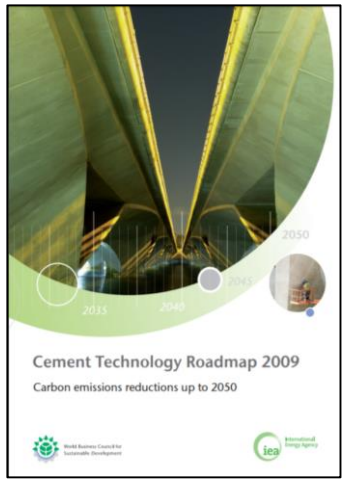
International Energy Agency

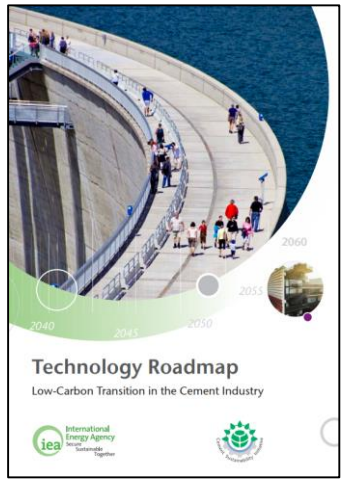
Ammonia Technology Roadmap

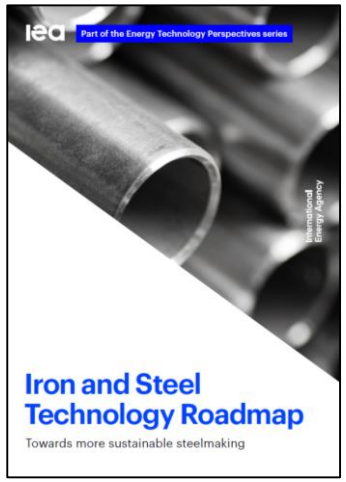
Towards more sustainable nitrogen fertiliser production

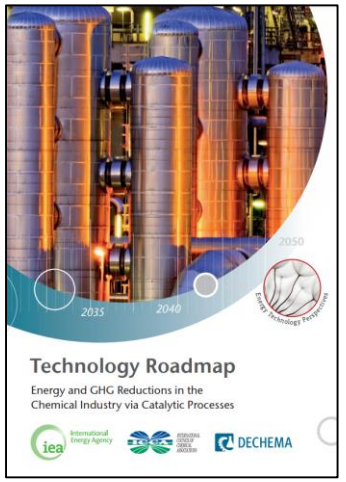
Launch webinar, 11 October 2021

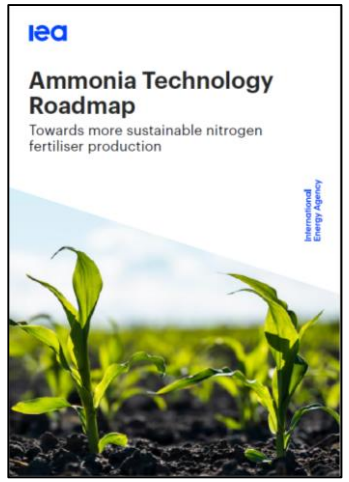
Ammonia Technology Roadmap: the latest in a long-standing series

