Networking Lunch
12:00 – 1:00 p.m. CT

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How are you feeling after lunch?

ⓘ Start presenting to display the poll results on this slide.

Hydrogen Mediated CO_2 Utilization

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Todd Taylor, Attorney at Law

Impact Counsel,

Avisen Legal

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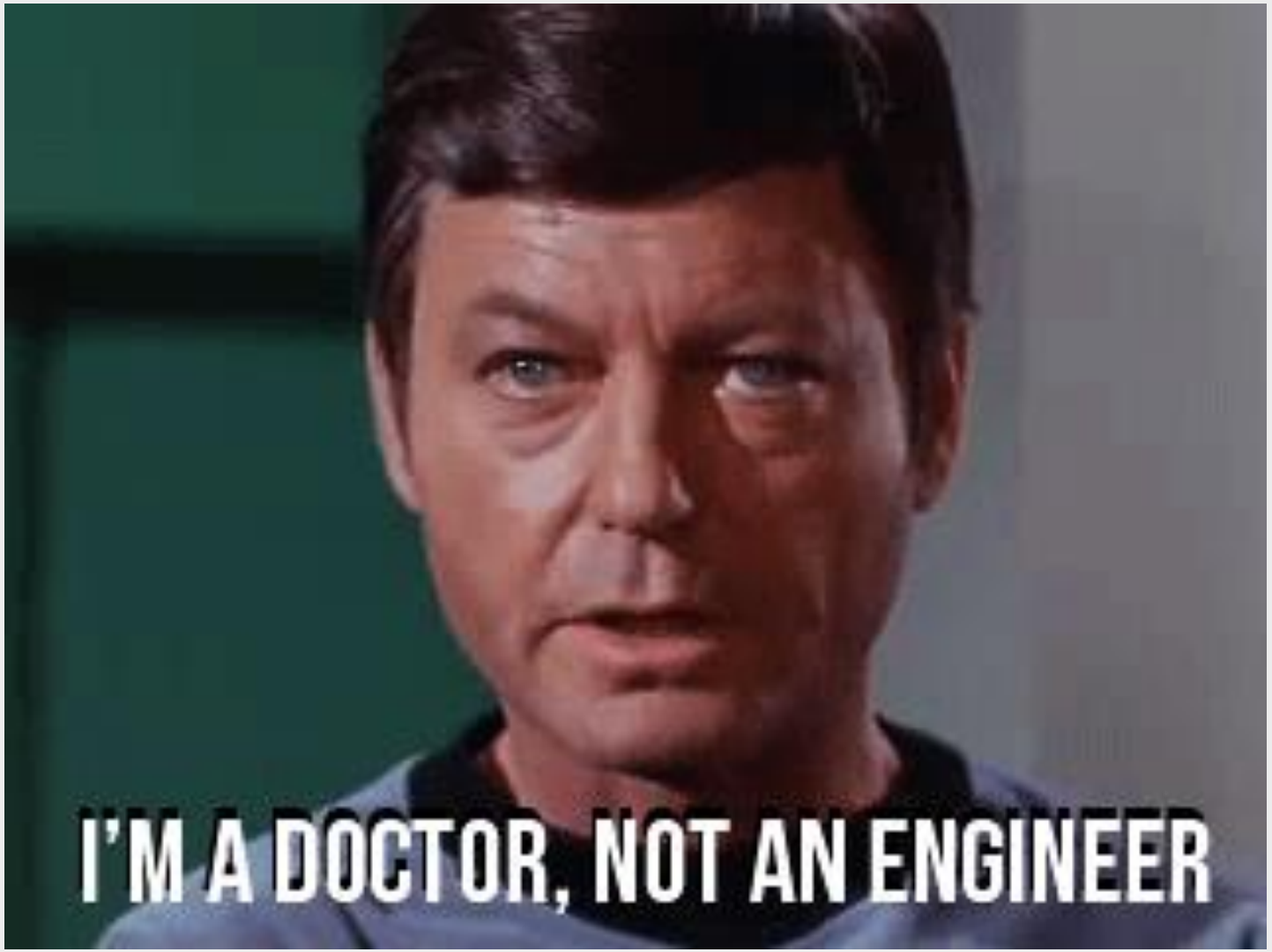
Hydrogen Mediated CO_2–

Applications and Technologies

Financial and Legal Issues

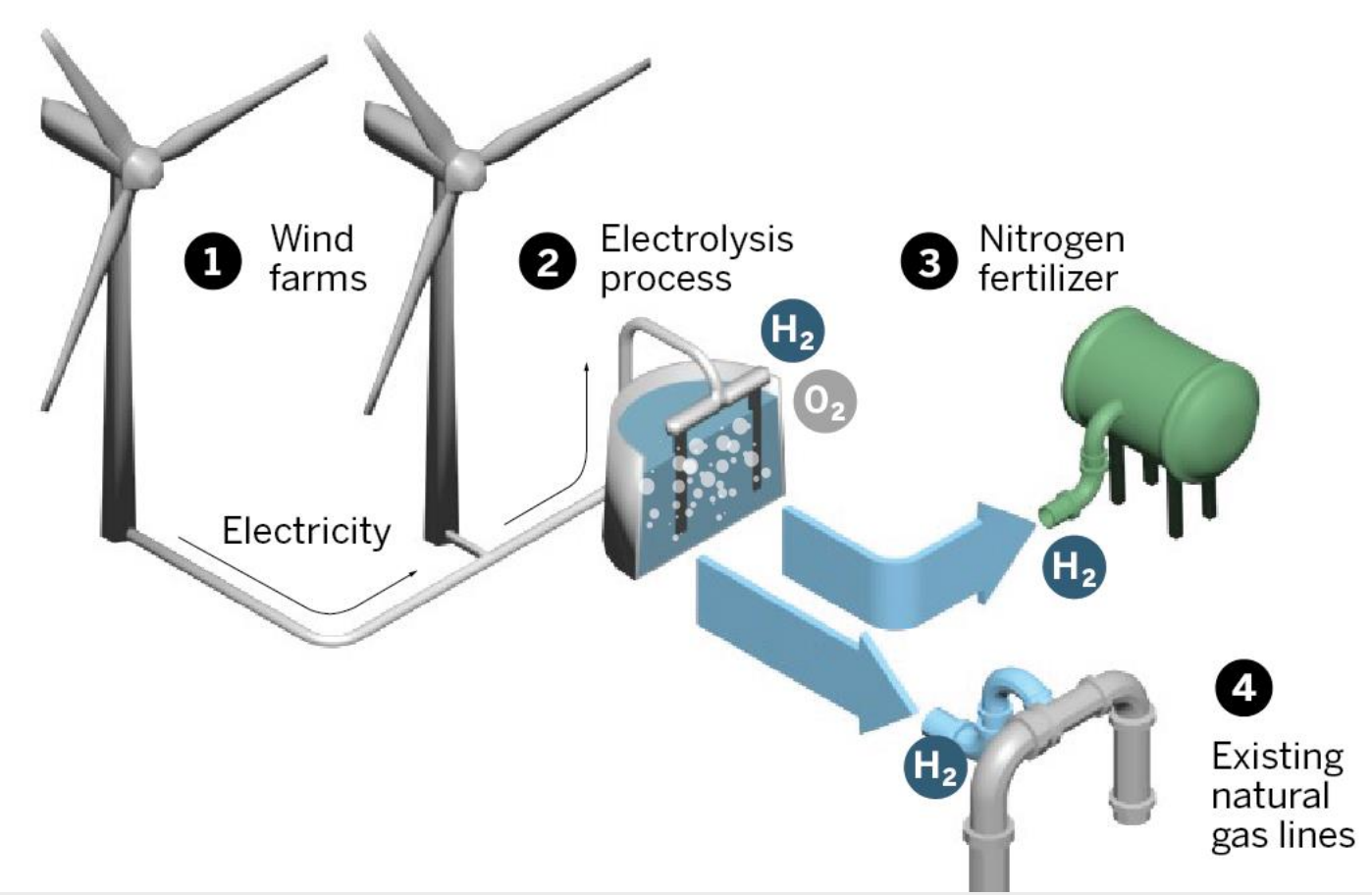
Disclaimer!



