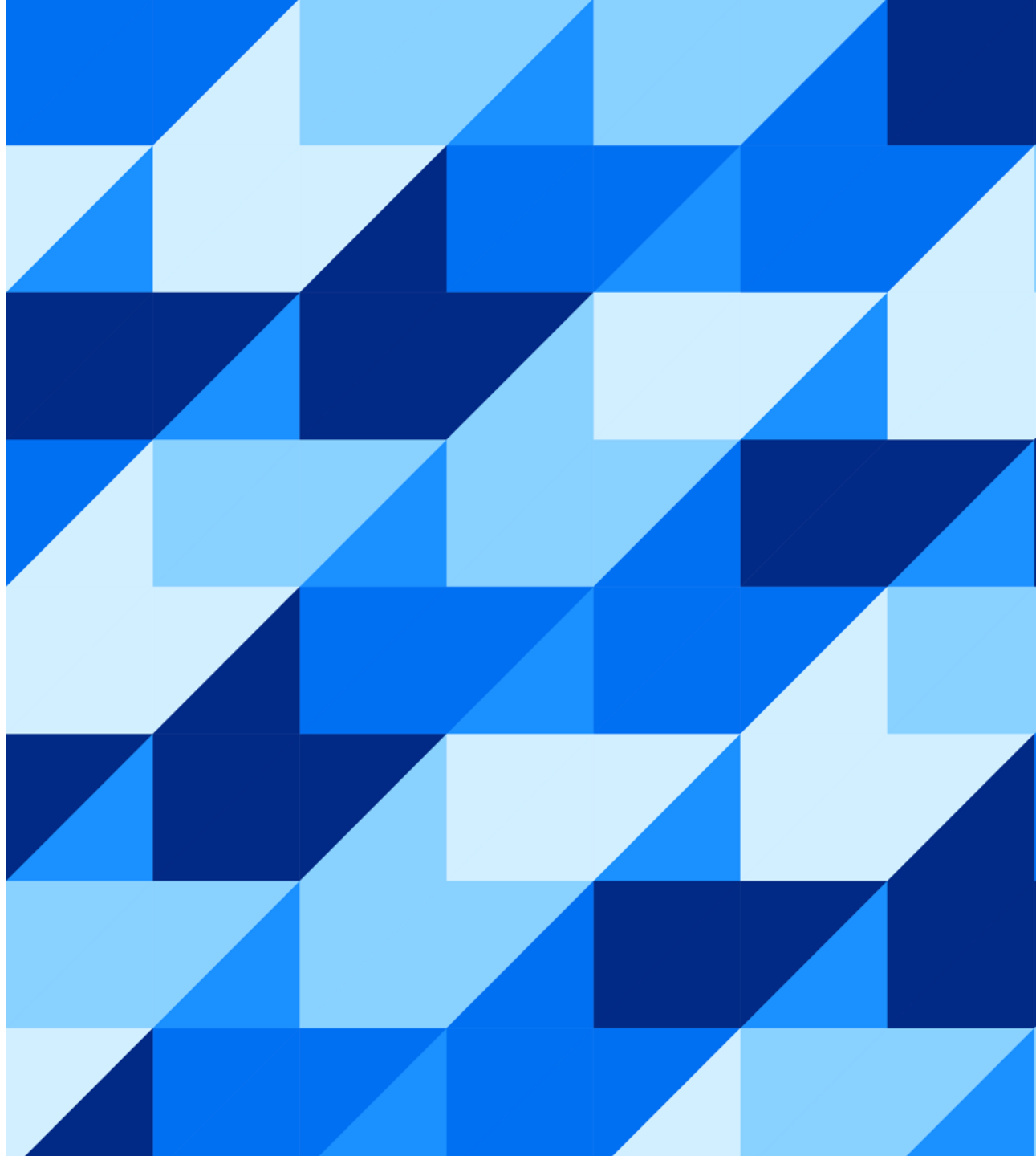

Solutions for Regulatory Requirements and Customer Needs

Peter Koop, SAP SE
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Public

Two step approach for sustainable success in the low carbon H2 market

1. Step:

- **Choose the right methodology and principles** to give regulation and politics the flexibility to be able to support the market ramp-up in the most efficient and fast way.
- **Give end-customers the data they need** to exactly calculate the CO2e footprint of their products and other needed ESG data points plus the ability to cope with a lot of different regulation/certification schemes globally.
- **Work together with certification bodies** to (semi) automate the whole process.