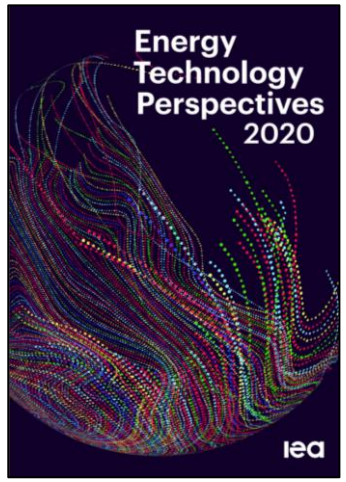


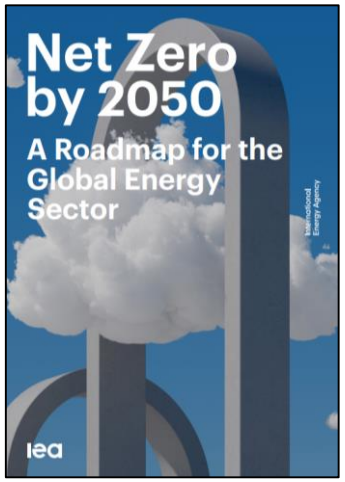


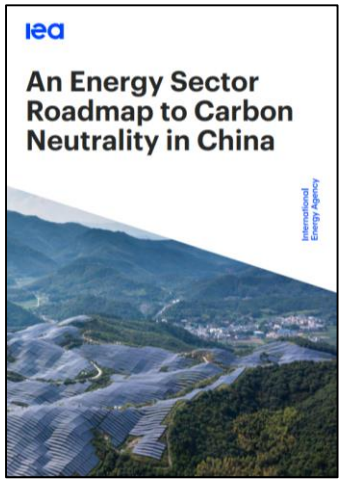








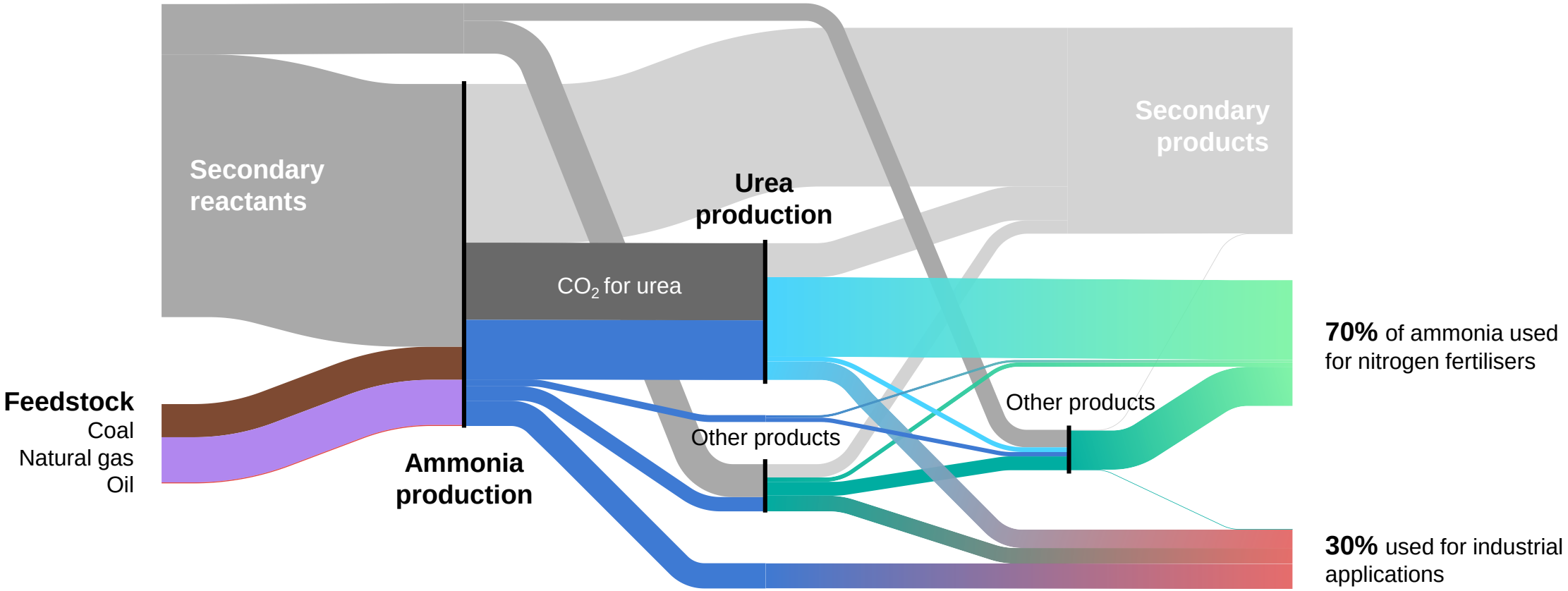




The IEA's roadmap series have covered numerous topics over the past decade, spanning three dimensions: technology roadmaps, energy system roadmaps and country roadmaps.

How is ammonia produced and used today?

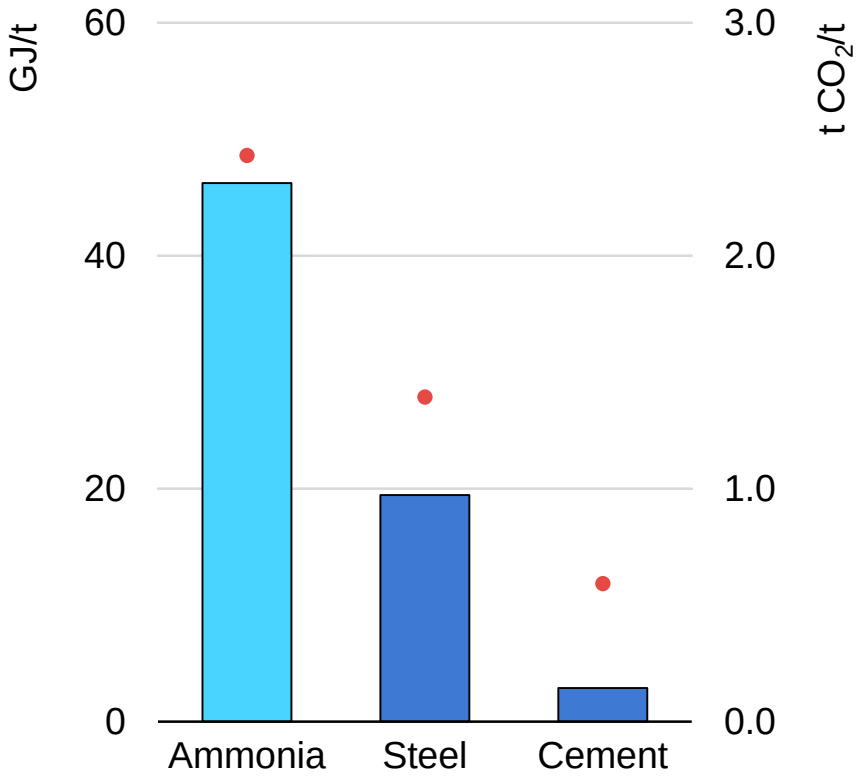
Mass flows in the ammonia supply chain: from fossil fuel feedstocks to nitrogen fertilisers and industrial products



