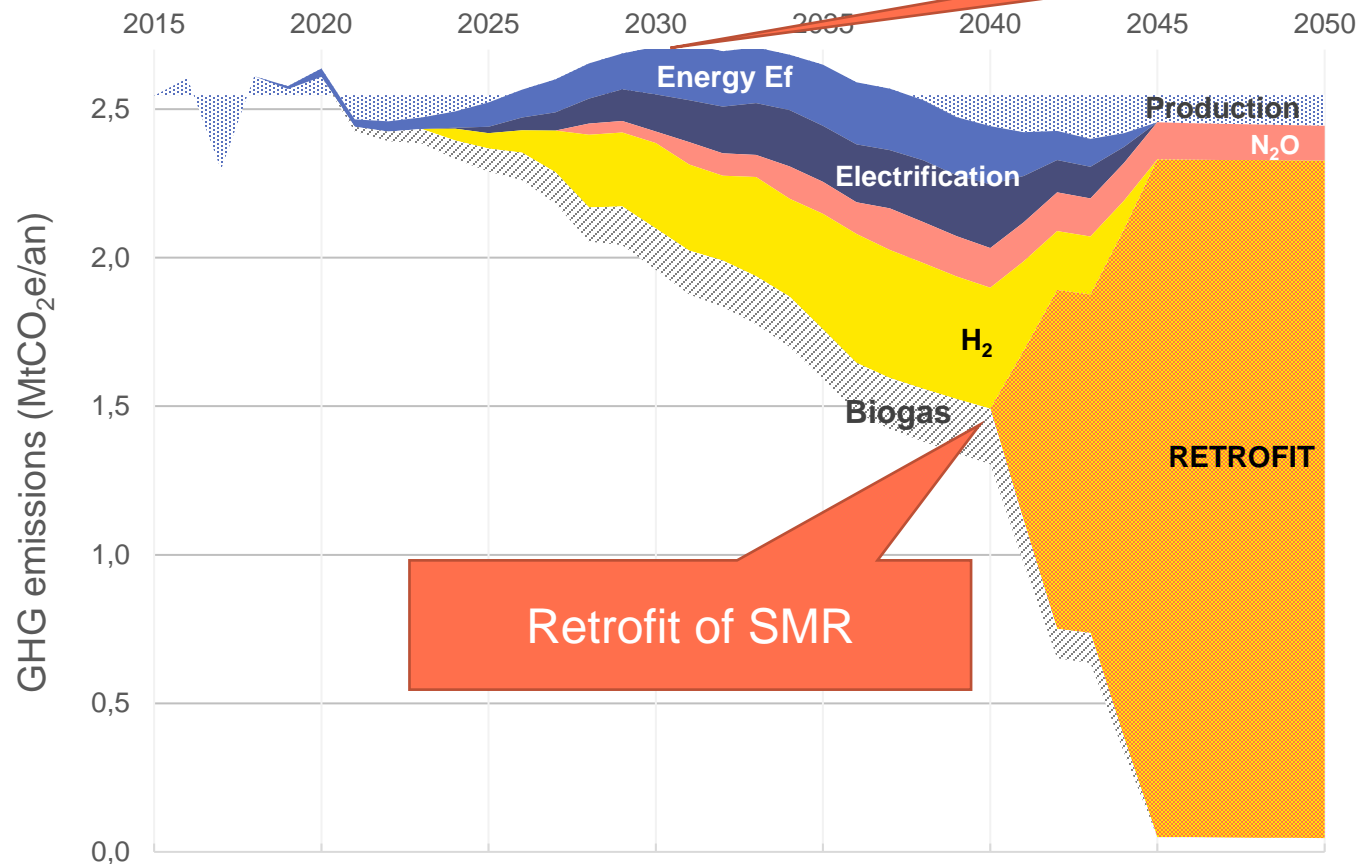
- 66 %
GHG emissions reduction vs 2015

Insufficient decarbonization:

- Stated policies are not sufficient
- Industrial decarbonization plan are not ambitious enough
- Need of infrastructures
- Lock-in of emissions after 2035

Resilience and renewable ammonia: a complete decarbonization!

