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Carbon Footprint Methodology

AEA Annual Conference

November 13 - 15

BRUSELAS • PARÍS • ROTTERDAM • WASHINGTON D.C. • SANTIAGO • BOGOTÁ

Agenda

- Scope and Data Quality
  - Well-to-gate
  - Certification of Inputs
  - Cutoff, defaults, and acceptable certification schemes
- Core Energy Inputs
  - Emissions calculation formula
  - Accounting for emissions with a single core energy input
  - Accounting for emissions with multiple core energy inputs
  - Hybrid plants
  - Batch/co-processing

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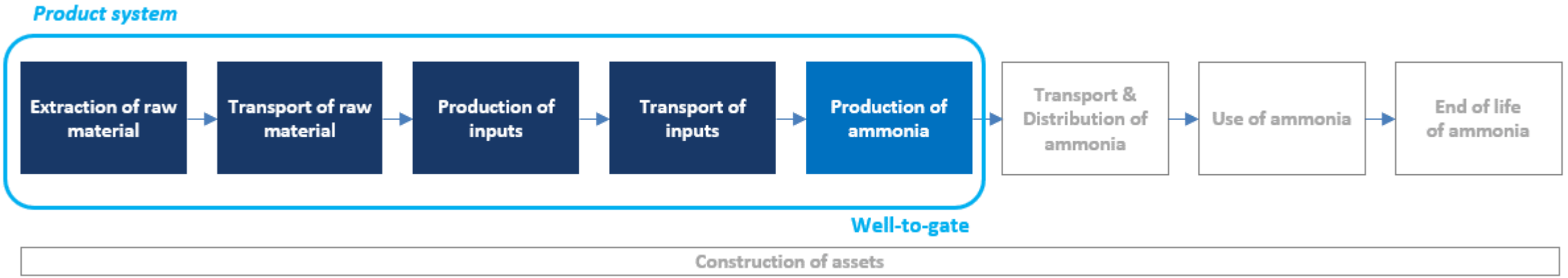
1 Scope and Data Quality

Scope of the AEA CFP Methodology is Well-to-Gate

Emissions from the construction of assets and downstream emissions are excluded

Included emissions in the well-to-gate product system:

- Extraction of raw materials used for ammonia production – e.g. – fossil fuels
- All production stages needed to produce liquid ammonia at atmospheric pressure of -33C
- This well-to-gate CFP is intended to provide a robust data input to any full life-cycle analysis of ammonia
- Carbon dioxide, methane, and nitrous oxides will be calculated using 100-year time horizon using CO2e factors from the 6th Assessment IPCC report



Excluded emissions in the well-to-gate product system:

- Downstream GHG emissions from subsequent refrigeration, transportation, and use of ammonia
- GHG emissions from the construction of assets in the product system

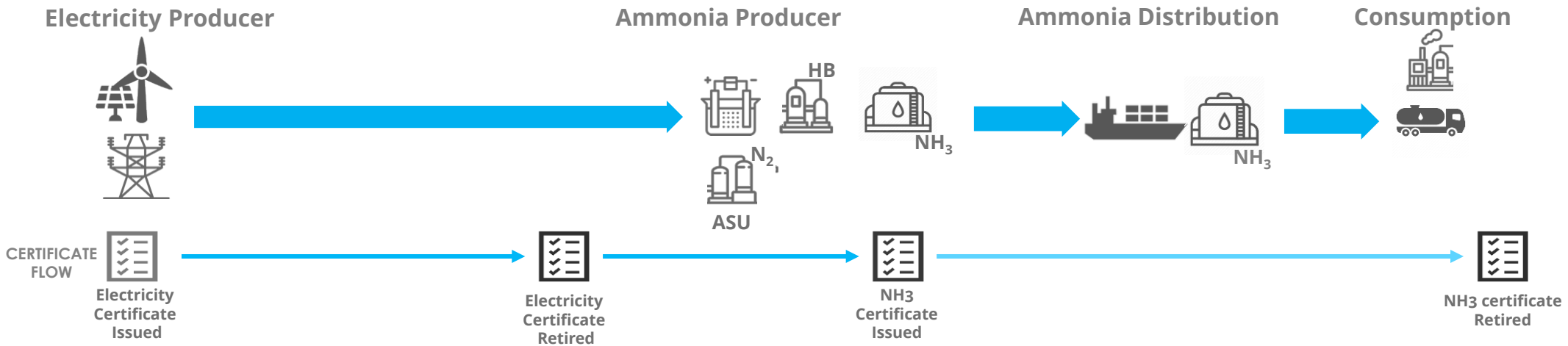
Ammonia production plants is focus of the audit process