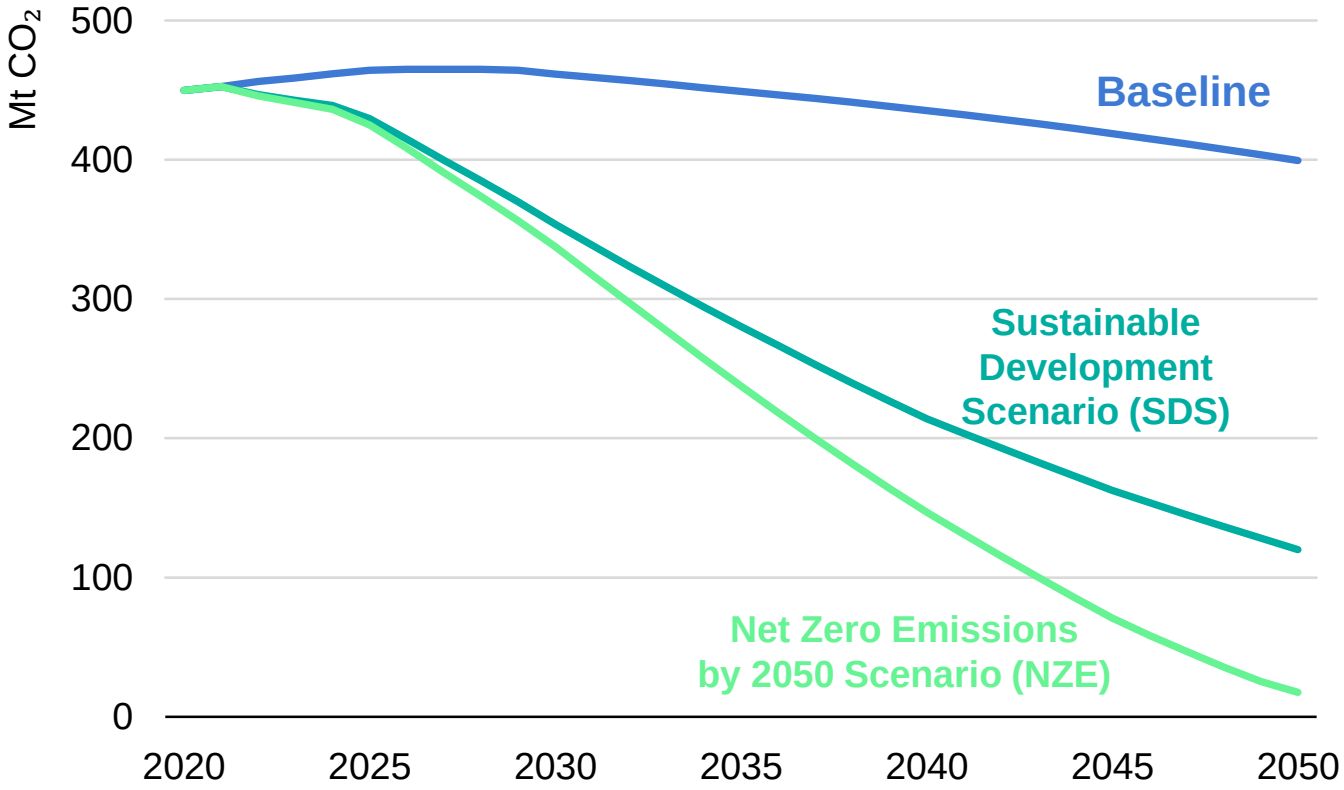
Ammonia is the precursor to all mineral nitrogen fertilisers, which together account for just under 70% of total ammonia demand, including the downstream usage of its derivatives.

An energy- and emissions-intensive industry

Energy and emission intensities for key industrial products



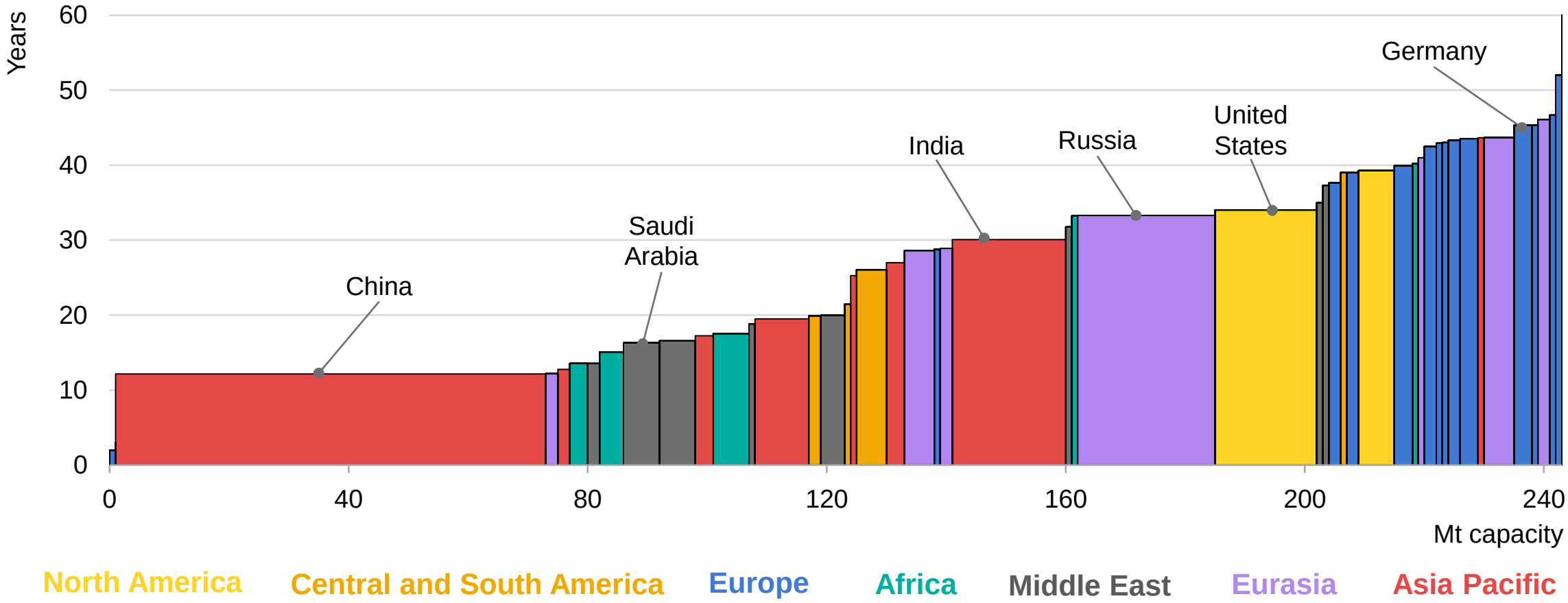
Direct CO_2 emissions from ammonia production