Decrease of imports



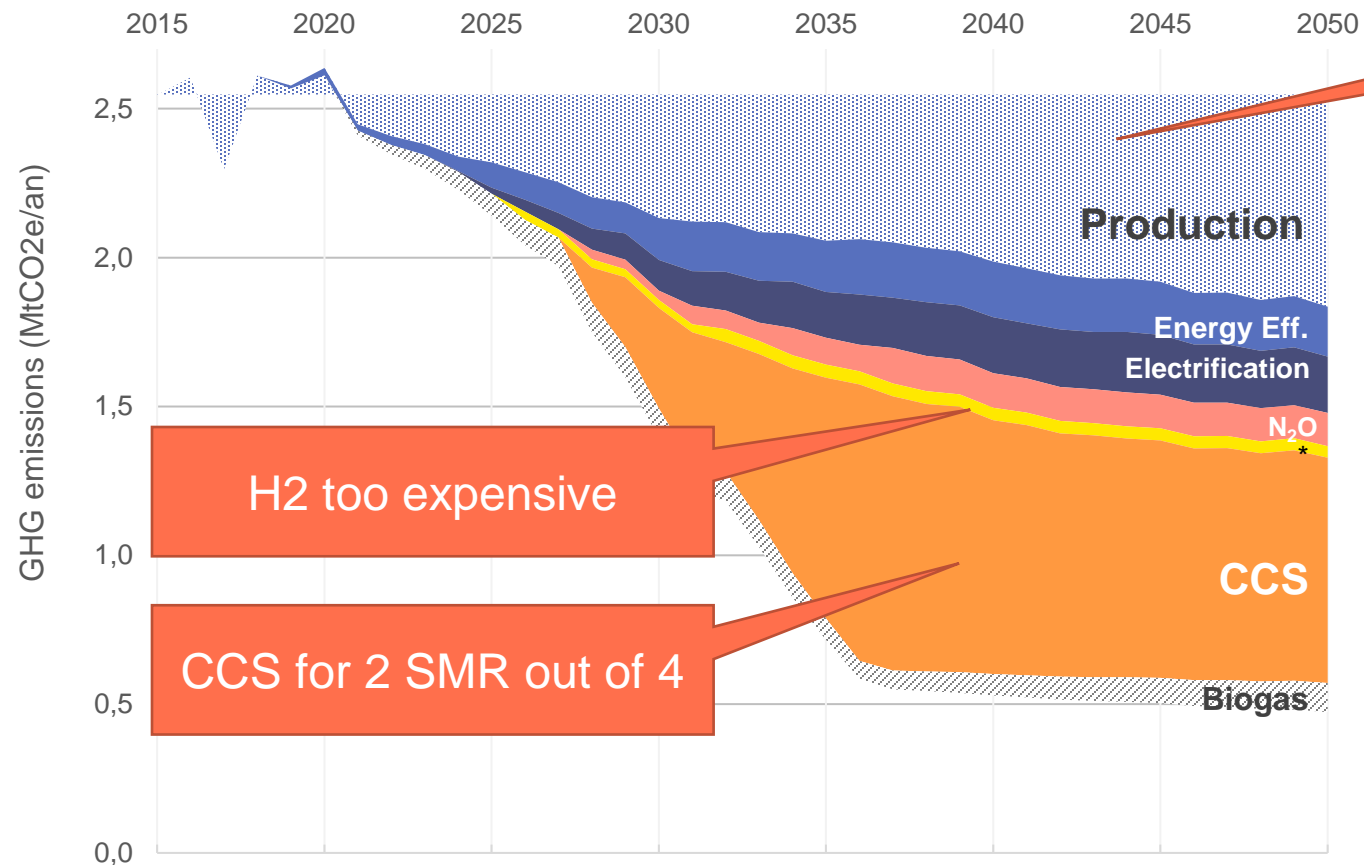
- 98 %

GHG emissions reduction vs 2015

Complete decarbonization:

- Low decrease before 2040
- Retrofit mandatory after 2040
- National H₂ strategy required (infrastructures, electrification...)
- No CCS to avoid lock-in

Low-carbon ammonia and globalization: a risk for the french industry



Increase ammonia and fertilizers imports

- 81 %
GHG emissions reduction vs 2015

- Without cheap green electricity, CCS is the only deep decarbonization lever
- High risk of offshoring

H2 too expensive

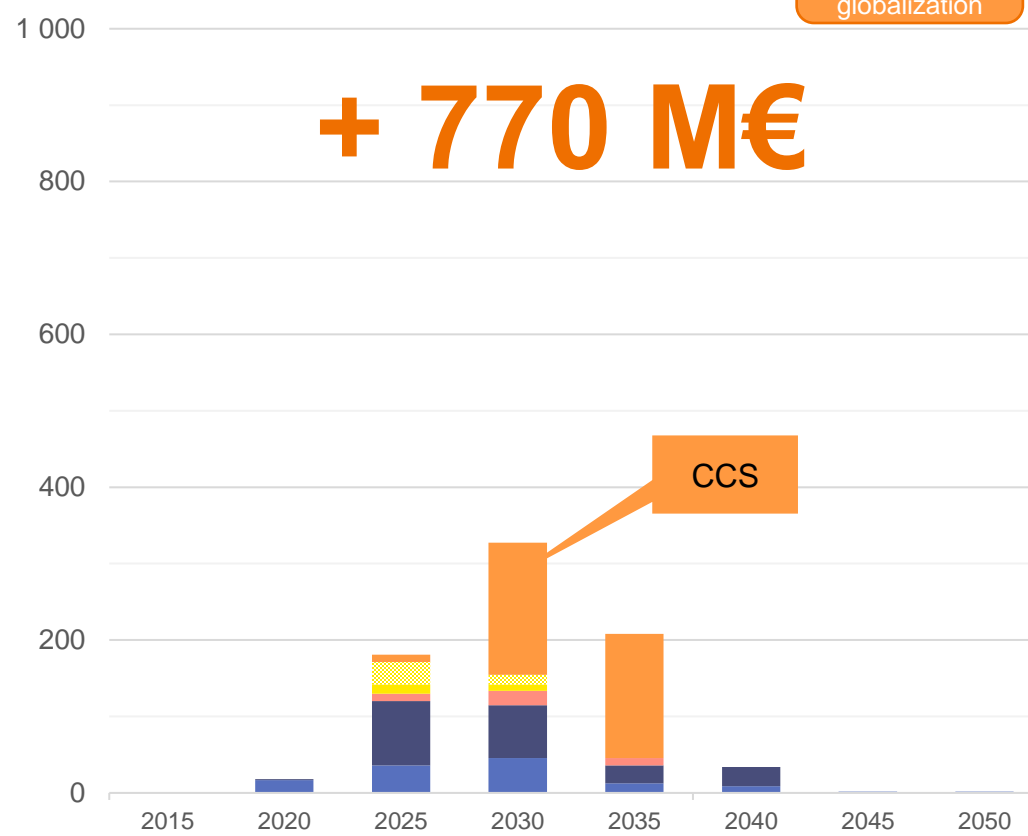
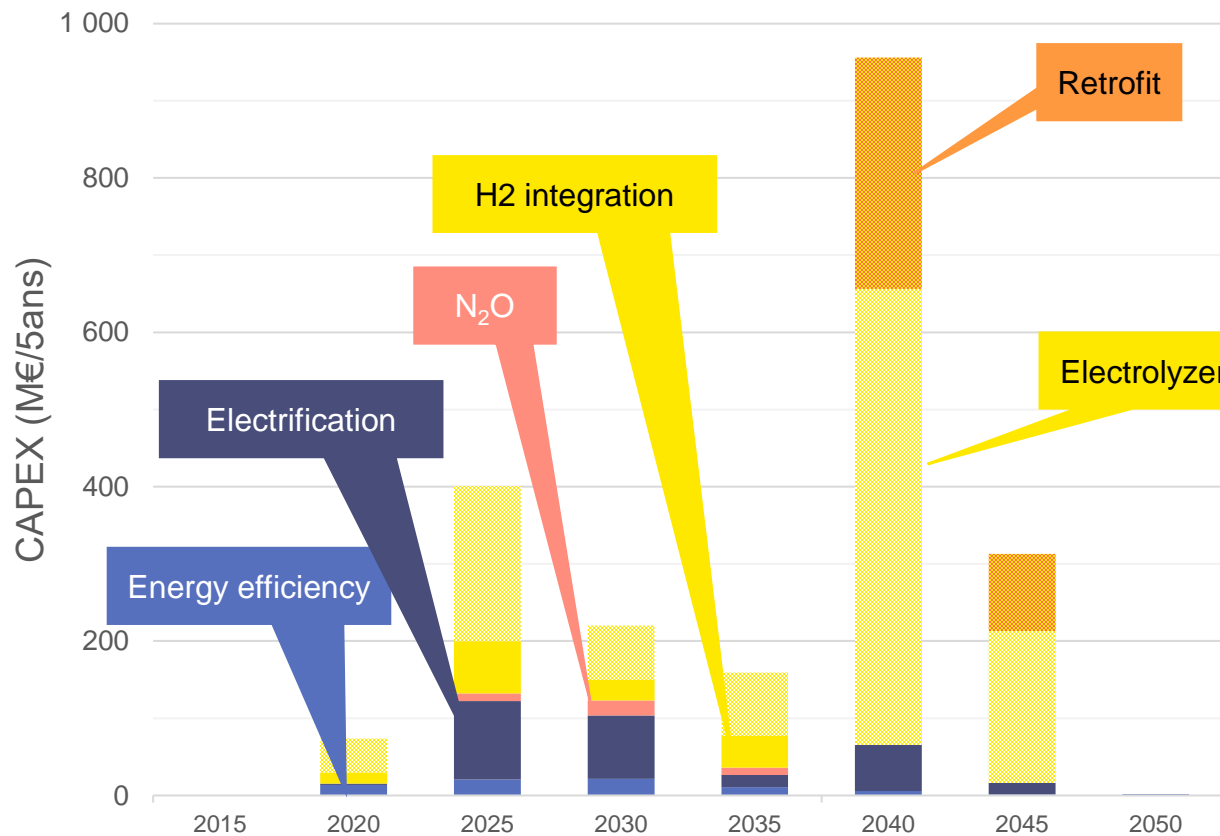
CCS for 2 SMR out of 4