Most items checked by auditors pertain to the activities carried out at the ammonia facility

Example Pathways

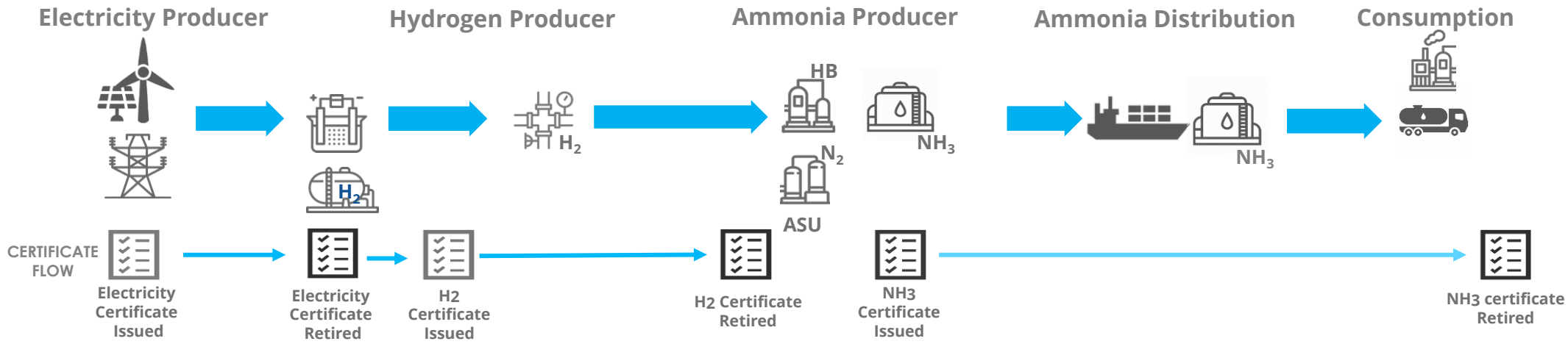
Hydrogen produced onsite

H2 certificate production or retirement is not required



Hydrogen produced offsite

H2 certificate is needed as part of the audit process



Providing Documentation for Certified Inputs

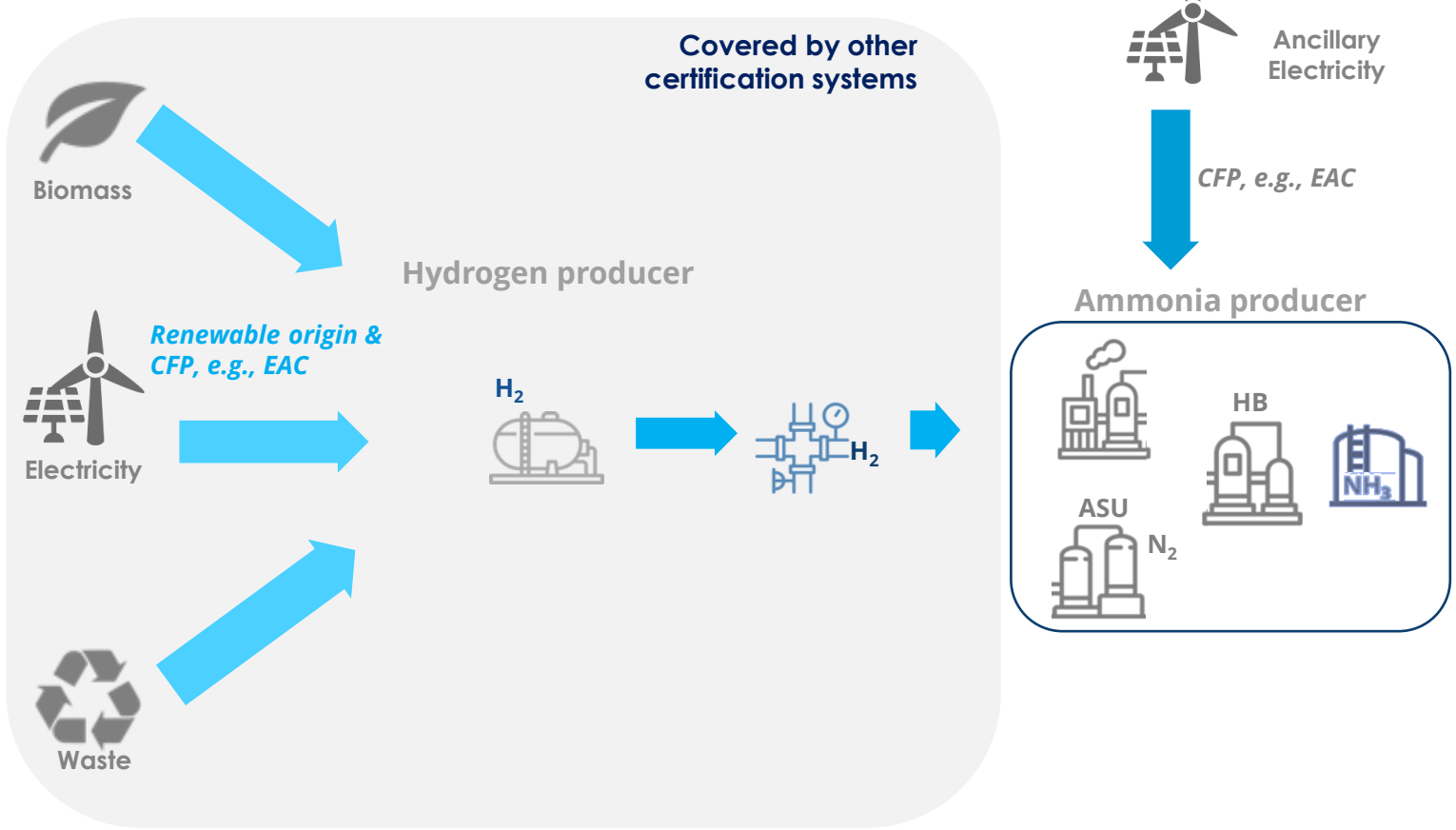
The certification of input materials by *other certification schemes* is required

Input Materials Requiring Certification:

- **Hydrogen** (if not integrated in NH3 plant)
- **Biomethane**
- **Electricity**
- **Responsibly Sourced Gas (RSG)**
- **Waste**

Examples of Appropriate Certification Schemes:

- **Hydrogen:** CertifHy, ISCC
- **Biomethane:** Better Biomass, REDcert, ISCC
- **Electricity:** i-RECs, RECs, GOs, other EACs
- **RSG**: MiQ, Trustwell



The ammonia production **cut-off criterion** permits the exclusion of emissions that contribute **< 2.5%** to the total carbon footprint or fall below an absolute threshold of **0.02 tCO2eq/tNH3**

Addressing Unknowns will Continued to be Developed

Governing committee to build on CFP methodology to address default emission factors

Input Materials Requiring Certification:

- **Hydrogen** (if not integrated in NH3 plant)
- **Biomethane**
- **Electricity**
- **Responsibly Sourced Gas (RSG)**
- **Waste**

- Priority is given to applying actual values based on measurements
- Default values can be used when there is minor/or undisclosed carbon footprint

Examples of Appropriate Certification Schemes:

- **Hydrogen:** CertifHy, ISCC
- **Biomethane:** Better Biomass, REDcert, ISCC
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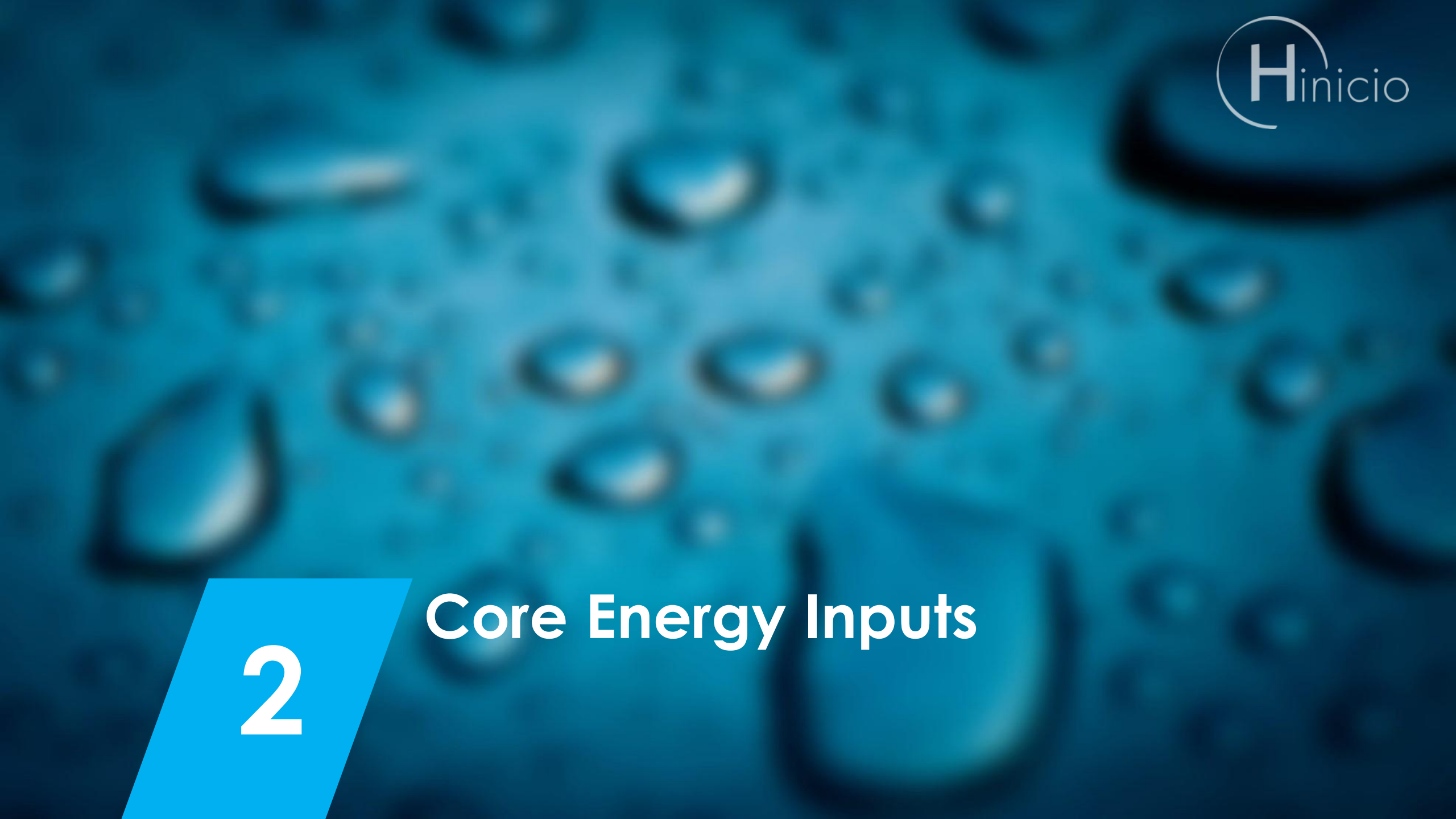
- Section 8 of the CFP methodology is still being updated to address appropriate certification schemes
- The governing committee will decide upon these aspect of the AEA CFP Methodology



2 Core Energy Inputs

Calculation of a GHG Footprint

Emissions produced from well to supply gate are needed to calculate the CFP

- Carbon footprint formula is simply emissions/tons of ammonia produced

$$CFP = \frac{E}{N}$$

CFP	carbon footprint of ammonia (t CO_{2eq}/t)
E	net lifecycle GHG emissions for quantity of ammonia produced in assessed time period (t CO_{2eq})
N	quantity of ammonia produced in assessed time period (t)

- Lifecycle emissions summing the emissions produced throughout supply chain within the product system boundary.

