

An aerial photograph of an industrial facility, likely a refinery or chemical plant, situated along a body of water. A large white ship is docked at a pier. The facility features a complex network of pipes, walkways, and storage tanks. The water is a deep blue, and the sky is clear. The overall scene is brightly lit, suggesting a sunny day.

Ammonia Carbon Intensity Framework v1.0

WHITEPAPER

Executive Summary

Ammonia Carbon Intensity Analysis

Ammonia (NH₃) is a versatile chemical essential for refrigerants, energy carriers and - most critically - agriculture, where **70-90% of global supply supports fertilizers that underpin food production.**

With an annual production of 230 million tonnes, conventional manufacturing is a major source of emissions. The sector relies on the **Haber-Bosch process**, which typically extracts hydrogen from natural gas through carbon-intensive steam methane reforming. While the industry is a priority for **decarbonization** through **Carbon Capture and Storage (CCS)** or **electrolytic hydrogen powered by renewables**, significant barriers remain. Despite net-zero targets, **adoption is hindered by high capital costs, infrastructure gaps, and uncertainty regarding how to effectively monetize low-carbon production.**

Sylvera's framework **assigns a comparable carbon intensity** to ammonia types produced around the globe, **shifting from discrete categories to a continuous scale.** This is key to **moving away from traditional - and inconsistent - categorical labels** (e.g., "green, blue, grey"), **which often conceal the true environmental and financial opportunities** within global production.

Our Approach

Using Sylvera's proprietary methodology, we calculate **carbon intensity** values by combining open-source databases with manual data extraction. **Our model integrates commodity-specific expertise with Life Cycle Assessment (LCA)** principles and leading emission factors databases to provide **representative modeling pathways** based on the best available data.

Understanding the Score

The results are composed of a **Carbon Intensity** value representing the expected tonne of CO₂e for 1 tonne of ammonia produced, and an attached **Confidence Score**, ranging from Very High to Very Low. This score reflects the completeness and relevance of the available facility data, as well as the representativeness of the emission factors used to generate the final assessment.

LCA Methodology

Framework Goal

The goal of the framework is to calculate **facility-specific carbon intensity values** for global ammonia production.

The framework is informed by the principles of ISO 14040, 14044, and 14067, and provide a **standardised approach to enable like-for-like comparisons across the global market**. It also provides an actionable alternative to the fragmentation of different reporting scheme requirements, presenting a carbon intensity continuum beyond the limiting industry categorisation.

This allow buyers and developers to identify where the strongest opportunities for carbon-related price premiums exist.

System Boundaries, Functional Unit, LCIA

Functional Unit: 1 tonne of ammonia (NH₃)

System Boundary: Cradle-to-gate

Included Processes:

- Fossil-fuel based: Well-to-tank (WTT) emissions for natural gas (steam reforming) and coal (partial oxidation), combustion and processing for hydrogen production. Haber Bosch Process. If present, emissions and removals from capture and storage of CO₂.
- Ammonia via electrolysis: Electricity generation, transmission and distribution (including losses) for powering electrolysis systems.

Allocation Approach: Ammonia bears the full carbon burden; co-products like urea are deemed to have zero emissions.

LCIA: IPCC 2021 - GWP100 (including biogenic CO₂)

Data Source

LCA Methodology

Data Source

Facility Activity Data	Background Data
Database: IEA Database, GEM Database	Database: EcolInvent 3.11
Manual Extraction: facility websites, articles, EPDs,	Other: open-source literature emission factors, peer-reviewed literature on energy and electricity intensities

Carbon Intensity Modeling

Description

The **Carbon Intensity** value, measured in tonnes of CO₂e per tonne of ammonia (tCO₂e/tNH₃), **allows the comparison of ammonia facilities' emissions on a single axis**. This value is calculated through a combination of public datasets and facility-specific data, LCA mapping, and common practice assumptions when necessary and appropriate. To reflect differences in data quality and data availability, **carbon intensity values are paired with confidence scores**.