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…

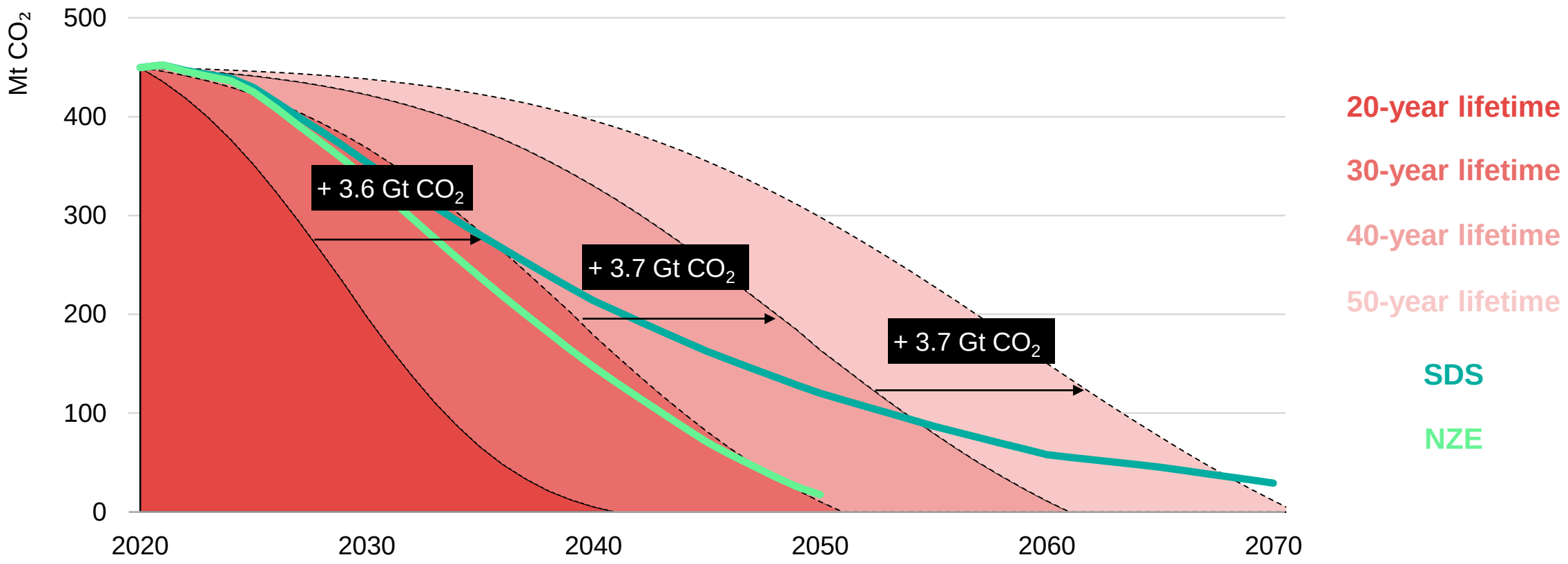
Geographic distribution and average age of key ammonia production assets



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.