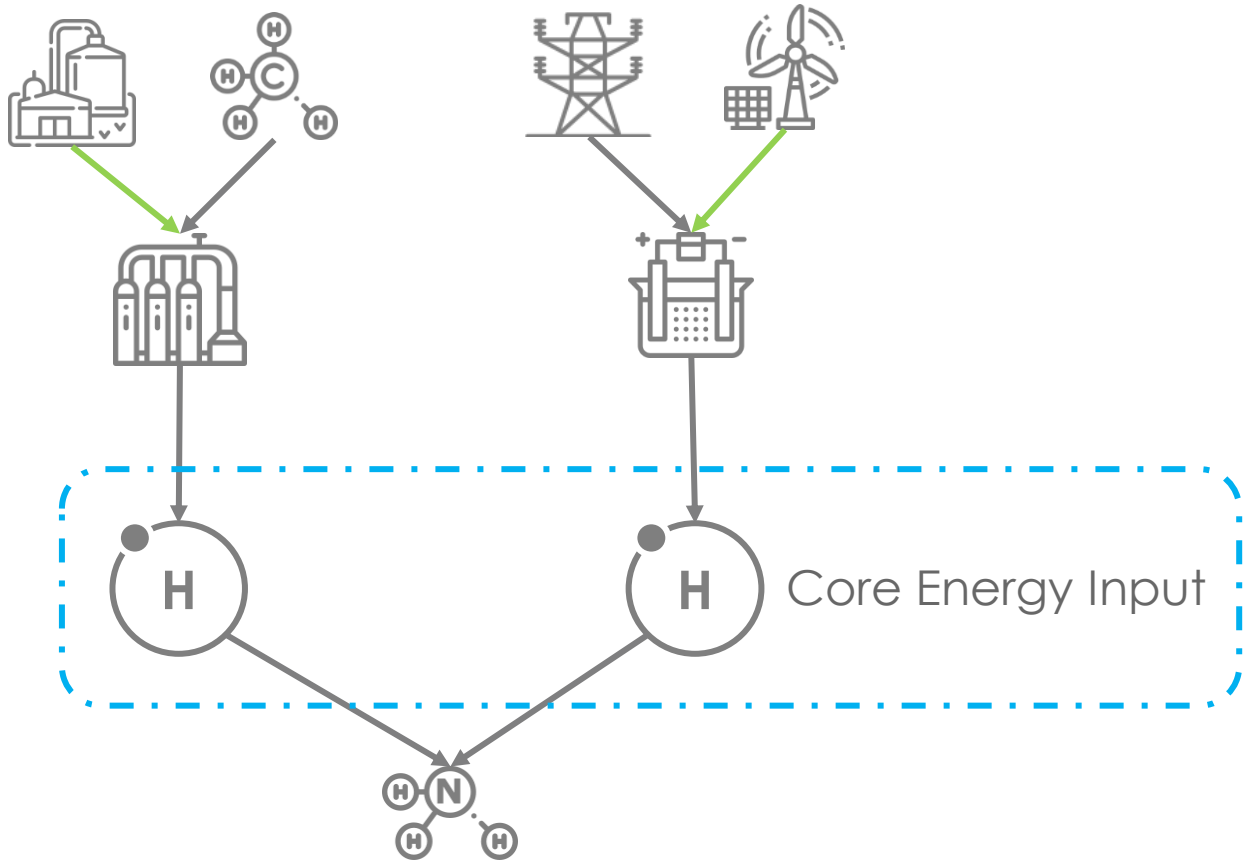
$$E = e_{input} + e_{process} - e_{removal}$$

e_{input}	GHG emissions from the supply of inputs, i.e., well-to-supply-gate emissions *related to the inputs* (t CO_{2eq})
$e_{process}$	GHG emissions from the production of ammonia *using the inputs* without considering removals such as CCS (t CO_{2eq})
$e_{removal}$	Net GHG emissions savings from carbon removals such as CCS (t CO_{2eq})