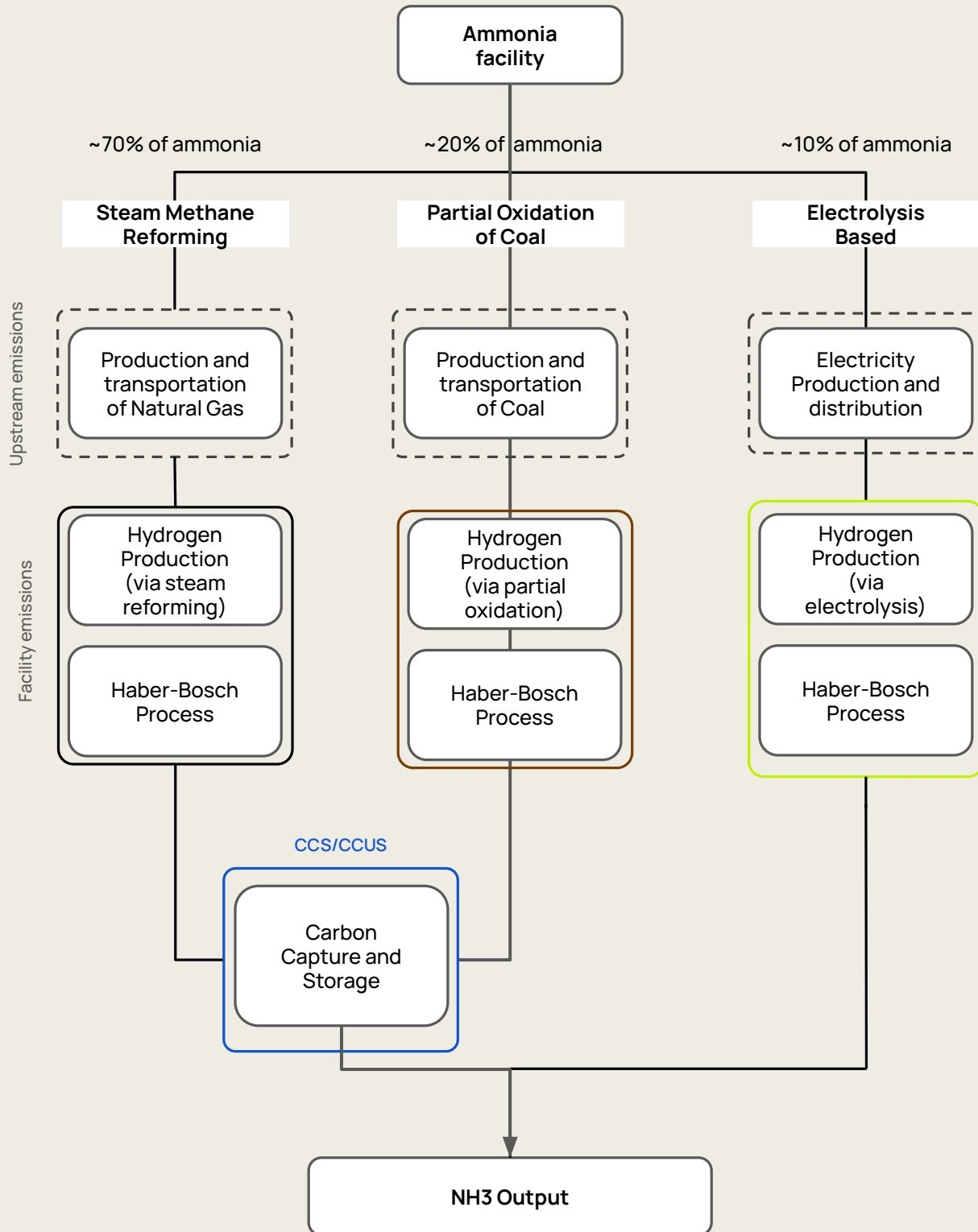
Scoring Logic

Three Carbon Intensity scoring pathways exist depending on production method.

- **Pathway 1 - Fossil-fuel based ammonia production**: Facilities using natural gas or coal for the production of hydrogen and ammonia.
- **Pathway 2 - Fossil-fuel + CCS/CCUS ammonia production**: Similar to pathway 1, but with the addition of Carbon Capture, Use and Storage systems.
- **Pathway 3 - Electrolysis based hydrogen and ammonia production**: Facilities using renewable or grid electricity (or a mix of both) for the production of hydrogen and ammonia.