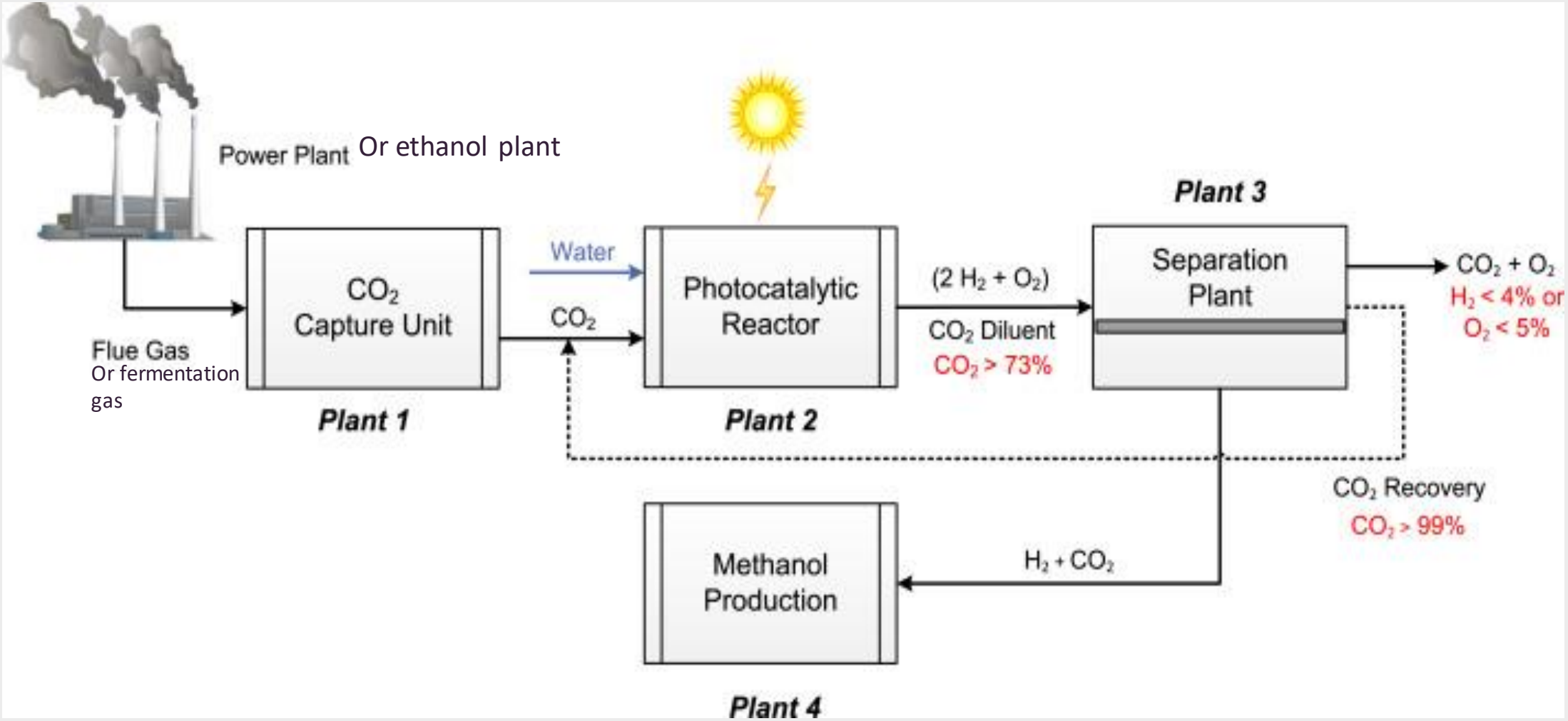
Hydrogen Mediated CO_2

- **A process involving hydrogen gas (H2) to convert carbon dioxide (CO2) into other useful chemicals or fuels.**
  - **Fertilizer (urea or ammonia)**
  - **Synthetic chemicals**
  - **Liquid fuels**
    - **Sustainable Aviation Fuel (SAF)**
    - **Methanol**
    - **Dimethyl Ether (DME)**
    - **Synthetic Diesel**

Basic Use Case



More Complicated Use Case



Inflation Reduction Act

- $369 billion in Energy Security and Climate Change programs over 10 years
- Reduce carbon emissions by roughly 40% by 2030
- Creates new Hydrogen (Section 45V) and Clean Fuel (45Z) Tax Production Credit
- Expanded Advanced Energy Project Investment Tax Credit (Section 48C ITC). Under the expanded Section 48C ITC, the IRA will award tax credits of up to 30% for a manufacturer's qualified investment in a qualifying advanced energy project:
  - projects to re-equip, expand or establish an industrial or manufacturing facility for the production or recycling of advanced energy components such as property designed to produce energy from solar, hydro, wind, geothermal deposits or other renewable sources (e.g., solar modules, inverters, and batteries);
  - projects that re-equip an industrial or manufacturing facility with equipment designated to reduce greenhouse gas emissions by at least 20%; and

Clean Hydrogen / Clean Fuel

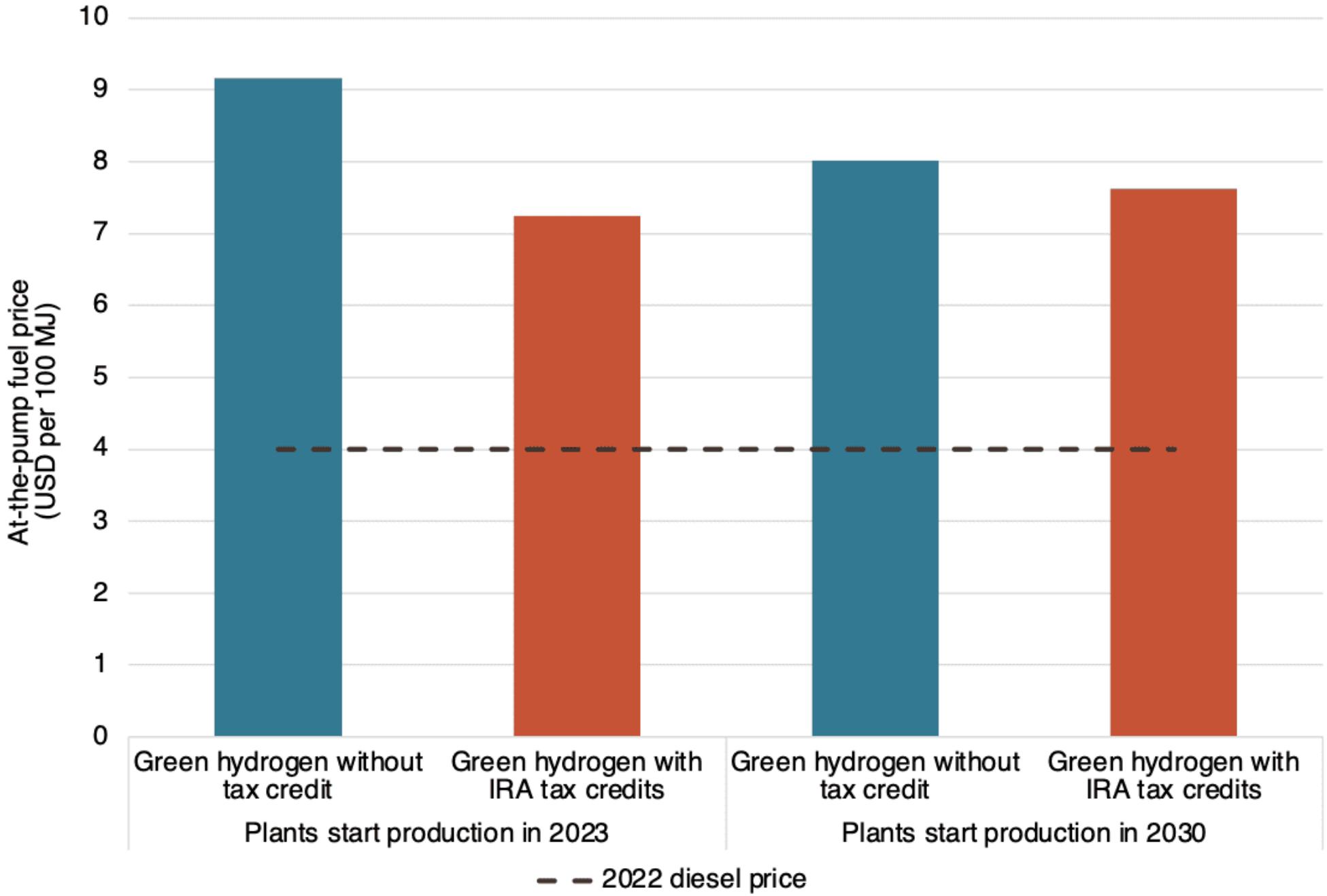
Clean Hydrogen – 45V:

- Tax credit of up to $3 per kilogram (kg)
  - based on the life-cycle greenhouse gas emissions rate of CO2 produced at a qualifying facility during the facility's first 10 years of operation.
  - If electricity produced from renewable resources is used, may be able to claim the clean hydrogen PTC in addition to tax credits on the renewable energy generation,
    - a clean hydrogen PTC may not be claimed in conjunction with a Section 45Q tax credit.

Clean Fuel – 45Z:

- After December 31, 2024 and ends December 31, 2027 (unless extended…)
- The Clean Fuel Production Tax Credit will be $1.00/gallon.
- Significantly higher PTC tax credits for SAF production
- Emissions Rate standards apply

Kg of CO_2 per kg of H_2	Credit Value ($)
4 - 2.5 kg CO_2	$0.60 / kg of H_2
2.5 - 1.5 kg CO_2	$0.75 / kg of H_2
1.5 - 0.45 kg CO_2	$1.00 / kg of H_2
0.45 - 0 kg CO_2	$3.00 / kg of H_2


10
9
8
7
6
5
4
3
2
1
0
At-the-pump fuel price (USD per 100 MJ)
Green hydrogen without tax credit
Green hydrogen with IRA tax credits
Green hydrogen without tax credit
Green hydrogen with IRA tax credits
Plants start production in 2023
Plants start production in 2030
2022 diesel price

Thank you.

Todd Taylor:
ttaylor@avisenlegal.com
612-325-5036

Alex Frescoln:
afrescoln@avisenlegal.com
515-490-5476


Avisen

Audience Q & A

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Mauricio Medici

Licensing & Business Development Manager, Stamicarbon

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12/8/2023

SUSTAINABLE FERTILIZER PRODUCTION – FROM GREEN AMMONIA TO CIRCULAR UREA - UAN

THE FAST TRACK TO A MORE SUSTAINABLE FUTURE

Mauricion Medici, New Business Development Manager

Minnesota Renewable Round Table Dec 2023

STAMICARBON

ABOUT US: STAMICARBON

- Stamicarbon is the world leader in the licensing and design of **urea, nitric acid, DEF, UAN plants** and related services, including the supply of proprietary equipment.
- Stamicarbon launched its own "**Stami Green Ammonia Technology early 2020"** suitable for small-mid scale plants aiming to support he Fertilizer industry decarbonization.
- Active in licensing of various technologies and in **project development** for the fertilizer and petrochemical industry.
- A **pioneering company** with a single-minded vision to help enable the world to feed itself and improve quality of life focused to **reduce the carbon footprint from the fertilizer industry, including carbon recycling**.

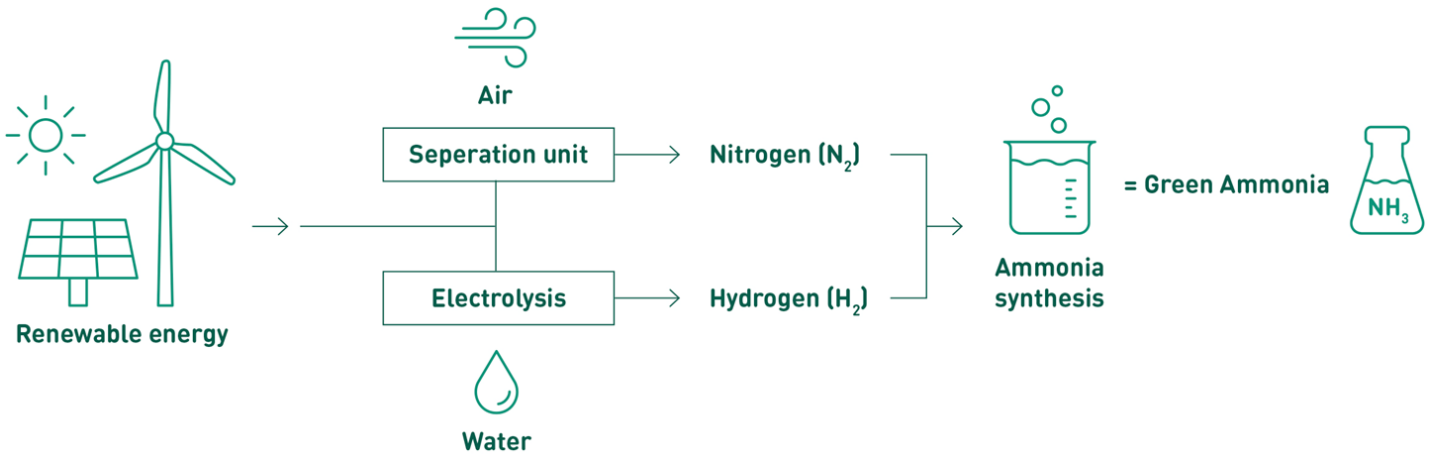
THE FUTURE IS SUSTAINABLE

To give hope to the next generation the food value chain needs to become more sustainable and ways of realizing affordable green energy storage need to be realized.

We believe Green Ammonia can play a key role in these challenges.