Core Energy Input

For ammonia production, hydrogen is the only core energy input

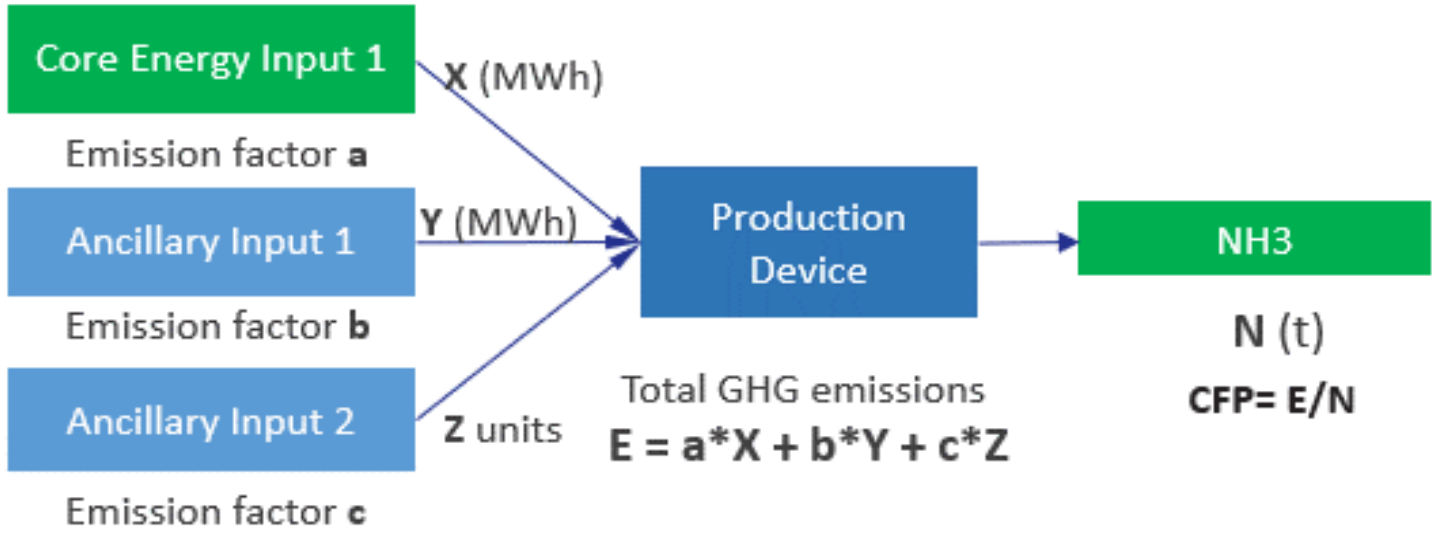
- Enables the co-production of ammonia with different environmental attributes because the co-processing hydrogen has different environmental attributes.
- An energy input that contributes to the energy content of the process output (in this case, ammonia), as reflected by its lower heating value.
- The notion of core energy input similarly applies to processes upstream of ammonia synthesis, such as hydrogen production
- In the case of ammonia synthesis, hydrogen is the only core energy input



Adapted from EU RED approach

Accounting for Emissions With a Single Core Energy Input

Emissions assigned to a share of ammonia are the emissions tied to the core energy input



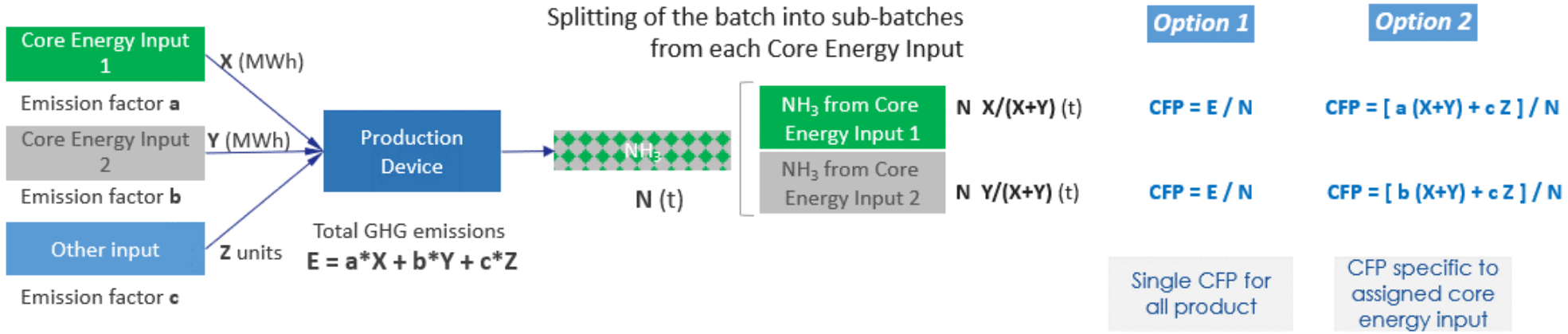
If ammonia is produced without generating any by-products, such as steam, and if the hydrogen used in the production process comes from a single core energy source, then the method illustrated can be employed to determine the ammonia's carbon footprint.