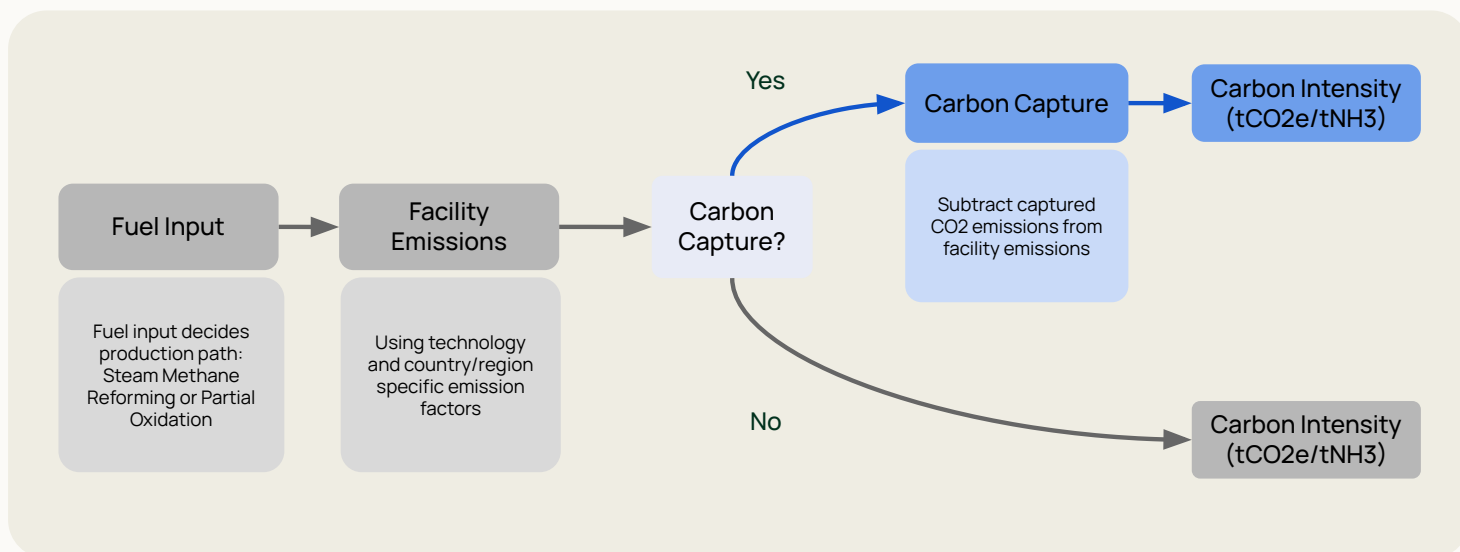
All pathways use cradle-to-gate LCA data, ensuring a consistent and comparable approach across production methods.

Carbon Intensity Logic



Fossil-Fuel Based Ammonia

CARBON INTENSITY MODELING



🔄 Scoring Logic

Pathway 1: Fossil-fuel based ammonia production

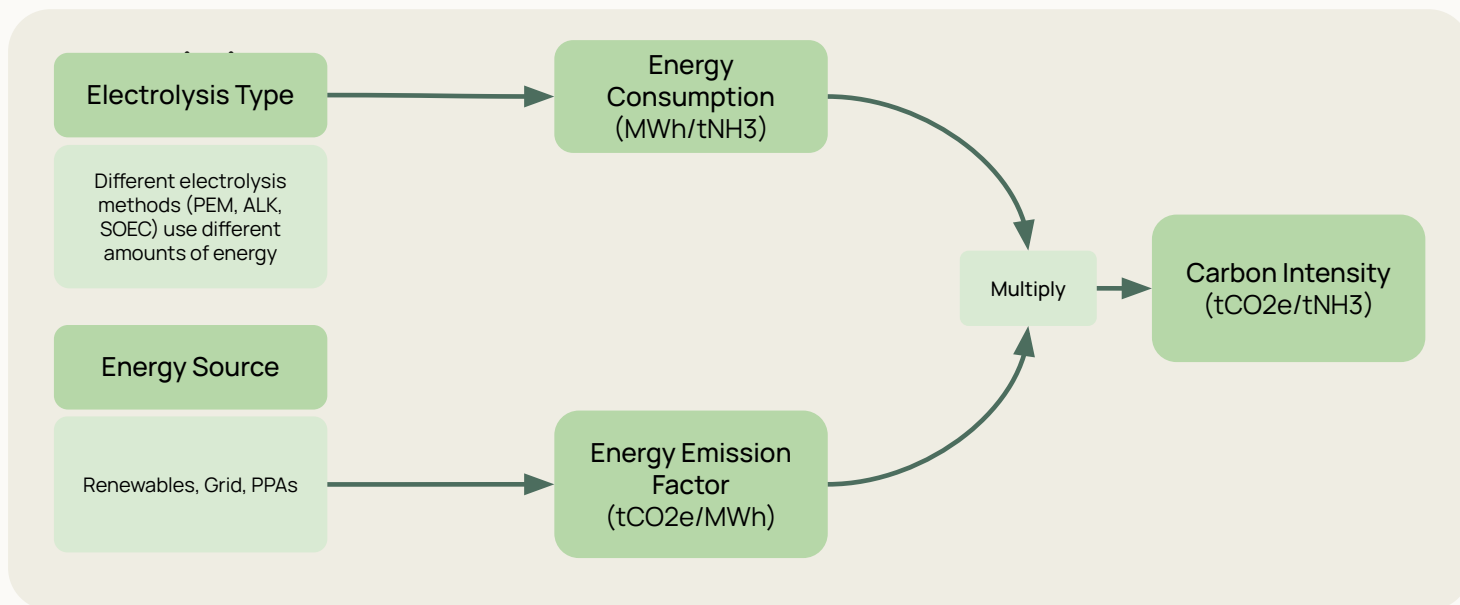
When no primary data is provided, facilities are assigned to either the Steam Methane Reforming (SMR) or the Partial Oxidation pathway based on the identified fuel input. Each facility is then assigned to an emission factor based on technology and location.

