Ammonia

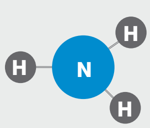
What is ammonia?

Ammonia is a stable chemical compound composed of two common elements: nitrogen and hydrogen. Each ammonia molecule consists of one nitrogen atom bonded to three hydrogen atoms (NH_3), making it both carbon-free and hydrogen-rich.

Ammonia occurs in nature with the breakdown of organic materials like plants, animals, and animal waste and is an important source of nitrogen for plants and animals.

In its natural state, ammonia is a colorless gas. With cold temperatures at atmospheric pressure, it becomes a liquid. Ammonia gas also dissolves easily in water creating ammonia solutions – like familiar household cleaners.

Ammonia is made from nitrogen and hydrogen



Hydrogen is the **most abundant element** in the universe.

78% **of the air we breathe** is nitrogen.

History of ammonia

Ammonia has been safely produced for more than 100 years. Improvements in technology and safety over the decades have made ammonia production one of the most efficient and safest industries in the world.

In the 1930s, German Nobel Prize-winning scientists Fritz Haber and Carl Bosch developed a process to produce ammonia by combining hydrogen and nitrogen using catalysts at high temperatures. The Haber-Bosch process paved the way for large-scale ammonia production, producing enough nitrogen-based fertilizer to feed the world's growing population, transforming global food production forever.

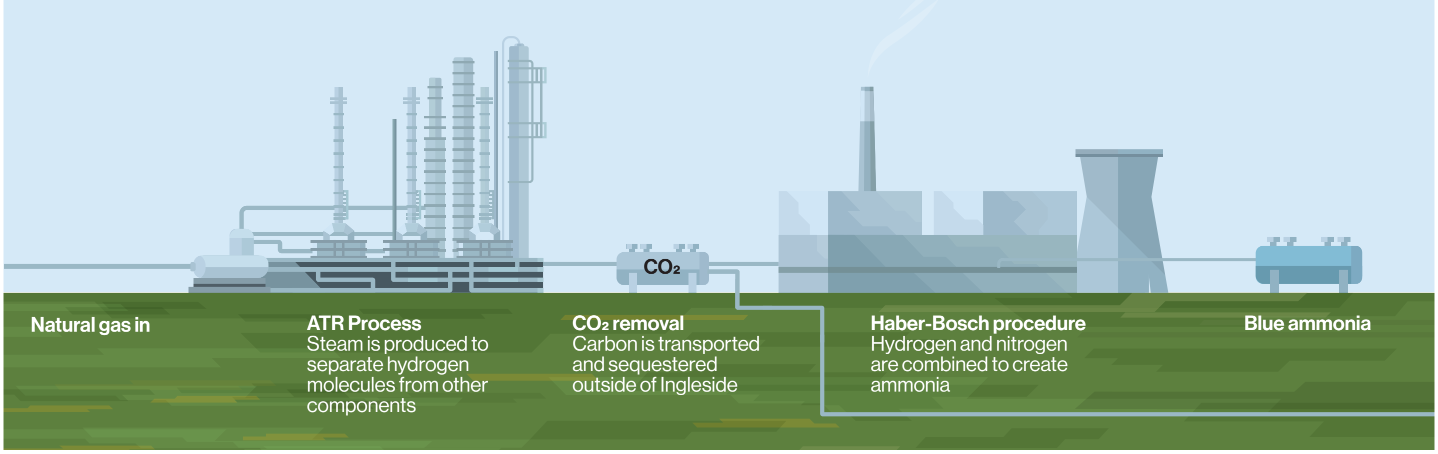
Ammonia today

Today, 80% of the ammonia produced is used as a component for fertilizer supporting food production worldwide. But ammonia can also be found in countless other products that we use every day: pharmaceutical products like acetaminophen (Tylenol®), amoxicillin, vitamins, and cosmetics, as well as an industrial refrigerant, essential for food production and storage.

Ammonia is one of the most produced inorganic chemicals worldwide. The existing infrastructure for production, storage, and transportation is the backbone of the global ammonia market and provides a vision for its future.

While ammonia itself is carbon-free, the process of producing ammonia creates carbon dioxide. Ammonia production currently accounts for ~1.2% of global CO_2 emissions.

The blue ammonia process



Blue ammonia is a game changer

Creating blue ammonia begins by extracting pure hydrogen from natural gas. Using a process called reforming, natural gas (CH_4) and water (H_2O) are combined at high pressures and temperatures. Hydrogen separates from carbon and oxygen—and carbon dioxide is formed as a byproduct.

In gray ammonia production, carbon dioxide is released. With blue ammonia, CO_2 is captured. This step is called carbon capture and storage, and is the difference between gray and blue ammonia.

Next, the Haber-Bosch process combines the separated hydrogen with nitrogen captured from the air to create ammonia. This cleaner manufacturing process is creating new opportunities for the use of ammonia worldwide.

Today, ammonia is color-coded by the carbon intensity of production methods. Carbon intensity is the amount of carbon, in the form of carbon dioxide, emitted into the atmosphere during production. The lower the carbon intensity, the more environmentally friendly:

Gray Ammonia

Highest carbon intensity and most common. Uses hydrogen made from fossil fuels, mostly natural gas, and releases CO_2 during production.

Blue Ammonia

60-95% fewer carbon emissions than Gray. Uses hydrogen made the same way as Gray, but Blue includes the process of carbon capture and storage (CCS), significantly reducing emissions.

Green Ammonia

Net-zero carbon intensity. Uses hydrogen produced by splitting water molecules with renewable electricity. Green is in the initial stages of development and not yet feasible on a commercial scale.

The vision for ammonia in the future

At current production levels, decarbonizing ammonia is important. However, blue ammonia is expected to increase the attractiveness of other applications for ammonia and significantly increase demand.

There are two reasons for this:

- **Ammonia is a cleaner fuel:** Unlike most traditional fuels, ammonia is a carbon-free molecule; it emits no carbon dioxide, soot, or sulfur oxide when it is burned. As a result, ammonia as a cleaner fuel for marine transportation and power generation is under development and expected to grow.
- **Ammonia is an efficient hydrogen carrier:** Hydrogen is promising as a clean fuel, but it is challenging to store and transport. Hydrogen requires very cold temperatures for bulk storage, which is energy-intensive. Ammonia's hydrogen-rich molecule offers a solution for transporting and storing hydrogen.

  Ammonia is easier to move and store. It can be readily converted back to hydrogen and nitrogen at the point of use. This combination makes ammonia an attractive option for long-distance hydrogen transportation or for areas lacking hydrogen infrastructure.

In addition to supporting the world's food supply, blue ammonia can give us a versatile new fuel with an exceptionally low carbon footprint. Demand for ammonia is expected to triple by 2050 and plans for increased production are ramping up worldwide.

For questions about Project YaREN, please contact us at **361-461-0995** or email **EIECCommHotline@enbridge.com**.