Two step approach for sustainable success in the low carbon H2 market

Methodology and Principles:

Precision and Granularity of Data: Ensure accurate underlying data, which allows for aggregation and flexibility in response to regulatory changes.

Transparency: Clearly present each calculation step to facilitate auditing and enable data-driven decision-making by end customers.

Security: Implement safeguards to prevent unauthorized alterations of information.

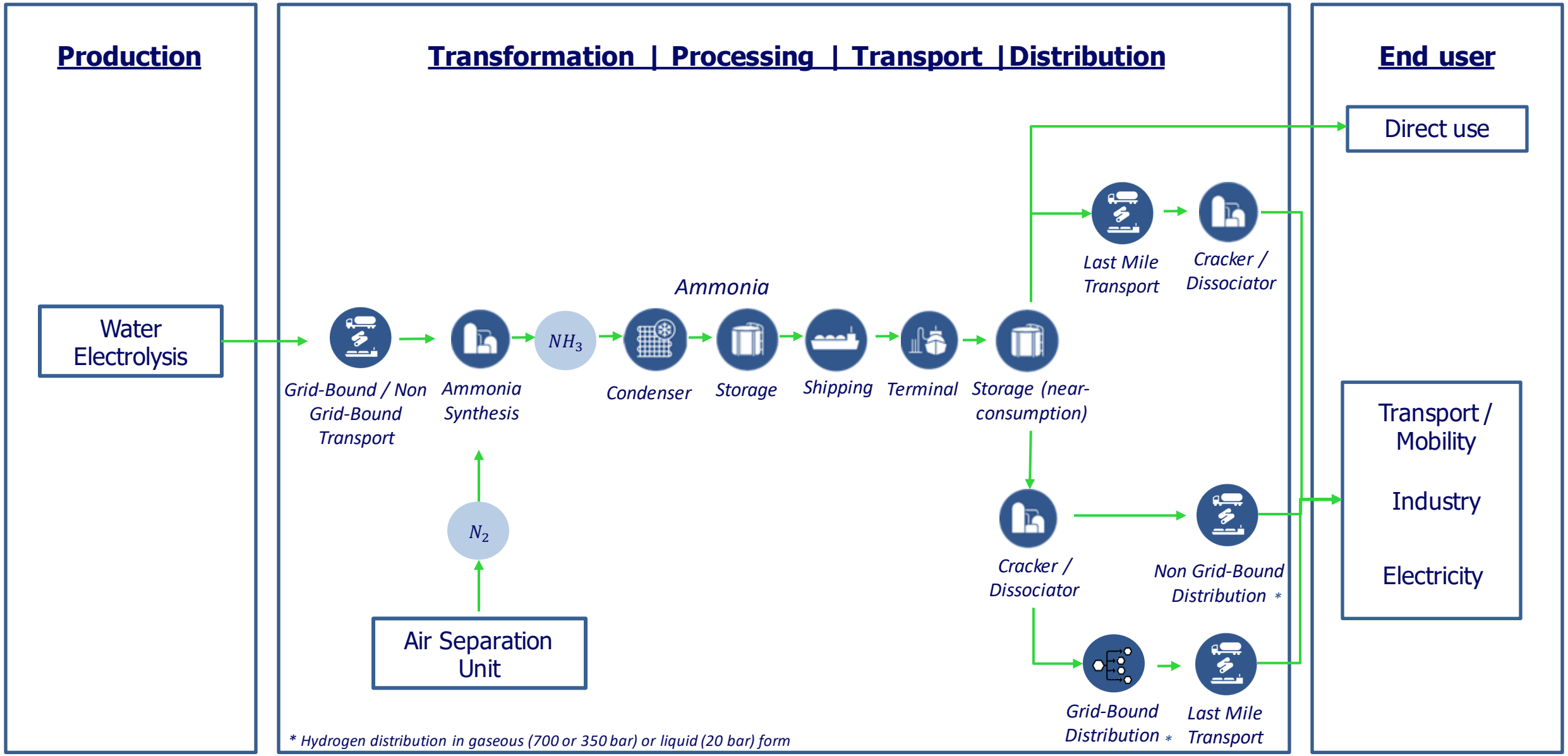
Technical inter-operability: Ensure the use of open technical standards of data exchange.