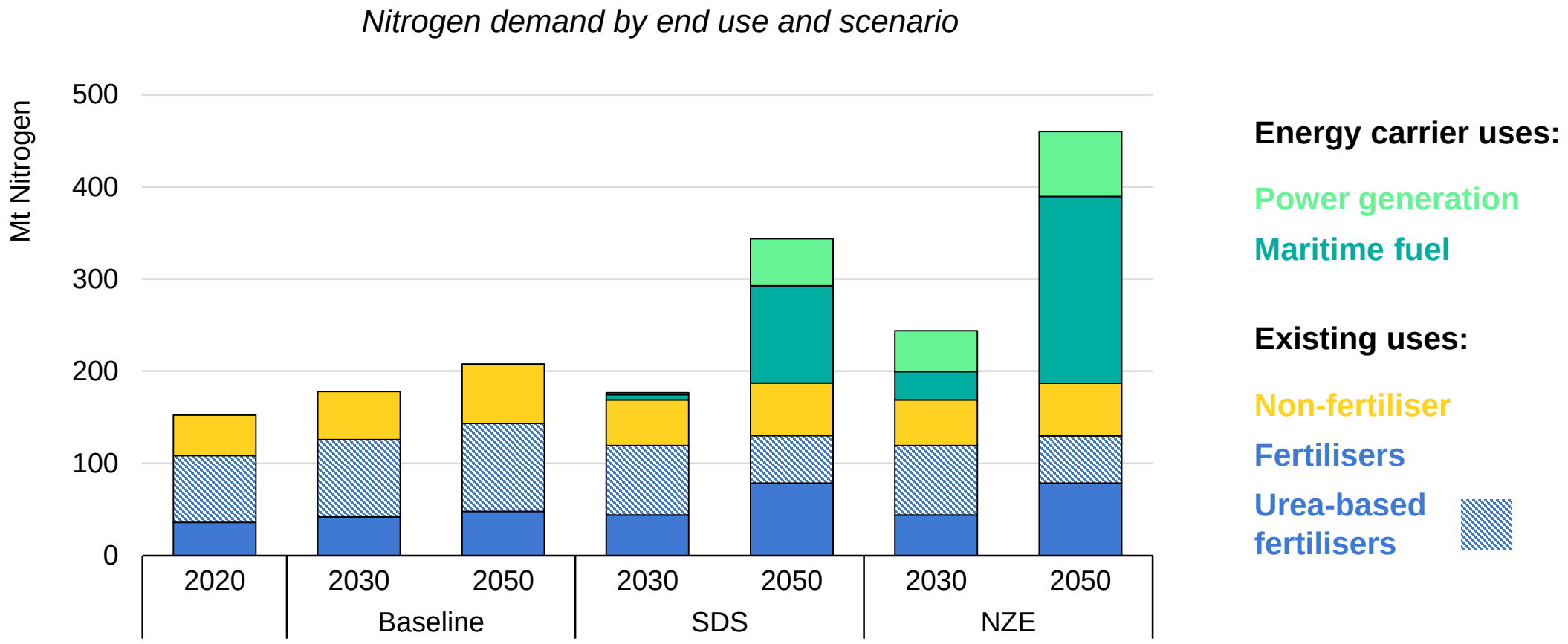
…and they give emissions momentum

Projected emissions from existing ammonia plants under different lifetime assumptions



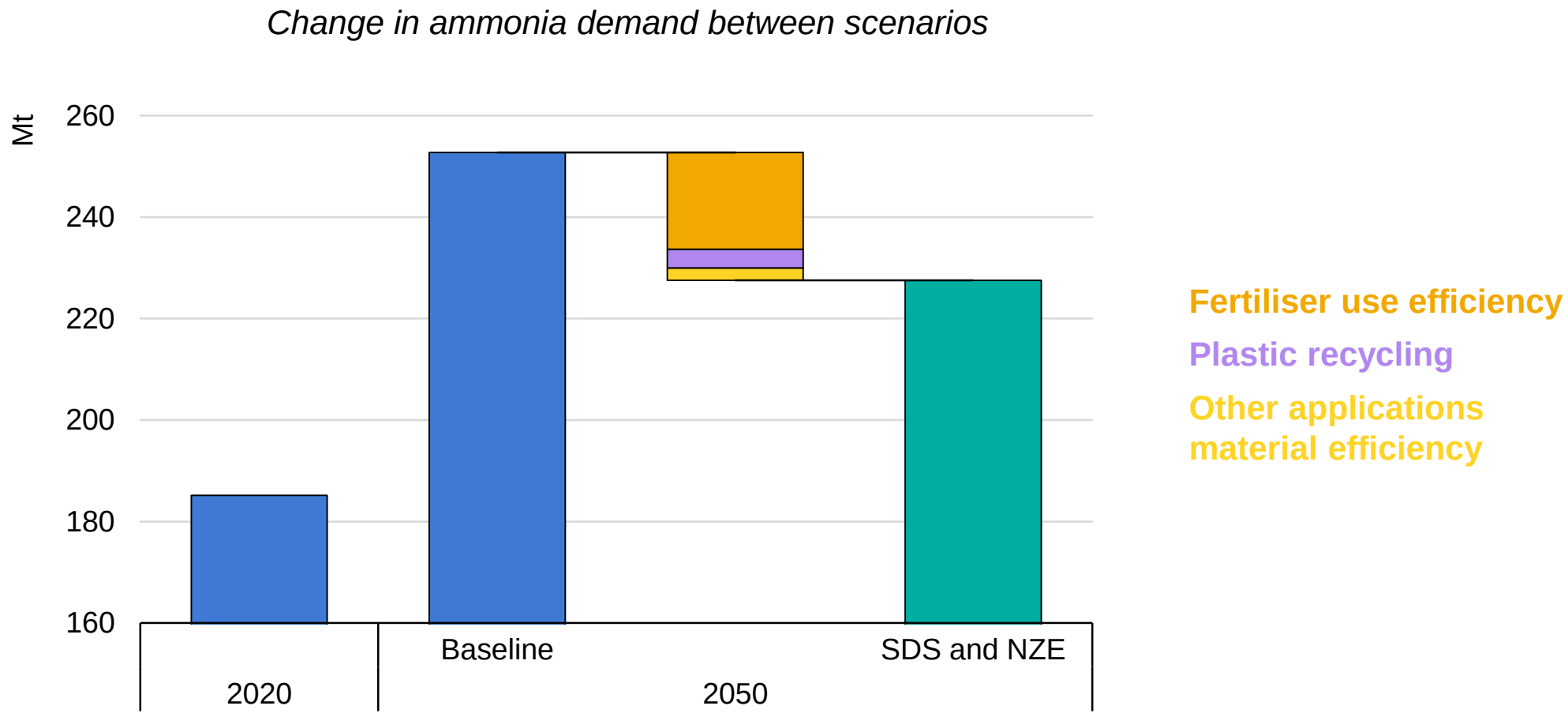
Emissions from existing ammonia facilities could amount to the equivalent of 10-35 years' worth of annual emissions from production in 2020.

Ammonia continues to play an integral role in a sustainable future



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

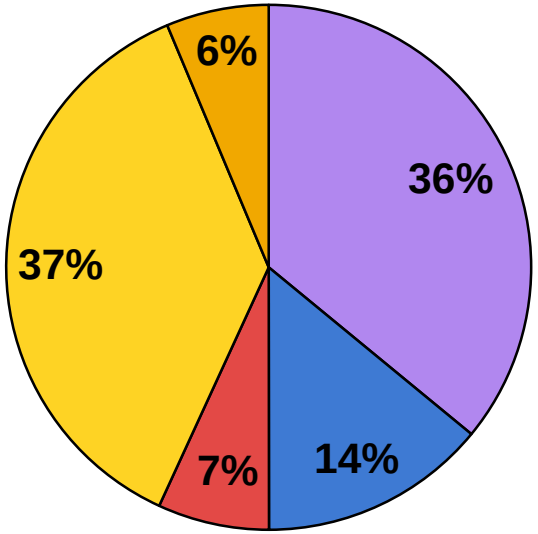


A portfolio of use and material efficiency measures reduce demand for ammonia by 10% in 2050, relative to the Baseline. Fertiliser use efficiency contributes 75% of the reduction.