Accounting for Emissions With Two Core Energy Inputs

A hybrid plant can produce two batches of ammonia with different CFPs

Co-processing

Using multiple core energy inputs with different environmental attributes



Option 1

- Single carbon footprint can be calculated for the entire batch

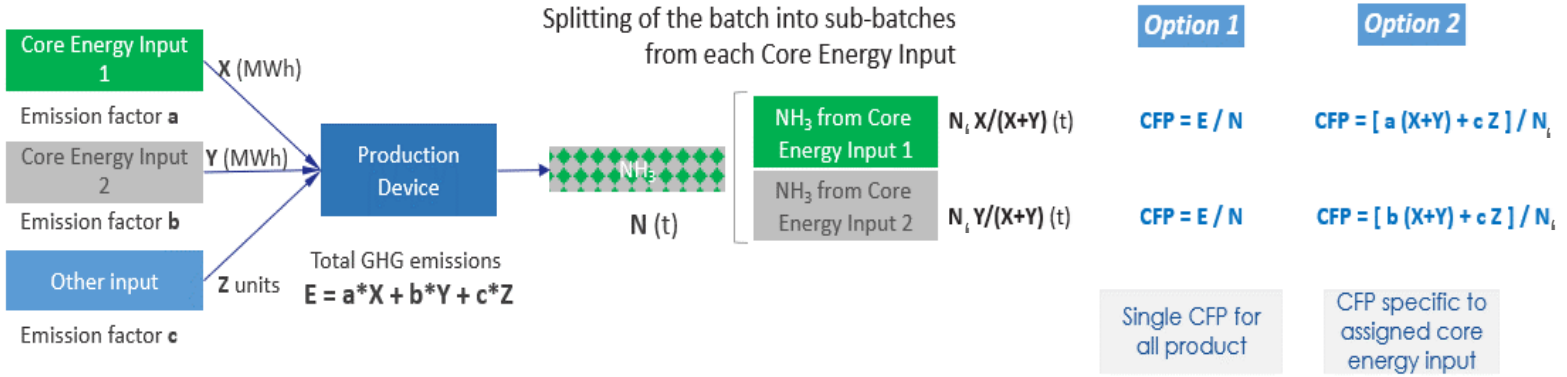
Option 2

- Assign different CFPs to sub-batches specific to each core energy source - each sub-batch is assigned a distinct CFP.
- Each sub-batch is constituted by a share of output equal to the proportion of the corresponding core energy input in total core energy input.

Accounting for Emissions With Two Core Energy Inputs

Example with simplified numbers

Input Data Points	
Tons of H2 required/ton NH3	0.2
Electricity required/ton NH3	0.04
Tons of ammonia produced (N)	1



Calculations

	Proportion of NH3	Quantity of H2 (tons)	Emission Factor H2 (t co2 / t H2)	Quantity of Electricity (MWh)	Emission Factor Electricity (t CO2eq / MWh)
Core Energy Input 1 (Renewable)	20%	0.04 (a)	0 (X)		
Core Energy Input 2 (Conventional)	80%	0.16 (b)	10 (Y)		
Electricity Input	1			0.04 (c)	0.4 (Z)

Results

Option 1
1.62 tCO2/tNH3

Option 2	
Core Energy Input 1	0.08 tCO2/tNH3 (per 0.2 tons)
Core Energy Input 2	2.52 tCO2/tNH3 (per 0.8 tons)

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