Independency: Ensure a technical solution that is free from any bias or influence, providing equal access and opportunities for all participants to avoid any conflict of interest and to increase market access, trust and scalability.

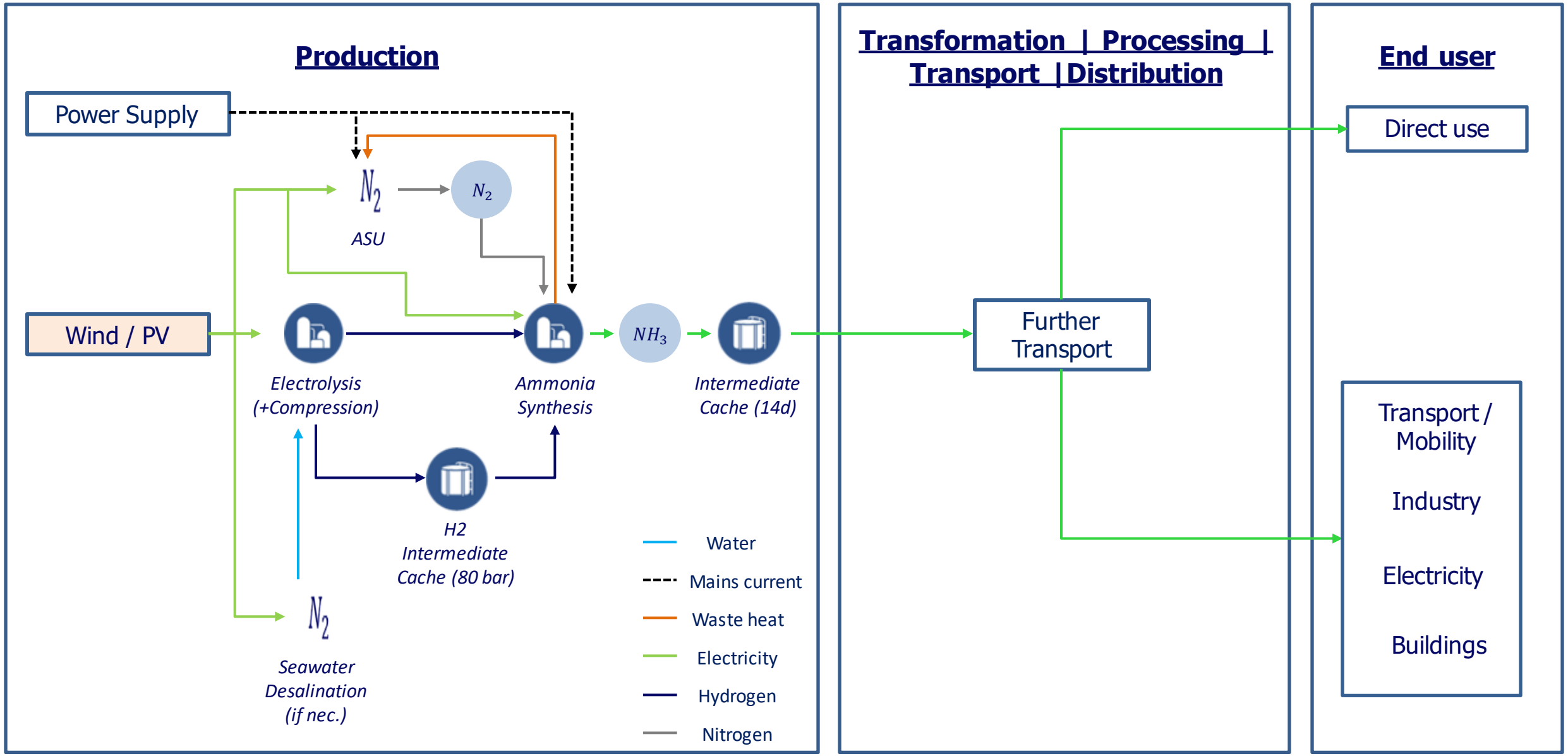
2. Step:

Once FID is there, start thinking about the **software architecture and tools** to be able to implement these principles to bring the H2 value chain together with the aim to be ready before H2 and derivatives are being produced, transported and consumed.