A portfolio of mitigation strategies is required

Cumulative direct CO_2 emission reductions from ammonia production, SDS relative to Baseline

2020 - 2030



0.4 Gt CO_2

Nutrient use and material efficiency

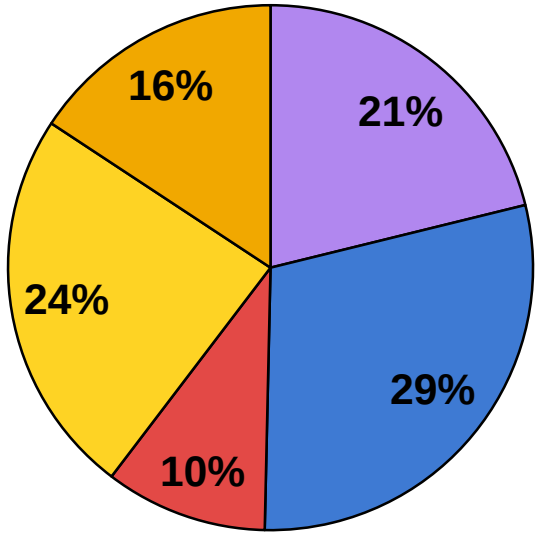
Electrolytic hydrogen

Other fuel shifts

Technology performance

Carbon capture and storage

2020 - 2050

