Ammonia Technology Roadmap
Towards more sustainable nitrogen fertiliser production

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Ammonia Technology Roadmap: the latest in a long-standing series

The IEA’s roadmap series have covered numerous topics over the past decade, spanning three dimensions: technology roadmaps, energy system roadmaps and country roadmaps.
How is ammonia produced and used today?

Ammonia is the precursor to all mineral nitrogen fertilisers, which together account for just under 70% of total ammonia demand, including the downstream usage of its derivatives.

Mass flows in the ammonia supply chain: from fossil fuel feedstocks to nitrogen fertilisers and industrial products

Ammonia production

- **70%** of ammonia used for nitrogen fertilisers
- **30%** used for industrial applications

**Feedstock**
- Coal
- Natural gas
- Oil

**Secondary reactants**

**CO₂ for urea**

**Urea production**

**Other products**
Ammonia production accounts for 2% of global final energy demand. Its emissions are reduced by 75% by 2050 in the Sustainable Development Scenario and by 95% in the Net Zero Emissions by 2050 Scenario.
Existing assets are long-lived and capital-intensive…

Around 30% of the existing stock of ammonia production capacity is based in China, with an average age of 12 years, compared with a global average age of around 24 years.
Emissions from existing ammonia facilities could amount to the equivalent of 10-35 years’ worth of annual emissions from production in 2020.
Ammonia continues to play an integral role in a sustainable future.

Nitrogen demand by end use and scenario

Energy carrier uses:
- Power generation
- Maritime fuel

Existing uses:
- Non-fertiliser
- Fertilisers
  - Urea-based fertilisers

Ammonia demand for fertilisers and other existing uses grows by 25% by 2050 in the Sustainable Development and Net Zero Emissions by 2050 scenarios. Use in the form of urea declines to reduce use-phase emissions.
Nutrient use efficiency contributes to lowering emissions

A portfolio of use and material efficiency measures reduce demand for ammonia by 10% in 2050, relative to the Baseline. Fertiliser use efficiency contributes 75% of the reduction.
A portfolio of mitigation strategies is required

Technology performance improvements and use efficiency deliver 70% of emission reductions to 2030. In the longer term, innovative technologies such as CCUS-equipped and electrolytic production are required.
CCS and electrolytic production dominate in a sustainable future

Near-zero-emission production routes account for 65% of total ammonia production by 2050 in the Sustainable Development Scenario and over 90% in the Net Zero Emissions by 2050 Scenario excluding production with CCU.
Technology strategies depend on the regional context

The electrolysis route makes important inroads in certain regional markets with access to low-cost renewable electricity and relatively high natural gas prices.
Cost competitiveness depends on the regional context

Electricity prices of about USD 40/MWh or lower are required for electrolysis to be cost-competitive with natural gas. The application of CCS to natural gas-based production becomes competitive at CO₂ prices of around USD 30/t CO₂.
The investment challenge is not insurmountable.

Cumulative capital investment required for process equipment in the ammonia industry in the Sustainable Development Scenario is comparable to that required in the Baseline scenario – around USD 400 billion.
Governments have a critical role to play in accelerating the transition

Driving force: stakeholder collaboration
Governments, ammonia producers, farmers, financial institutions and other actors

Framework fundamentals
Establishing plans and policy for long-term CO₂ emission reductions
Mobilising finance and investment

Targeted actions for specific technologies and strategies
Production technologies
Managing existing assets and near-term investment
Creating a market for near-zero-emission ammonia products
Developing earlier-stage near-zero-emission technologies

Use phase
Improving use efficiency for ammonia-based products

Necessary enabling conditions
Enhancing international co-operation and creating a level playing field
Planning and developing infrastructure
Tracking progress and improving data
Conclusions

• Ammonia makes an indispensable contribution to global agricultural systems through its use for fertilisers. It is also used for various industrial applications. Demand is expected to continue growing in the future.

• Ammonia production today relies on fossil fuels and is emissions-intensive. The industry’s current trajectory is unsustainable – a change of course is needed.

• Using ammonia more efficiently can ease the burden on near-zero-emission technology deployment. Improving the performance of existing technologies is important, but alone cannot deliver savings needed.

• The heavy lifting with respect to emissions reductions must be done by deploying near-zero-emission technologies, primarily CCS and electrolytic hydrogen, along with the required supporting infrastructure.

• While the transition will not be easy, the investment and innovation challenges are not insurmountable.

• Governments have a central role to play in enabling the transition. Action from ammonia producers and other stakeholders is also crucial.

• Time is of the essence – the current decade is critical to lay the foundation for long-term success.