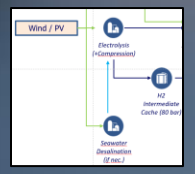
Example: Green ammonia supply chain



Green ammonia supply chain



Deep Dive into the CO2e calculation of the mass of produced Hydrogen

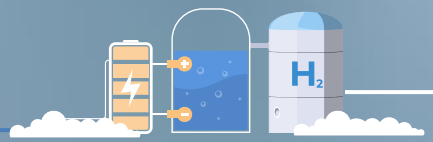


How can we calculate the CO2e for the hydrogen coming out of the electrolyser and what are additional data points that could be important?

certificate of origin, geo location of the meters, voltage level of the grid used, bidding zone, method of production (color), date of the production of the renewable power plant, social criteria like the involvement of women, no use of drinking water in dry regions, investments into the local communities, no relocation of people for the project, professional treatment of the wastewater of the desalination facility etc.

n timeseries from the supply side (PV, wind etc.)

Service to calculate the CO2e of electricity taken from the grid not covered by the PPA's



Measurement of the H2 production in the same time intervals (e.g. 15 min.)

Additional data relevant for customers and regulation

PPA's

Difference

Division

Addition

Transfer to mass balancing system and tokenization

Further Transport

m timeseries from the demand side (electrolysers, desalination etc.)

Resulting time series in kWh X CO2e/kWh

Resulting time series in CO2e per mass of H2

Complete time series in CO2e per mass of H2

If applicable, applying the same methodology to desalination and adding the CO2e per mass of water on top of the CO2e coming from the electricity usage from the grid. Also valid for all other related consumption (e.g. office, pumps, cooling etc.)

GreenToken by SAP | Tracking Hydrogen by Source

1 Hydrogen Production
Origination

Green | Grey | Blue via CCS

2 Mixing at Storage & Handling
Comingling of Hydrogen types

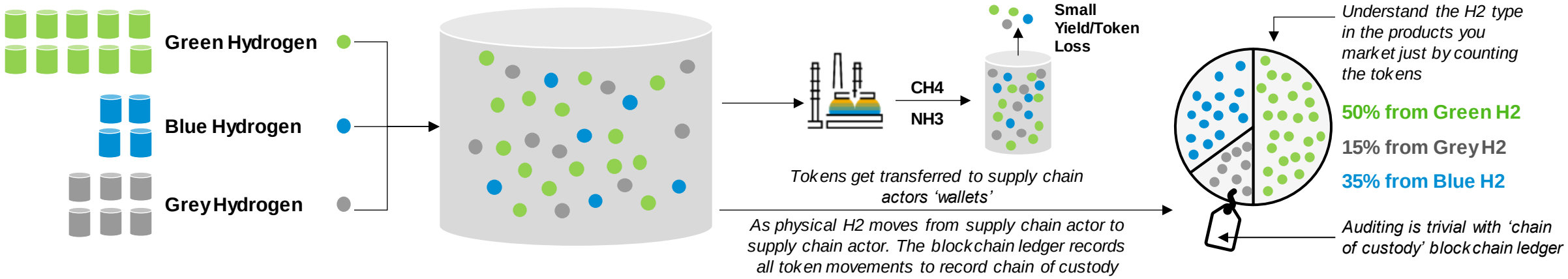
Underground storage | Storage and handling | Storage tanks

3 H2 Product production
Yielding of Tokens at Ratio

Chemical conversion | Ammonia production

4 H2 Marketing–
Mass Balance Reporting

Industrial customer | Refinery | Refueling / Fuel Cell Application | Power generation



IMMUTABLE CHAIN OF Custody (blockchain) ACROSS MULTIPLE BUSINESS PARTNERS

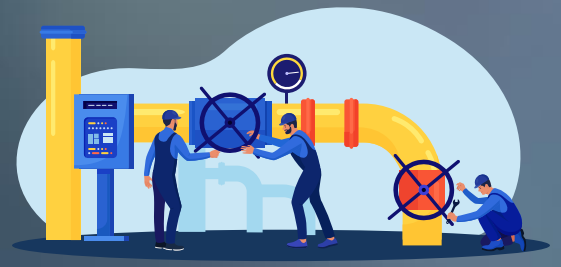
Green, blue and grey tokens are minted onto a blockchain at 1st point of aggregation (storage) based on hydrogen source type. 1 token = 1g of H2. Other facts can be stored like certificate of origin, location/plant.