Pathway 2: Fossil-fuel + CCS/CCUS ammonia production

An additional calculation is considered for facilities that capture and store or use CO₂, that would otherwise be emitted into the atmosphere. Facility-reported CCUS percentages are used when available; otherwise, a default “common practice” value is applied in order to model the emissions reduction. Similarly, emissions from the capturing and storing systems are modelled based on primary data or, when not available, literature proxies.

Electrolysis Based Ammonia

CARBON INTENSITY MODELING



Scoring Logic

Pathway 3: Electrolysis based hydrogen and ammonia production

Electrolysis type: the electrolysis type used is sourced from IEA and facility-reported data. When facility-specific information is not available, consumption rates are averaged from scientific literature. Energy consumption from both electrolysis and the Haber-Bosch process is captured within this value.

Energy source: the energy source is taken from IEA, and supplemented by facility-reported data when available. Electricity emission factors are sourced from Ecolnvent, based on geography and energy type (e.g. solar, onshore or offshore wind).

The energy emission factor is multiplied by the energy consumption rate to calculate the final Carbon Intensity score.

Confidence Score Logic

Description

Each carbon intensity assessment is accompanied by a **confidence score** that reflects **how reliable and complete the underlying data and assumptions are**. It indicates how much trust users should place in the analysis, given data availability and quality.

Scoring logic

The confidence score aggregates across three components:

1. Facility data reliability
2. Data completeness for key emission drivers
3. Emission factor Quality

Each score is reported on a 1-5 scale, where:

- 1 = very high confidence
- 5 = very low confidence

Very High Confidence

The data is primary source data provided directly by the owner and backed by verifiable evidence, modeled with recent and representative emission factors.

High Confidence

The data is provided by the owner or extracted by official sources, sense-checked and covering most of the emissions hotspots. The carbon intensity is modeled with recent and representative emission factors.

Fair Confidence

The data is extracted from public records, websites, or databases. Accuracy is maintained through cross-checking or "controlled data gaps", and the data covers about half of the total emissions.

Low Confidence

The data is gathered from public sources, but it is incomplete or unverifiable. Information covers less than half of expected emissions, leaving significant room for error.

Very Low Confidence

Facility technologies and energy inputs are fully unknown. The coverage is unknown, representing a significant risk of inaccuracy for any carbon intensity claim.

Facility Data Reliability and Completeness

Confidence Score Logic

Description

Data Reliability: this component evaluates **how reliable and verifiable** the facility-level information used in the carbon intensity assessment is.

Completeness: this component evaluates **how complete the data** is for the main emissions drivers.

Scoring Logic

Data Reliability scores depend on whether facility data was sourced directly from owners or official documentation, and if key operational features affecting emissions—such as carbon capture and storage technology—have been explicitly reported and confirmed.

Facilities only relying on default dataset values receive lower confidence scores, while facilities with verified, quantified production and technology data receive higher confidence.

Completeness scores depend on whether the type of technology and consumption inputs are reported and confirmed at the facility-specific level or a producer-wide level.

Facilities which do not provide exact or facility-specific ammonia production information receive lower confidence scores, whereas facilities with verified information receive higher scores.

