

Draft Green Ammonia Protocol

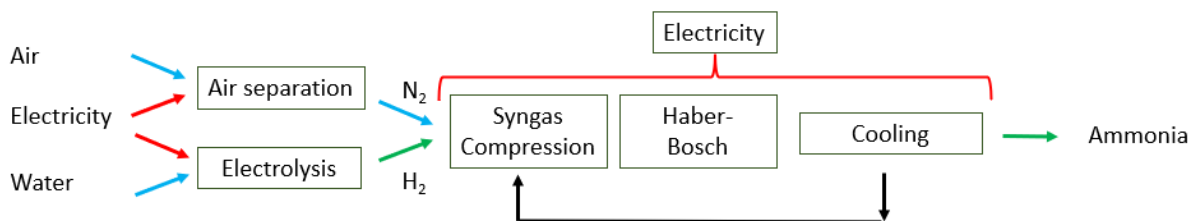
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1. **Summary.** This protocol provides guidance to green hydrogen project developers in measuring greenhouse gas emissions associated with green ammonia production in accordance with requirement 5e of the Green Hydrogen Standard.
2. **Background.** Requirement 5E of the Green Hydrogen Standard includes provisions focussed on demonstrating that green hydrogen is produced from renewable energy sources with close to zero emissions. The Green Hydrogen Standard applies the methodology for the electrolysis production pathway being developed by the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE 2021) as outlined in the *Working Paper Methodology for Determining the Greenhouse Gas Emissions Associated with the Production of Hydrogen*. Requirement 5E **expects** project operators to calculate and report on the emissions associated with the storage, conversion and delivery of H₂ and its derivatives. Noting that the majority of export-oriented green hydrogen projects plan to ship green ammonia, GH2 has prioritised providing guidance on this topic. The guidance will be revised taking into account ongoing work by the IPHE and others. Additional guidance materials addressing ammonia transportation and storage is under consideration. Guidance will be prepared for other green hydrogen derivatives.
3. **Definition of Green Ammonia.** GH2 accreditation and certification requires that green hydrogen projects that operate at ≤ 1 kg CO_{2e} per kg H₂ (taken as an average over a 12-month period) as per the electrolysis production pathway defined by the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE). Noting the typical electricity requirements for ammonia production, GH2's definition of Green Ammonia is:

Green ammonia is ammonia produced using green hydrogen (as defined above) with 100% or near 100% renewable energy with close to zero greenhouse gas emissions ($\leq .3$ kg CO_{2e} per kg NH₃ taken as an average over a 12-month period).

The GH2 Board will review the performance of GH2 accredited projects on an annual basis, with the expectation that the boundaries of the emissions assessment framework can be widened, and that the emissions thresholds will be lowered in accordance with emerging best practice.

4. **Technology Scope.** The Haber Bosch (HB) process (also called Haber ammonia process, or synthetic ammonia process) for synthesizing ammonia from hydrogen and nitrogen.
5. **Process Description**



High purity nitrogen (N₂) is obtained by separating air. There are three main methods of separating N₂ from air: cryogenic distillation, pressure swing adsorption (PSA), and membrane separation.

The gas mixture containing N₂ and H₂ is compressed to the operating pressure of the HB reactor and enters the electricity-driven HB synthesis loop. The single-pass conversion rate for ammonia is low (circa 15%), so recycling of unreacted syngas is needed. There is a pressure drop around the HB synthesis loop. To overcome this, the recycled gas mixture needs to be recompressed to the operating pressure of the HB reactor. In the HB synthesis loop, the electricity is required almost exclusively for syngas/recycle gas compression. The synthesis loop does not need an external heat source, since the HB reaction is exothermic, and the utilization of reaction heat through heat integration is sufficient to satisfy the process heat demand. Pumping energy is also required to circulate cooling water.

6. **Emissions Sources in Green Ammonia production.** The major component relates to the electricity supply as outlined below. GH2 is preparing guidance on the emission factors that should be applied for electrolysis, with the expectation that the same standards would be applied to green ammonia production.

GHG emissions summary for green ammonia

Process unit/stage	Key emissions sources	Other emissions sources
Air separation unit	Electricity for relevant units	n/a
Syngas compression	Electricity for relevant units	
Haber-Bosch (HB)	Electricity for relevant units	
Cooling	Electricity for relevant units	HFC (or other refrigerant) emissions

7. **Hydrogen leakage.** GH2 is developing guidance to address fugitive hydrogen emissions, which would also apply to ammonia production

8. **Embodied emissions.** GH2 encourages project operators to calculate and report on the embodied emissions associated with green ammonia production, including embodied emissions associated with: (i) purchased energy (grid) and energy produced on site (off grid); (ii) construction of green ammonia production facilities, and (iii) construction of storage, conversion and delivery infrastructure. These emissions are not included in the threshold as per §3 above. GH2 will collaborate with partner organizations to develop and apply methods consistently to all energy providers.