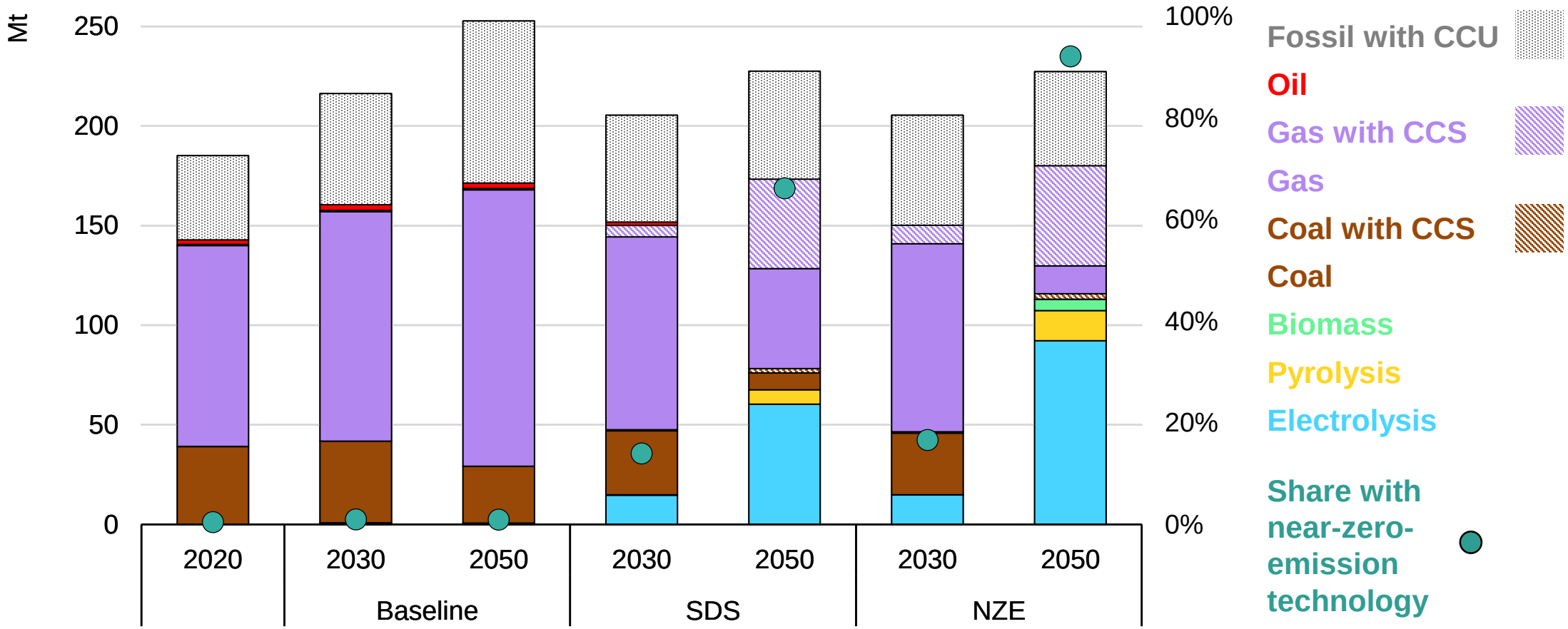


4.6 Gt CO_2

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

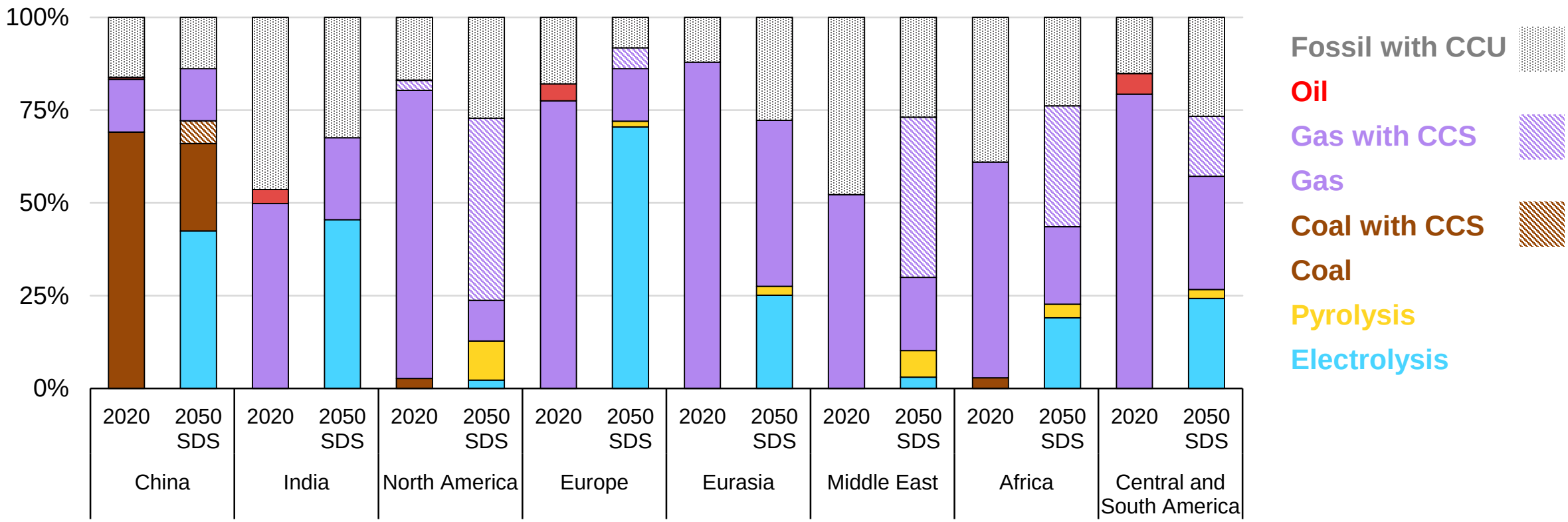
Global ammonia production by technology and scenario



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.

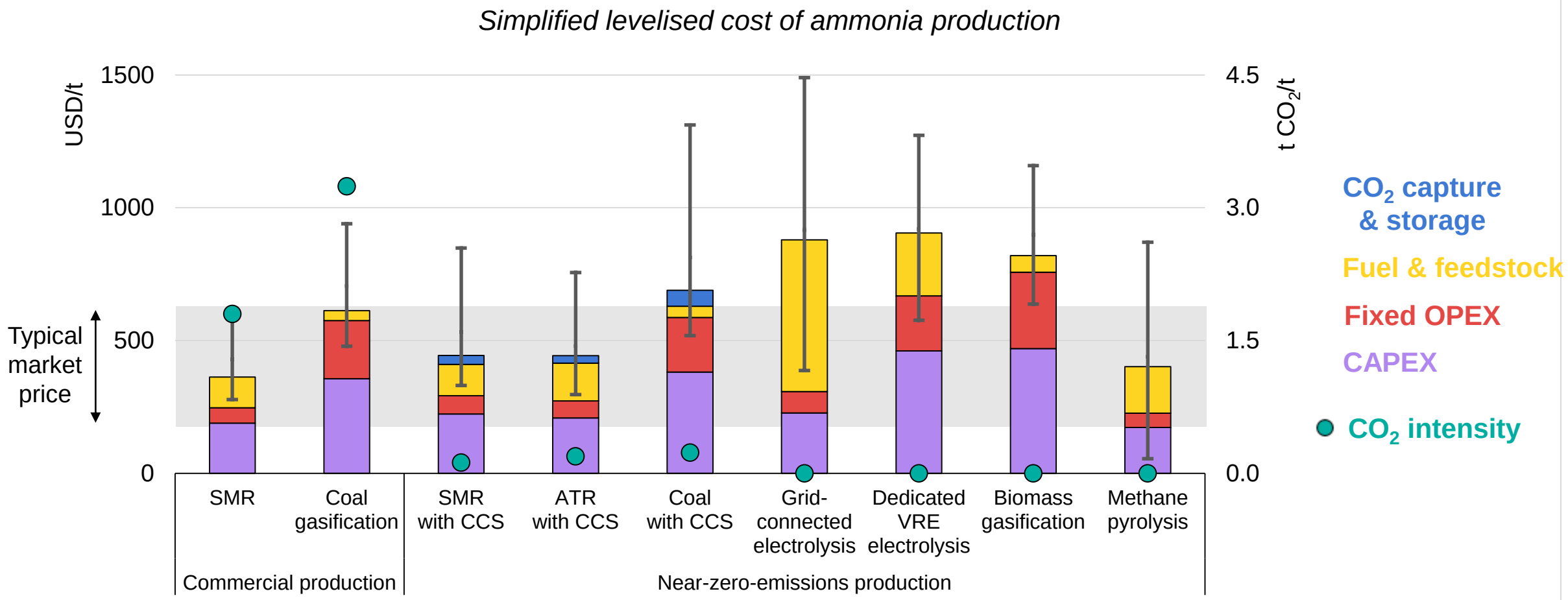
Technology strategies depend on the regional context