And here's why…

WHAT'S GREEN AMMONIA

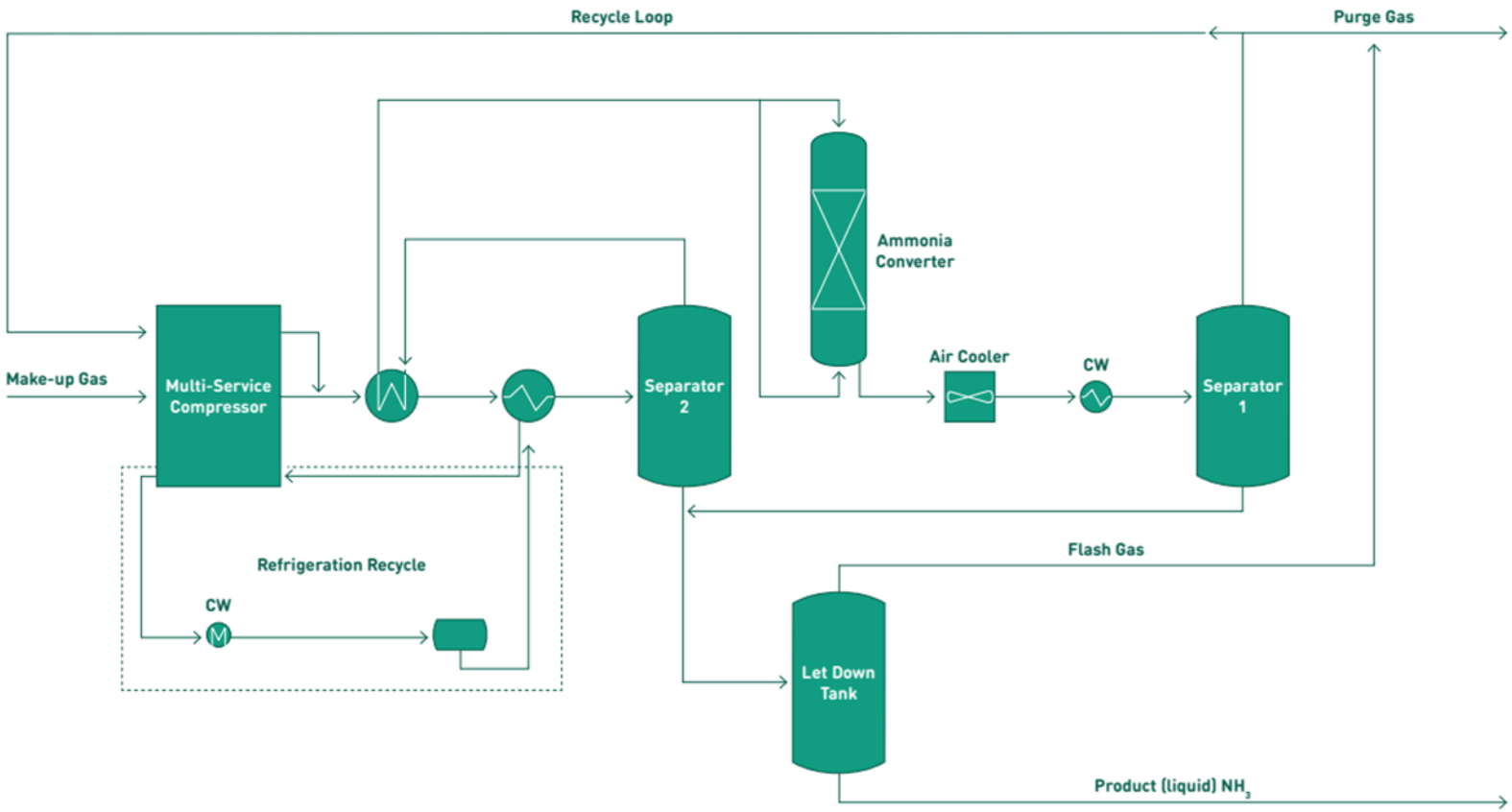


DID YOU KNOW?

As it's a liquid ammonia is easy to store and transport to plants where it can be used as feedstock. So green ammonia is an excellent vector to transport energy.

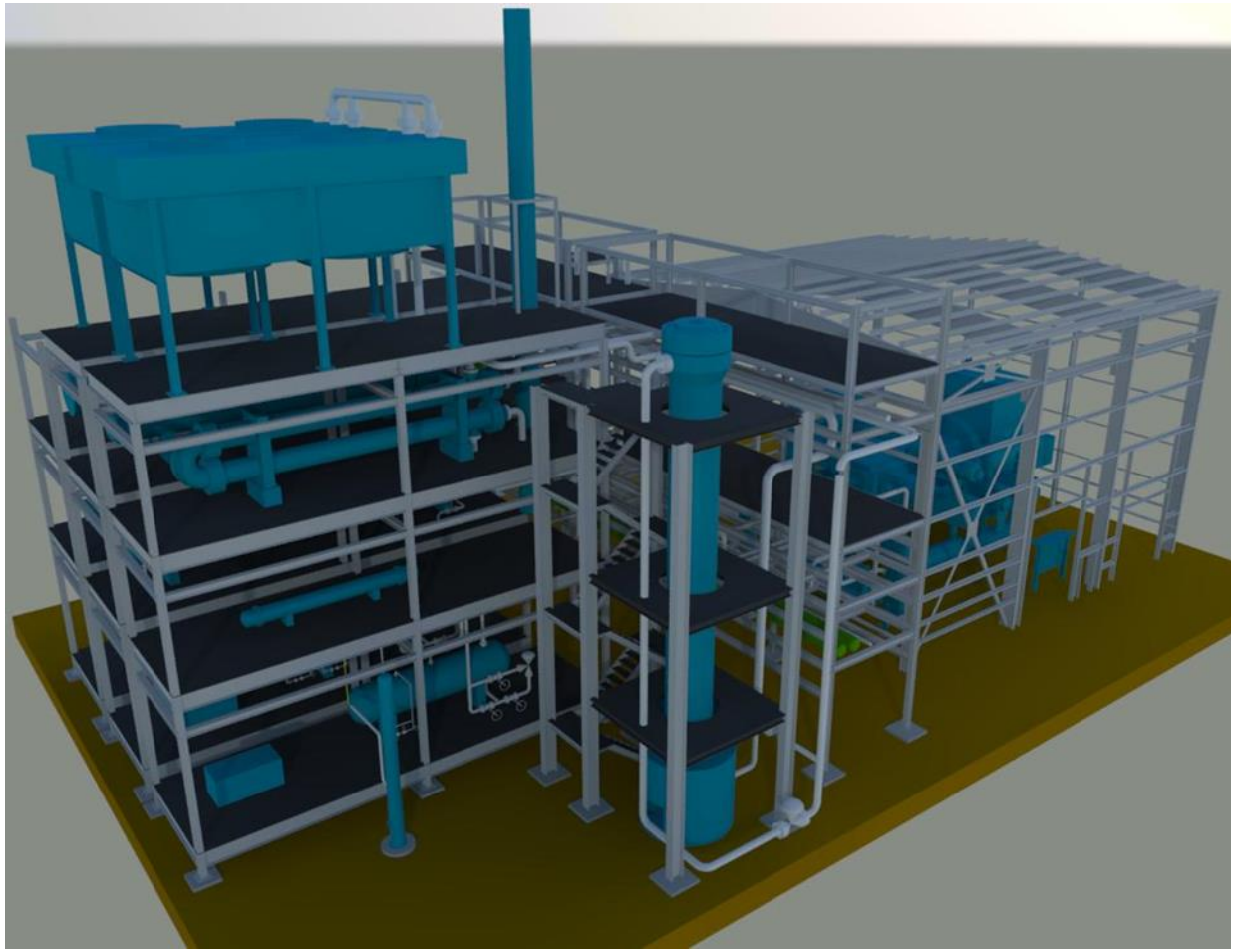
And the infrastructure is already in place. There's a worldwide network of ports, pipelines, storage facilities and well-established shipping routes.

STAMI GREEN AMMONIA TECHNOLOGY PROCESS FLOW DIAGRAM



- Proven Haber-Bosh process.
- Lean design, minimum nr of equipment - simple Hex and separator vessels.
- Single reciprocating compressor.
- High conversion rate with low catalyst volume.
- Majority of produced NH3 is condensed by means of CW.
- Integrated NH3 refrigeration circuit.
- Typical turn down ratio 40%
- Minimum Utilities requirement:
  - CW
  - Instrument air
  - No steam/condensate is produced or required.

