



Reducing GHG Emissions with NH₃

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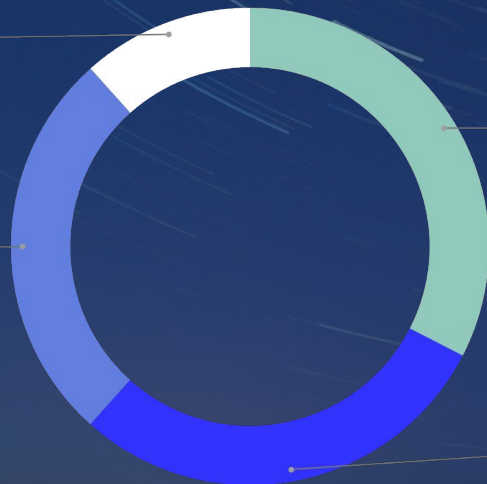
GHG Emissions by Sector.



Agriculture
11.6%



Industry
26.7%



Transportation
32.6%



Electricity &
29.1%

Transportation of People & Goods (28%)

- Shipping
- Aviation
- Trains, Trucks, and Mobility

Electricity & Power (25%)

- Grid, Grid Balancing, & Off-Grid/Microgrid
- Co-firing

Industry (23%)

- Steel / Smelting
- Specialty Chemicals

Agriculture (10%)

- Fertilizer
- Potable Water

Why NH₃?



Production

- Inputs are renewables, seawater, and nitrogen
- Known & New Technology
- No competition with agriculture on arable land
- Useful by-products: potable water and oxygen

Storage

- Boiling point is -33 Celsius or can be stored at ambient temperatures with 10 bar pressure
- Not highly flammable
- Moved by ships, trucks, trains, and pipelines and currently handled in over 400 ports

Emissions

- If combusted will produce NO_x, easily solved with ammonia
- Strong smell at 1ppm
- Slip is not an option

Scalability

- See Production
- Economies of scale
- Moore's Law equivalent

Emissions Progress by Industry.

Transportation of People & Goods

- Shipping can use biofuels and methanol now and ammonia shortly, with engines, ammonia ships, and a global regulator with teeth
- Aviation can use zero emission fuels in ~20 years, eKerosene and biofuels in the meantime
- Trains, Trucks, and Mobility may be in less need of molecules depending

Electricity & Power

- Grid Balancing & Off-Grid – hydrogen and perhaps ammonia (storage) can offset intermittencies much like batteries but with less weight, industrial waste, no blood mining
- Co-firing – not just a Japanese dream

Industry

- Steel – Green steel made with hydrogen is moving though could retrofit and use ammonia
- Specialty Chemicals – Many chemicals use ammonia or hydrogen that can cracked back from NH₃

Agriculture

See Biofuels & Fertilizer

Ammonia Shipping Requirements & Next Steps.

IHTF/ISO

- COP28 Success
- Agreed lifecycle methodology to track, calculate and compare emissions intensity apples to apples
- Mutual recognition
- Industry ownership
- Required for trade and distinguish with facts not colors

Infrastructure

- Soft: Regulations, Safety Standards, Digitization of Shipping & Ports, Data Collection to stop 'Hurry and Wait'
- Hard: Engines, Vessels, Berths, Pipelines & Ports
- Spend taxes on 'Global South' and shared infrastructure

Offtake/Demand

- Offtake ideal for financing and supply chain
- Laws and Regulations carrots and sticks to drive demand and deter overuse
- ZEMBA and other buyer's clubs
- H2Global
- Supply Subsidies

IMO

- IMO MEPC80 Results: Net Zero ~ 2050, 5% Zero Emissions Fuels by 2030, 30%(40%) Emissions Reduction in 2030, 40% (50%) by 2040, 100% by 2050
- Involve member states in the hydrogen economy, especially 'Global South'
- Demonstrations



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