GreenToken uses these 3 concepts (1) mass balance, (2) tokenization and (3) chain of custody. Just by counting the tokens you instantly know the % mix of H2 types and their origins at any point in the supply chain.

H2 can be processed to new products. The tokens are digital twins of the physical H2 and get converted to H2 product tokens at the same yield, but still retain their original green/blue/grey origins.

With **GreenToken** it is trivial to understand the source of H2 and H2 products that you are marketing. The token count, tied to the mass you are selling, reveals the color % mix and allows easy chain of custody auditing.

CO2e Calculation of Transport



Calculation of CO2e for the pipeline (e.g. compressor) depending on energy input:

- Electricity (grid based) using the same methodology as for H2 production
- Hydrogen (CO2e is known)
- Natural gas or diesel (CO2e from mass burned devided by throughput)

Calculation of CO2e for the shipping depending on energy input and data available:

- CO2e from mass of fossil fuel combusted on the trip
- Hydrogen, ammonia or methanol (CO2e are known)
- Using generic databases to calculate the CO2e for the trips if individual volumes of energy used is not made available

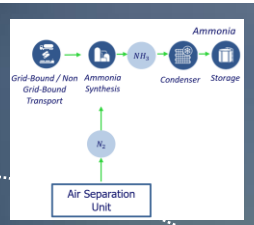
Calculation of CO2e for the transport via train depending on energy input and data available:

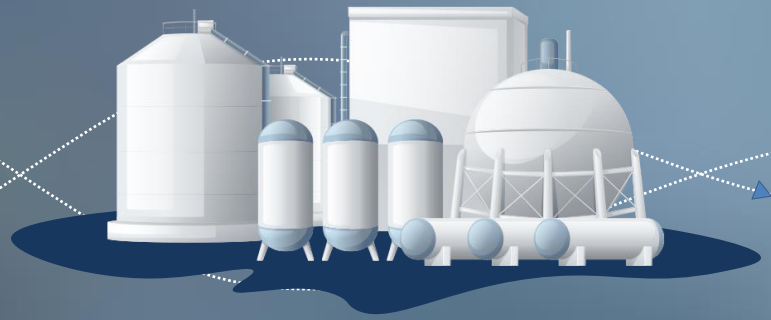
- Electricity (grid based) using the same methodology as for H2 production
- CO2e from mass of fossil fuel combusted on the trip
- Hydrogen (CO2e is known)
- Using generic databases to calculate the CO2e for the trips if individual volumes of energy used is not made available

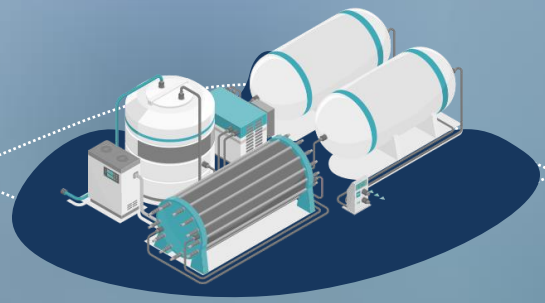
Calculation of CO2e for the transport via truck depending on energy input and data available:

- Electricity (grid based) using the same methodology as for H2 production
- CO2e from mass of fossil fuel combusted on the trip
- Hydrogen (CO2e is known)
- Using generic databases to calculate the CO2e for the trips if individual volumes of energy used is not made available

CO2e emissions from the ammonia production and cracking







Energetic input into the ammonia plant consists of fossile fuels and electricity

To calculate the CO2e emissions of electricity, we use the same methodology as for the H2 production

+

To calculate the CO2e emissions of the fossile fuel input, we measure the mass of the input, calculate the CO2e emissions and add the global average of the literature values of the fossile fuel value chain on top

+

In addition, we also include the CO2e of the operations necessary to run the ammonia plant (offices, company cars etc.)