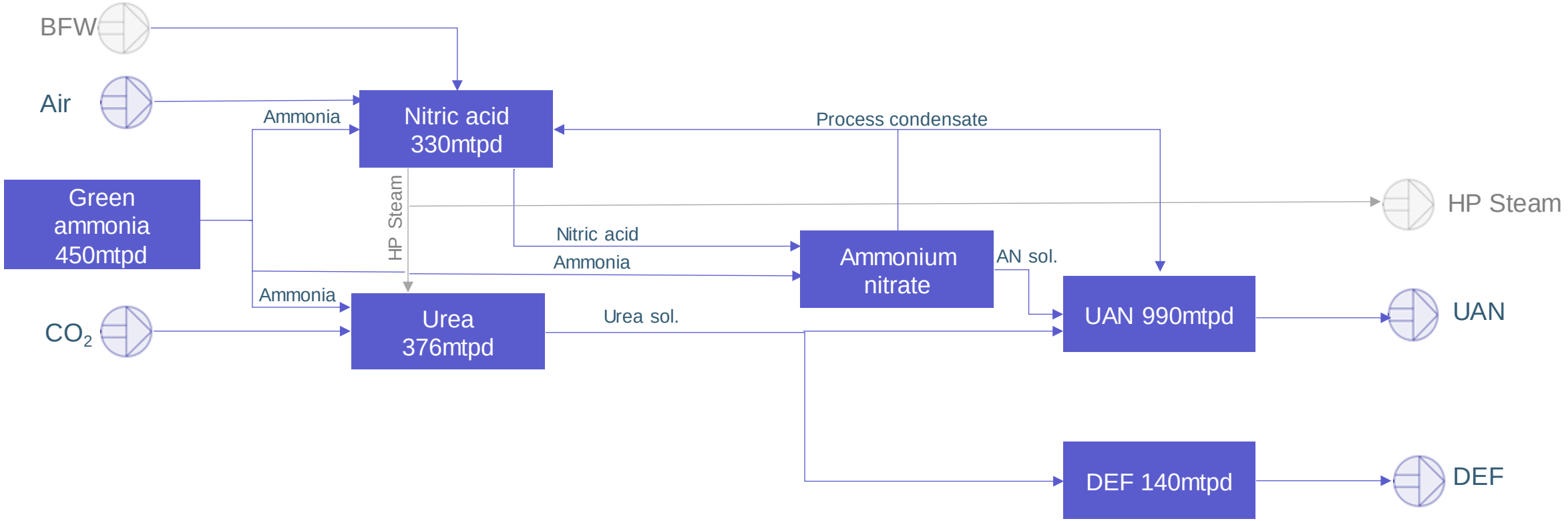
STAMI GREEN AMMONIA TECHNOLOGY
3D MODEL VIEW OF A 450MTPD PLANT



A ONE-STOP-SHOP FOR SMALL-MID SCALE GREEN FERTILIZERS PLANTS

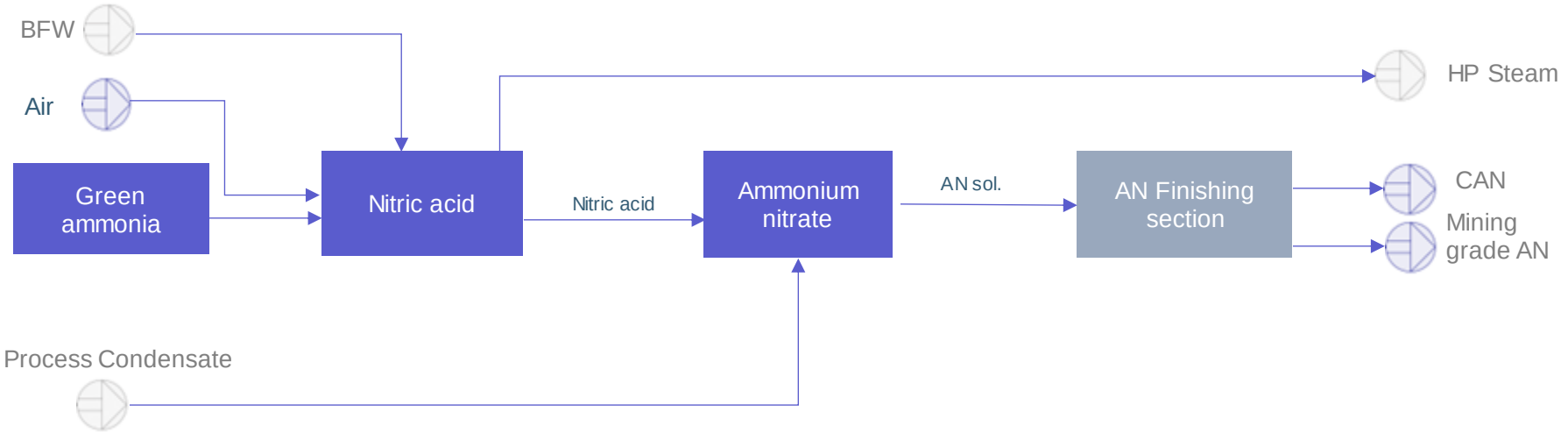
- Stamicarbon developed a new standard for the green ammonia market, integrating with urea, nitric acid and ammonium nitrate processes at small-mid capacities
- Our Stami technology packages includes the license and the engineering requirements to build small-mid scale sustainable fertilizer plants of standardized capacities
- Together with sister companies we can also help you with project development, feasibility studies, financing and complete E&C solutions.

ALL THE WAY FROM GREEN NH3 TO UAN AND DEF IN THE US MIDWEST UNDER ENGINEERING PHASE



* Gothenburg Fertilizers complex (UAN-DEF – Green NH3 Early Works under execution by KT, construction to start Q2-2024

ALL THE WAY FROM GREEN NH3 TO NITRATE FERTILIZERS



- Kenya Green Fertilizers - CAN production – Feasibility Study Completed by NextChem.
- Greenfield Nitrogen - Iowa, Green NH3 – Feasibility Study Completed by NextChem.
- Minbos Resources - Angola (CAN & Mining grade AN – Feasibility Study Completed by Stamicarbon

FINAL REMARKS

Stami Green Ammonia technology is a perfect solution to decarbonize the fertilizer industry and more.

Small - Medium size plants play a crucial role to bridge the technological gap in accelerating the Green Ammonia transition to decarbonize various industry sectors.

Stami Green Ammonia technology is a lean, proven, robust and reliable design.

Green Nitrate fertilizers plants are available today, based on proven technologies as well as Circular Urea.

Stami Green Ammonia is the “most competitive technology design” for small and mid-scale applications both in Capex and Opex.

THANK YOU

STAMICARBON

Feel free to contact me for more information: ***Mauricio.medici@stamicarbon.com***

Audience Q & A

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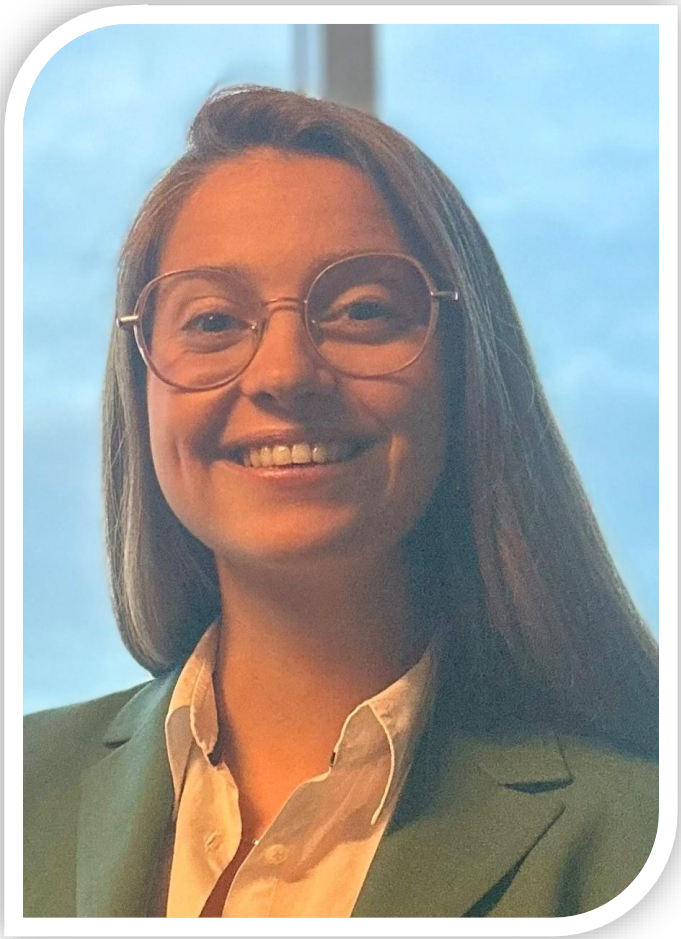

Nathalie Beken

Investment Associate

Azimuth Capital Management

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CAPITAL MANAGEMENT

Hydrogen-mediated CO_2

2023 Minnesota Renewable Energy Roundtable

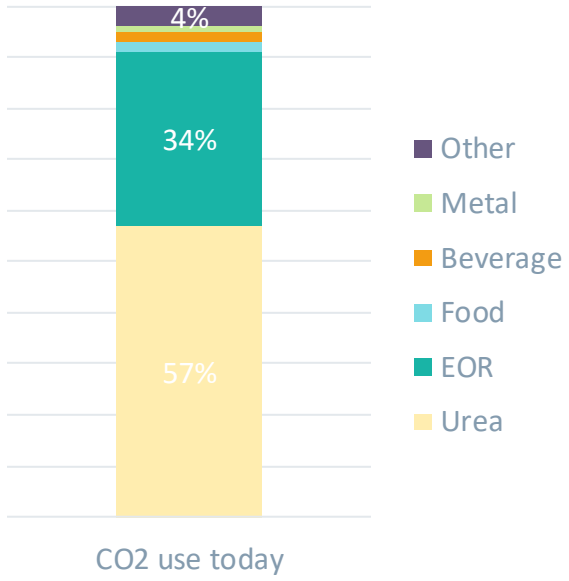
December 2023

What is hydrogen-mediated CO_2?

