

Opportunities and risks of ammonia as energy carrier in decarbonization strategies (TFRN Inf. Doc to WGSR-63)

Rasmus Einarsson

11th Annual TFTEI Meeting

2025-10-08

rasmus.einarsson@slu.se

Opportunities and risks of ammonia as energy carrier in decarbonization strategies

Note submitted by the co-chairs of the Task Force on Reactive Nitrogen¹

Summary

This note provides information to the Working Group on Strategies and Review of the UN-ECE Convention on Long-range Transboundary Air Pollution about potential implications of introducing ammonia (NH₃) as an energy carrier as part of decarbonization strategies, including possible emissions of ammonia, nitrous oxide (N₂O) and nitrogen oxides (NO_x), implications for transboundary air pollution and possible interactions with international nitrogen (N) market prices.

Ammonia holds potential as a carbon-free energy carrier, especially in applications where electrification is not feasible. If produced using renewable energy and used scrupulously, ammonia could contribute substantially to mitigation of global greenhouse gas (GHG) emissions. However, there are several substantial risks that need to be addressed. Crucially, there is a risk of high life-cycle GHG if ammonia is produced from fossil sources and/or if nitrous oxide is released in the use phase. In addition, other emissions of reactive nitrogen in the form of ammonia and nitrogen oxides can lead to large negative effects on air quality, ecosystems and human health. A coordinated policy response is urgently needed to create incentives and regulation ensuring beneficial outcomes for climate, ecosystems, and human health.

Introduction

1. Ammonia (NH₃) is attracting substantial attention in research and industry as a potential energy carrier in strategies to mitigate greenhouse gas (GHG) emissions. International bodies such as the International Energy Agency (IEA) are highlighting ammonia as a fuel alternative, particularly for

Special thanks to

Fredric Bauer, Lucy Gilliam, Kentaro Hayashi, Kayuza Nishina, Tanner Tuttle, Mark Sutton

<https://unece.org/environment/documents/2025/05/informal-documents/agenda-item-2-ammonia-energy-carrier>

Ammonia (NH₃) as energy carrier

Summary of informal document submitted by TFRN to WGSR-63

- **NH₃ is a carbon-free energy carrier.**
Considerable industry interest for use as liquid fuel in shipping, stationary combustion, etc.
- Large-scale adoption **could increase global NH₃ use by factor 10.**
- **Risk: increased nitrogen air pollution**
 - Emissions of NH₃, nitrogen oxides (NO_x), nitrous oxide (N₂O)
- **Risk: low or negative climate benefit**
 - Use-phase emissions of N₂O
 - Current NH₃ production is entirely dependent on fossil energy
- **Policy response urgently needed** to ensure life-cycle net benefit

Ammonia (NH_3) as energy carrier

Substantial risk of low or negative climate benefit:

- **N_2O emissions in use phase** can counteract benefit compared to fossil fuel.
- **NH_3 currently produced using fossil energy** has no climate benefit.
- **Blue NH_3 = fossil-based with carbon capture and storage (CCS)**
 - (1) is not yet available at scale and
 - (2) has upstream emissions from fossil gas infrastructure.
- **Green NH_3 = produced from renewable energy**, an option in principle but
 - (1) is not yet available at scale and
 - (2) would compete with other uses for renewable energy.

Ammonia (NH₃) as energy carrier

Substantial risks of increased nitrogen air pollution:

- Multiple air pollutants with effects on biodiversity and health:
 - fuel-sourced NO_x emissions
 - NH₃ slip = unburnt NH₃ from engines
 - N₂O emissions from engines
- There are inherent trade-offs between these pollutants.
- Severe lack of data and monitoring of real-world emissions:
 - lab and simulation emissions are not representative
 - part-load characteristics of ship engines are poorly documented

What's next?

The issue is on the draft 2026-2027 Workplan

- Nothing really promised
- But a possibility to work on it and report to WGSR
- “Subject to availability of resources”

<i>Workplan item</i>	<i>Activity description/objective</i>	<i>Expected outcome/deliverable</i>	<i>Lead body(ies)</i>	<i>Resource requirements and/or funding source</i>
2.2.7	Examine risks of use of ammonia as a fuel	Policy brief or information note presented to WGSR	TFRN, TFTEI, TFIAM	Subject to availability of resources