Transitions pathways for ammonia deep decarbonization: a case study of France
What is the purpose of an industrial net-zero pathway?

- Technological choice?
- Change in the market?
- Funding gap?
- Line: The transition is not linear

2015

2050

Show the turning points!
What are the limits of industrial net-zero pathways?

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

Not adapted to the French situation

➢ Transcription needed
ADEME’s pathways

ADEME’s pathways

Systemic

Transition Sectorial Plans


TRAN SITION(S) 2050
DECIDE NOW
ACT 4 CLIMATE

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

Techno

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

Cost

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

Market

Several scenarios

Public and private action plan

FRUGAL GENERATION

S1

REGIONAL COOPERATION

S2

GREEN TECHNOLOGIES

S3

RESTORATION GAMBLE

S4

European policies

• Private funding
Origin of nitrogen products consumed in France (2015)

Ammonia French market

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

Production : 53 %
Imports : 47 %

Large share of imports

Large share for chemistry

Specific fertilizer mix

Ammonium nitrate
Urea
Nitrogen solutions
Ammonia

ADEME – DETI / Service Industrie
Ammonia French industry

4 Sites

1,5 Mt Capacity

11 MWh/tNH₃
120 % BAT

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

3 % industrial emissions

Small and medium sites
Energy efficiency required
SMR: 3 decarbonization challenges

1. 91% of the emissions for H₂ production
2. CO₂ process already captured and concentrated
3. Strong chemical integration process

- CO₂ process: 51% CO₂e
- CO₂ combustion: 40% CO₂e
- N₂O process: 9% CO₂e
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

MARKET

Agriculture: from agroecology to precision agriculture

From sovereignty to globalization

TECHNO

From H₂ to CCS

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**

- **15 % H₂ integration without retrofit**

- **CCS on process emission only**

**GHG emissions reduction vs 2015**

- 66 %

**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!

- 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

- 81%
GHG emissions reduction vs 2015

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

Increase ammonia and fertilizers imports

H2 too expensive
CCS for 2 SMR out of 4
Investments comparison

+ 2 100 M€

Resilience and renewable ammonia

+ 770 M€

Low-carbon ammonia and globalization

CAPEX (M€/5ans)

H2 integration

N₂O

Electrification

Energy efficiency

Electrolyzers

Retrofit

Electrolyzers

CCS
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 chose 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, …)