And why is it important?

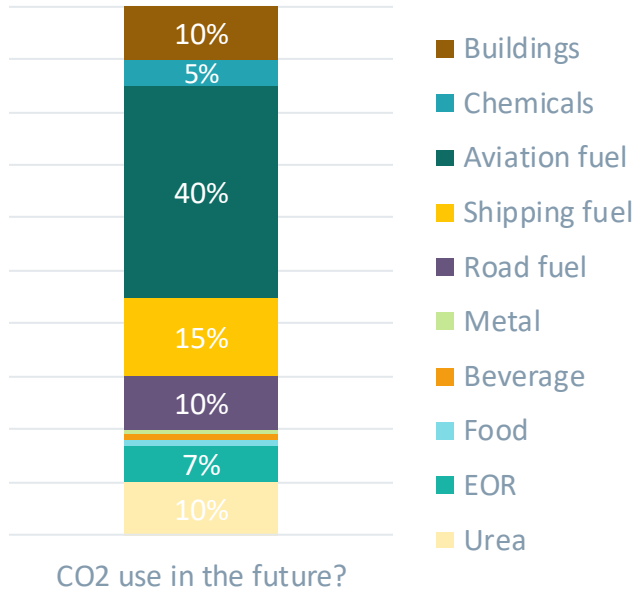
CO_2 production and use today[1]

- CO_2 is produced from fossil fuel processing
- CO_2 is used for Urea production, EOR, Food & Beverages, Metal production, …



CO_2 production and use in the future[2] – hydrogen mediated?

- CO_2 could be produced from Direct Air Capture, point capture of cement, power plants, ethanol, SMR plants, fermentation…
- CO_2 can be combined with hydrogen to make valuable hydrocarbons which can be used as fuels, but also to make chemicals or use in the building industry



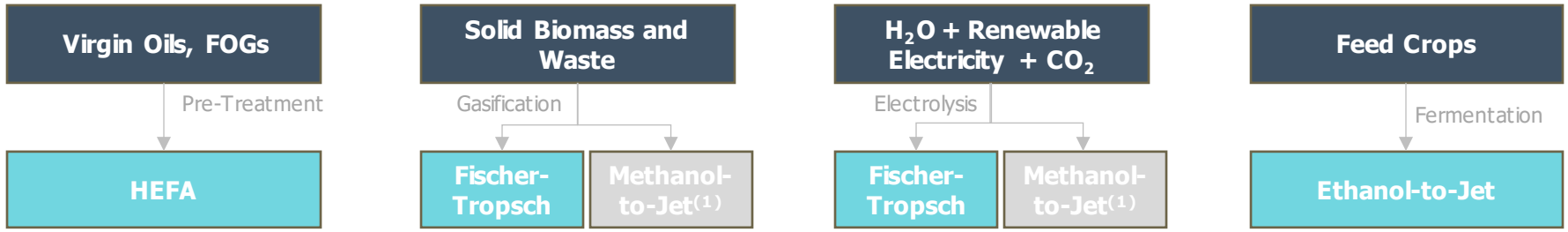
Howard Herzog, Senior Research Engineer at MIT Energy Initiative stated: "The amount of CO_2 we can use is simply dwarfed by the CO_2 that needs to be captured for climate reasons. If we're going to do this on the billion ton a year level, most of it's going to have to go into the ground." - Even better would be using the carbon to create valuable hydrocarbons.

1) Putting CO_2 to use, IEA, Sep 2019
2) Example hypothesis

Azimuth focuses on hydrogen-mediated CO_2 in the context of SAF

eFuels are just one of the many different SAF pathways available

Each has notable pros and cons linked to feedstock availability, technical maturity of method and resulting carbon intensity



	HEFA	Fischer-Tropsch	Methanol-to-Jet(1)	Ethanol-to-Jet
Advantages	▪ Can be fed into existing refinery processes ▪ Only currently commercially producing pathway	▪ Waste and solid biomass are cheap and widely available feedstocks	▪ Lowest Carbon Intensity (CI) ▪ Potential to produce limitless quantities of jet fuel	▪ Higher SAF yield than HEFA (91% vs. 78%) ▪ Mature process steps ▪ New market to support US corn ethanol industry that supplies volumes to gasoline blending
Disadvantages	▪ Finite feedstock availability	▪ Feedstock handling and pre-treatment of solid biomass is expensive and challenging ▪ Hard to make a positive business case out of transporting waste ▪ Methanol-to-jet not yet a valid pathway	▪ Prohibitively expensive until cost competitive electrolytic hydrogen and CO_2 feedstocks will be available ▪ Methanol-to-jet not yet a valid pathway	▪ High capital requirements ▪ Significant water consumption ▪ Carbon Intensity reduction is controversial and depends on exact production method ▪ Competition with food industry
CO_2 reduction potential(2)	>80%	>85%	Up to 100%	15-80%

1) Not an approved ASTM pathway – anticipated in 2024
2) CORSIA, ICCT paper 2021-11, WEF+McKinsey 2020-11

Azimuth focuses on hydrogen-mediated CO_2 in the context of SAF

eFuels are just one of the many different SAF pathways available

Each has notable pros and cons linked to feedstock availability, technical maturity of method and resulting carbon intensity