Emission Factor Quality

Confidence Score Logic

Description

This component assesses the **representativeness and methodological consistency** of the emission factors used in the carbon intensity calculation.

Scoring Logic

Emission factors are assessed against **five criteria**:

1. Geographical representativeness
2. Temporal representativeness
3. Technological representativeness
4. Data Source reliability
5. Methodological consistency with the study goal and scope, and across facility-level assessments

Disclaimer

Sylvera Limited and its affiliates (together, “Sylvera”) provide assessments, analysis and reports in relation to the voluntary and compliance carbon markets, green commodities and associated products and sectors, which vary in depth and intended purpose (“Opinion”). In addition, Sylvera provides data and analytics products to allow insights into trends, pricing and retirement patterns in the voluntary and compliance carbon markets and green commodity markets (including by reference to other data, such as greenhouse gas emissions) (together, “Data Products”).

Opinions are, and will be construed solely as, a statement of opinion, and not statements of current or historical fact, investment or financial advice, endorsements or criticisms of any project, nor recommendations to take or not take a particular action by Sylvera or its directors, employees, contractors, agents or shareholders (collectively, the “Sylvera Parties”). Opinions do not address any other risk or assessment, including but not limited to market value risk or price volatility, and do not take account of any objectives or requirements of a user (a “User”). Opinions are the collective work product of Sylvera, and no individual, or group of individuals, is solely responsible for an Opinion. Opinions are not facts and, therefore, cannot be described as being “accurate” or “inaccurate.”

Each User will, with due care, make its own study and evaluation of a project before taking any decisions or actions and will take any investment decision solely at its own risk, and nothing provided by the Sylvera Parties should be a substitute for the exercise of independent judgement, skill and expertise by a User. Equally, each User is responsible for the conclusions that it draws from any use of the Data Products, and acknowledges that, by providing the Data Products, Sylvera is not expressing any judgement or opinion, nor providing investment, financial or any other advice.

Sylvera adopts all reasonable measures to ensure the information that it relies upon or makes available is of sufficient quality and from sources that Sylvera considers to be reliable and/or independent. Notwithstanding, Sylvera cannot independently verify or validate all of the information used or made available. As a result of the possibility of human, technical and/or other error, all information is provided on an “as is” basis without representation or warranty of any kind, express or implied by the Sylvera Parties. Each User agrees that no oral or written information given by Sylvera Parties in respect of the an Opinion, or its Data Products shall constitute a representation or a warranty. The Sylvera Parties make no guarantee of accuracy, completeness, timeliness, or availability. THE SYLVERA PARTIES EXPRESSLY DISCLAIM ANY AND ALL EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, ANY WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR USE, FREEDOM FROM BUGS, SOFTWARE ERRORS OR DEFECTS, THAT THE DATA PRODUCTS' FUNCTIONING WILL BE UNINTERRUPTED OR THAT THE DATA PRODUCTS WILL OPERATE WITH ANY SOFTWARE OR HARDWARE CONFIGURATION. In no event shall a Sylvera Party be liable to any party for any direct, indirect, incidental, exemplary, compensatory, punitive, special or consequential damages, costs, expenses, legal fees, or losses (including, without limitation, lost income or lost profits and opportunity costs or losses caused by negligence) in connection with any use of the Opinions or Data Products even if advised of the possibility of such damages.

Opinions and/or Data Products may include inaccuracies or typographical errors, and there may be times when Opinions and/or Data Products are unavailable. Sylvera has no obligation to keep Opinions and/or Data Products updated, but Sylvera may make modifications and/or changes to Opinions, and/or Data Products at any time, for any reason, and the User assumes the sole risk of making use of / relying on Opinions and/or Data Products. The Sylvera Parties shall not be responsible for any errors or omissions (negligent or otherwise) in any Opinions and/or Data Products.

Opinions and Data Products are not intended for use by any person as a benchmark, as that term is defined for regulatory purposes, and must not be used in a way that could result in them being considered a benchmark except with Sylvera's express written agreement. In particular, Opinions and Data Products are not intended, and should not be used to, provide advice or recommendations, or influence any decision in respect of, any specified investment (as that term is defined in The Financial Services and Markets Act 2000 (Regulated Activities) Order 2001).

Sylvera has not consented to being named an “expert” or any similar designation under applicable securities laws.

Sylvera may receive compensation for its Opinions and/or Data Products, normally from purchasers of carbon credits or market operators. Sylvera reserves the right to disseminate its opinions and analyses.