Ammonia production by region and process route



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

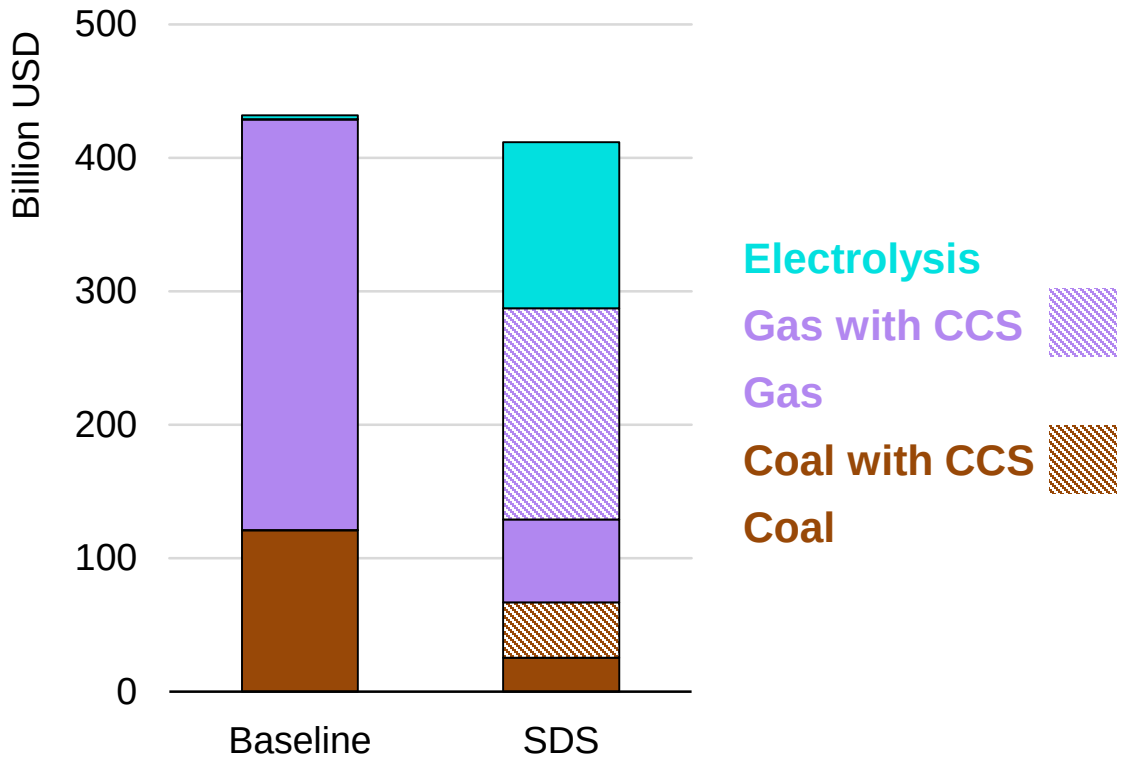
Cost competitiveness depends on the regional context



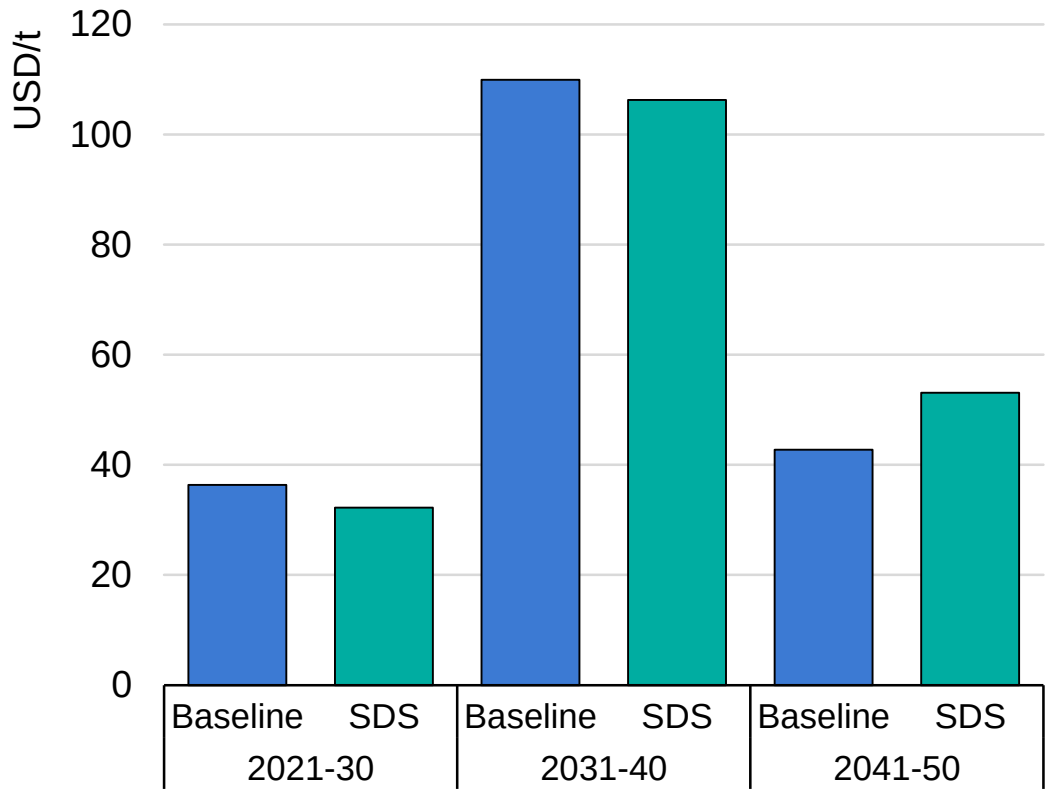
Electricity prices of about USD 40/MWh or lower are required for electrolysis to be cost-competitive with natural gas. The application of CCS to natural gas-based production becomes competitive at CO_2 prices of around USD 30/t CO_2.

The investment challenge is not insurmountable

Investment in process equipment, 2021-2050



Investment in ammonia production per tonne



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 CO_2 emission reductions
- Mobilising finance and investment

Targeted actions for specific technologies and strategies

Production technologies			*Use phase*
Managing existing assets and near-term investment	Creating a market for near-zero-emission ammonia products	Developing earlier-stage near-zero-emission technologies	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.