	Virgin Oils, FOGs	Solid Biomass and Waste		H_2O + Renewable Electricity + CO_2		Feed Crops
	Pre-Treatment	Gasification		Electrolysis		Fermentation
	HEFA	Fischer-Tropsch	Methanol-to-Jet(1)	Fischer-Tropsch	Methanol-to-Jet(1)	Ethanol-to-Jet
Advantages	▪ Can be fed into existing refinery processes ▪ Only currently commercially producing pathway	▪ Waste and solid biomass are cheap and widely available feedstocks		▪ Lowest Carbon Intensity (CI) ▪ Potential to produce limitless quantities of jet fuel		▪ Higher SAF yield than HEFA (91% vs. 78%) ▪ Mature process steps ▪ New market to support US corn ethanol industry that supplies volumes to gasoline blending
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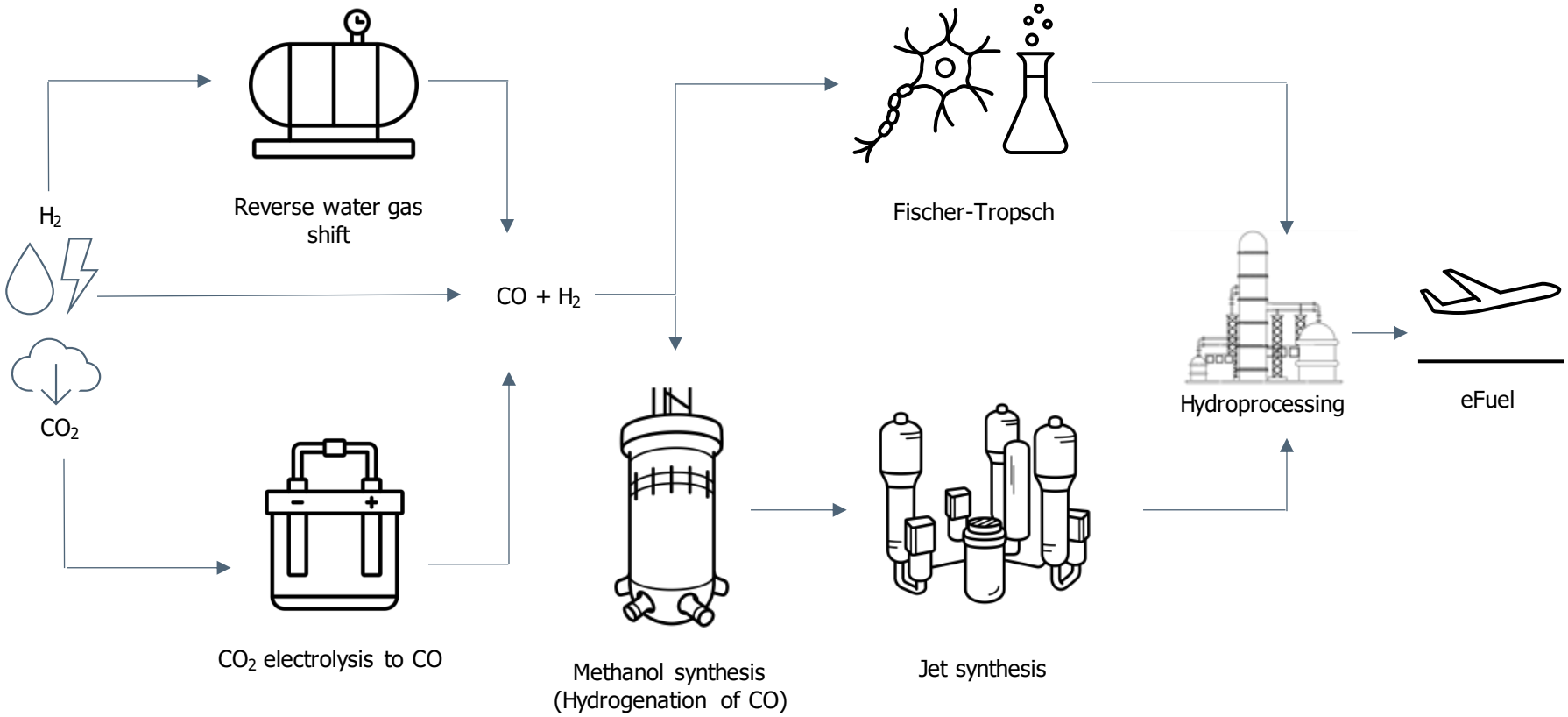
CO_2 reduction potential(2)	>80%	>85%		Up to 100%		15-80%

eFuels

1) Not an approved ASTM pathway – anticipated in 2024
2) CORSIA, ICCT paper 2021-11, WEF+McKinsey 2020-11

Two routes exist for the production of eFuels

Fischer-Tropsch or jet synthesis from methanol



Whichever route is taken, CO_2 and low-carbon hydrogen are the necessary building blocks

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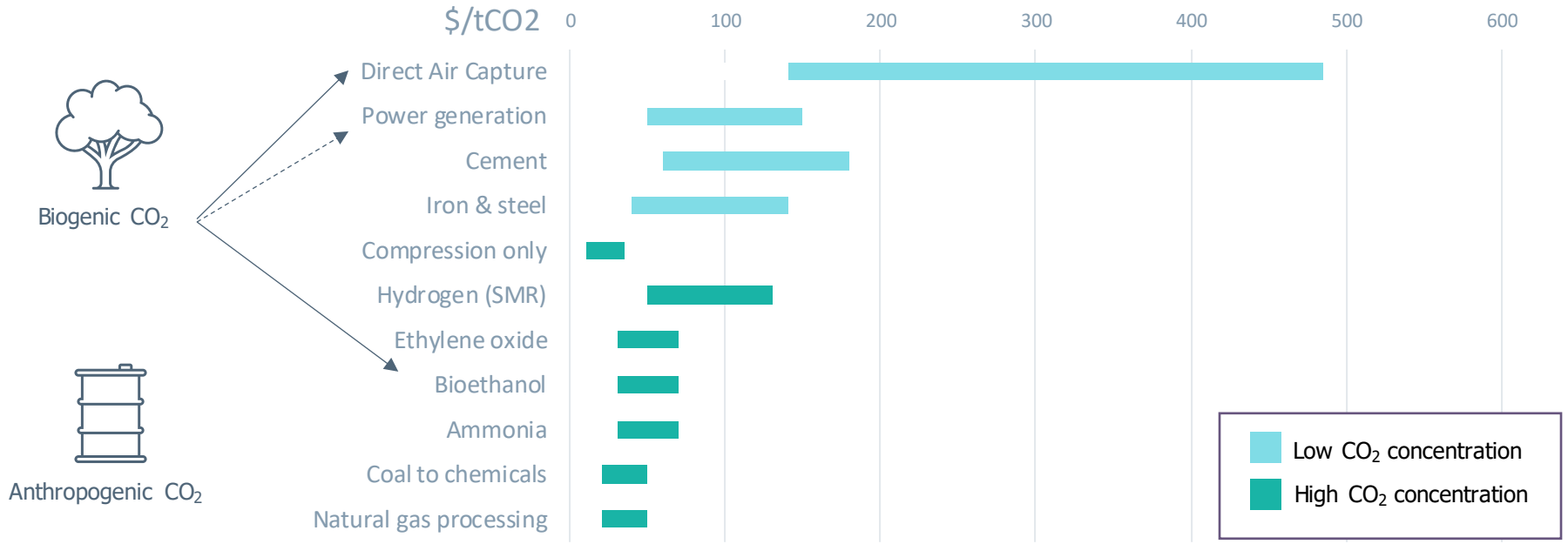
What will be the biggest challenge to successfully scale the production of eFuels?

ⓘ Start presenting to display the poll results on this slide.

Reasonably-priced feedstock availability will be a big challenge

Potential sources of CO_2, their cost(1) and transport options



Historical CCUS projects failures

- According to DOE, there were 149 CCUS projects announced globally
- By 2020, 100 of those projects had been terminated
  - >70% of gas processing projects have succeeded
  - This is 60% for other industrial projects
  - And only 10% of power plant projects
- Main reasons of failure are threefold
  - Higher project capital costs
  - Lower level of technological readiness
  - Low credibility of CO_2 revenues

CO_2 transport

- Gaseous (pipeline) or liquid form (shipping and tanks)
  - In US, 2500 km of CO_2 pipelines exist, mostly for EOR projects in Texas
  - CO_2 is transported overseas but in limited amounts because of limited demand
- Commercial pipelines for CO_2 transport & storage are a commercial challenge, cfr. Cancellation of Heartland Greenway Pipeline Projects by Navigator CO_2 Ventures

→ Even if CO_2 can be captured, its transport will be the next challenge

1) *Is carbon capture to expensive?,* IEA, Feb 2021

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What market incentive exists to use biogenic CO2 instead of anthropogenic CO2?

ⓘ Start presenting to display the poll results on this slide.

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What is the likelihood of a CO2 pipeline connecting the US farm belt being built?

ⓘ Start presenting to display the poll results on this slide.