Investments comparison

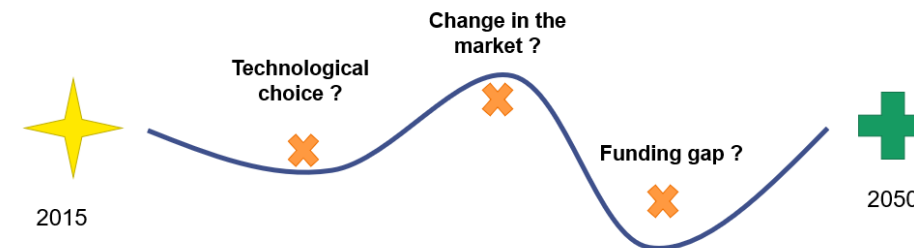
Resilience and
renewable
ammonia

+ 2 100 M€

Low-carbon
ammonia and
globalization

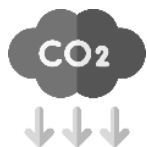


Summary for decision makers



The decrease in fertilizer consumption can be offset by the reinforcement of the value chain:

- Agriculture: choose AN (more efficient) rather than nitrogen solutions, green certification label
- New renewable ammonia markets: maritime transport, H₂ storage and transport



Need of H₂ and/or CCS strategies:

- 2 sites require H₂ integration then retrofit
- 2 sites have the choice between CCS and H₂, but have to choose today to avoid lock-in emissions after 2035



A mandatory public support to help start the transition

- Infrastructures and electrification required
- H₂ is very expensive and need to be supported (CfD, PIIEC, gas taxes, ...)



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