Energetic input into the ammonia cracker consists of electricity

To calculate the CO2e emissions of electricity, we use the same methodology as for the H2 production

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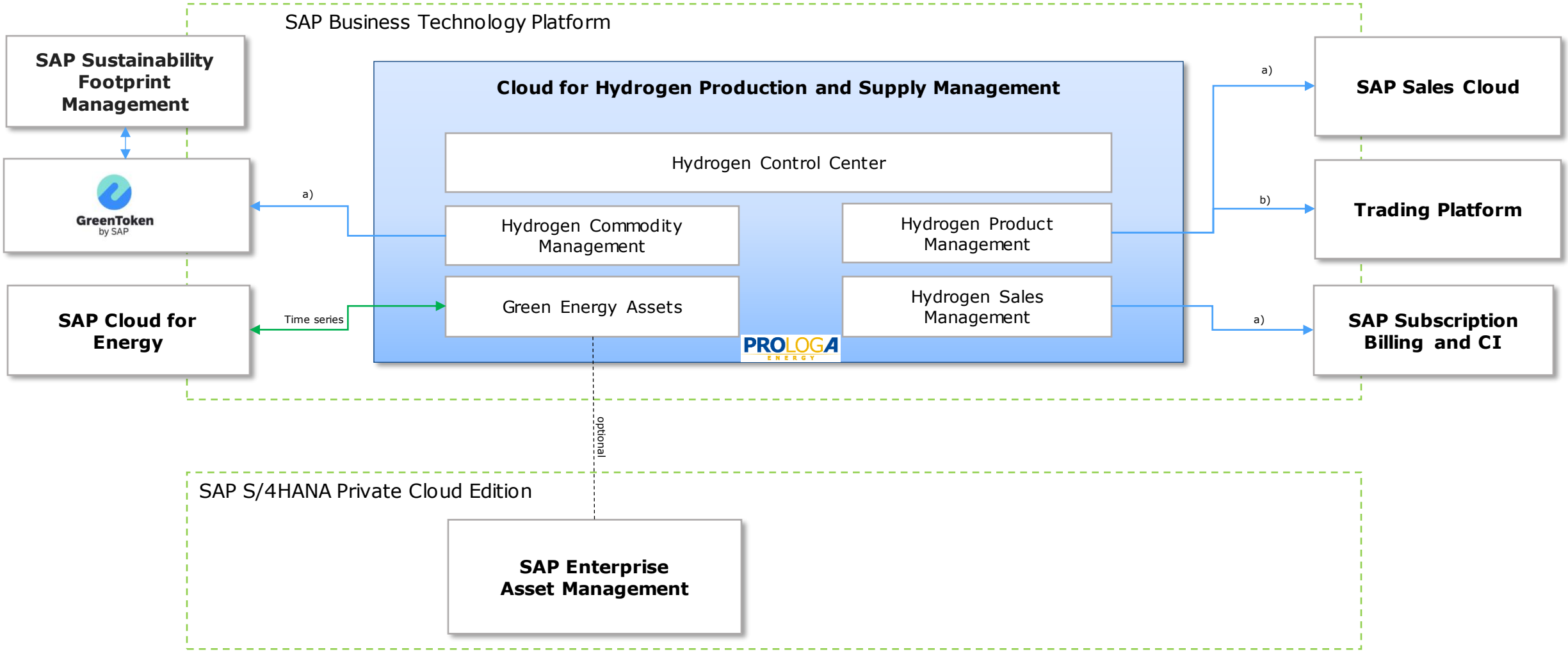
In addition, we also include the CO2e of the operations necessary to run the ammonia cracker (offices, company cars etc.)

Solution Design: Cloud-based end-to-end process coverage



a) planned Integration b) API defined

Thank you.

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For more information about the topic, please have a look at following paper:
H2Global-Stiftung-Policy-Brief-05_2023-EN.pdf (hydrogeneurope.eu)