Reasonably-priced feedstock availability will be a big challenge

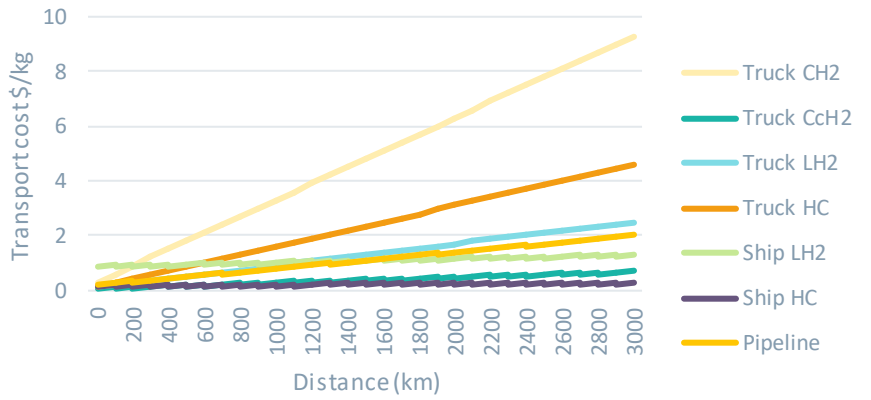
Potential sources of H_2, cost(1) and transport options

	Grey		Green		Blue	Turquoise	Pink	Other
	SMR	*High electrolyzer CAPEX cost* *High electricity OPEX cost*	Electrolysis renewable electricity	*Alternative, cheaper sources of low-carbon H_2*	SMR with carbon capture	Methane pyrolysis	Electrolysis nuclear electricity	E.g. waste gasification
Avg cost today	2 $/t		6 $/t		3.5 $/t	2.5 $/t	2.5 $/t	1 $/t
Production vol 2022	94 Mt		<1 Mt		<1 Mt	<1 Mt	<1 Mt	<1 Mt

H_2 transformation and transportation costs are significant

- Hydrogen is transported in compressed gaseous form (pipeline or truck), compressed cryogenic form (truck), liquified (ship or truck), or through means of a carrier like ammonia (ship or truck)
- Transformation costs vary
  - Compressed gaseous (500 bar) ~1$/kg
  - Compressed cryogenic (350 bar) ~2$/kg
  - Liquified (12 bar) ~3$/kg
  - Conversion to carrier and back ~2$/kg
- The best transport method varies with distance but adds between 0.5 and 2 $/kg (see graph on the right)

H_2 transport costs for different means of transport(2)



1) *Analysing the future cost of green hydrogen,* PwC, Feb 2023; Green and Blue Hydrogen Current Levelized Cost of Production and Outlook, GEP, Jan 2023; *Whether green, blue, or turquoise, hydrogen needs to be clean and cheap*, Bulletin of the Atomic Scientist, Jan 2021
2) Berna, Cesar & Vargas-Salgado, Carlos & Alfonso-Solar, David & Escrivá, A.. (2022). Hydrogen Production from Surplus Electricity Generated by an Autonomous Renewable System: Scenario 2040 on Grand Canary Island, Spain. Sustainability. 14. 10.3390/su141911884.

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What will the 2035 merit order supply curve of SAF look like?

ⓘ Start presenting to display the poll results on this slide.

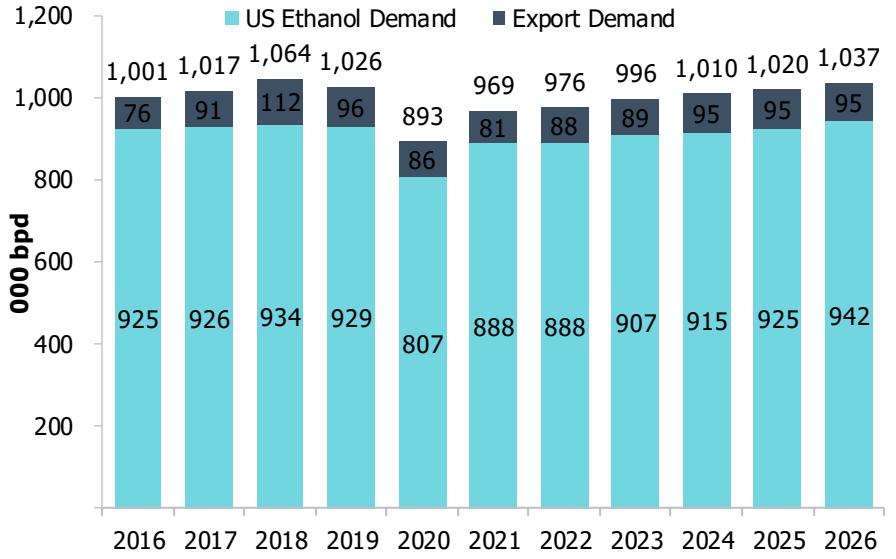
AtJ seems most logical pathway until H_2 & CO_2 production scale up

Subsidies, maturity of industry and optionality of AtJ solution help to de-risk investment

SAF Revenue Drivers: US Current Structures

SAF Premium to Conventional Jet Fuel	▪ Assumed premium to capture additional costs of producing SAF over traditional fuel (i.e., more hydrogen, natural gas, capex etc.)
D4 RIN Value	▪ SAF qualifies under the Renewable Fuel Standards policy, however, it generates fewer RINs per gallon than renewable diesel (1.6 vs. 1.7 respectively)
LCFS	▪ Petroleum jet fuel is not a deficit generating fuel in active LCF program and therefore does not incur LCF compliance costs which would increase the value of the alternative renewable fuel (SAF)
SAF Blenders Tax Credit	▪ $1/gallon tax credit until 2025. New clean fuels production tax credit (45Z) will provide up to $1.75/gallon tax credit depending on CI reduction until 2027
Renewable Diesel	▪ AtJ processes produce up to 91% SAF with remaining balance to renewable diesel. RD generates 1.7 RINs per gallons and obtains blenders tax credit (until 2025)

US ethanol plants had 87% utilization rate in 2022

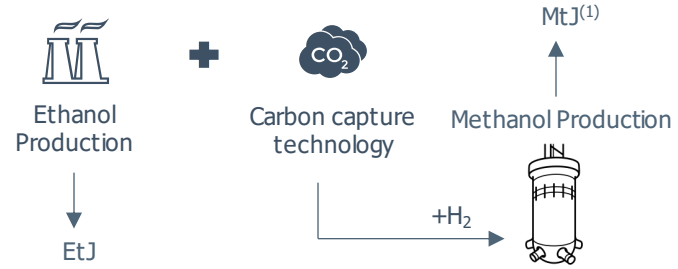


AtJ optionality

Feedstock optionality

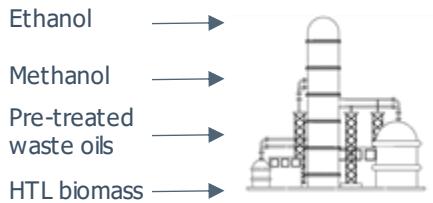
- Corn
- Agricultural waste
- Sugarcane

Carbon-capture optionality (even in combinational with MtJ(1) production)



End-use optionality

Hydroprocessing is universal



1) Not an approved ASTM pathway – anticipated in 2024.

Azimuth and $1B Fund V at a glance

Experienced Energy Transition GP Raising Fifth Fund Targeting PE Returns and Quantified Carbon Mitigation

Azimuth Capital Management

History & Geographic Reach

Azimuth has **20 years of investing experience**, with a total AUM $5.8 billion[1] and offices in the San Francisco Bay Area and Calgary, along with team presence in Denver, Houston, Seattle, Vancouver and New York.

Operating Experience

Every Partner and Operating Partner on the Azimuth team has a technical background or has worked as an operational leader.

TESLA voltera Shell ExxonMobil Schlumberger bp

Executable Opportunities

The fund has **four ready-to-execute inception opportunities** that offer unique return and impact outcomes along with scaled co-invest.

RECOVER H Cycle MOUNTAIN VIEW CLEAN ENERGY monolith

AVEE Strategic Focus

Low Carbon Fuels

60% of Fund V

Clean Hydrogen Production

Waste to Fuels

Carbon Capture and Sequestration

Resources to Support Electrification

20% of Fund V

Sustainable Lithium Production

North American Battery Material Production

End of Life Battery Recycling

Low Carbon Electricity Production and Storage

20% of Fund V

Decarbonized Fuel Storage

Optimized Geothermal Power

AVEE targets areas of the energy transition that are less crowded and offer larger opportunity for economic and environmental performance.

AZIMUTH CAPITAL MANAGEMENT

1) All amounts are stated in Canadian dollars; past performance is not indicative of future performance. Includes funds and co-invest, realized and unrealized value as at December 31, 2022.

Thank you!

Curious to hear your thoughts and connect during the next networking break, or feel free to reach out.

Nathalie Beken
Investment Associate
nathalie@navigatingenergy.com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