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Hydrogen Enabled Biofuels

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Cecilie Engell Sorensen

General Manager,

Biogasclean North America

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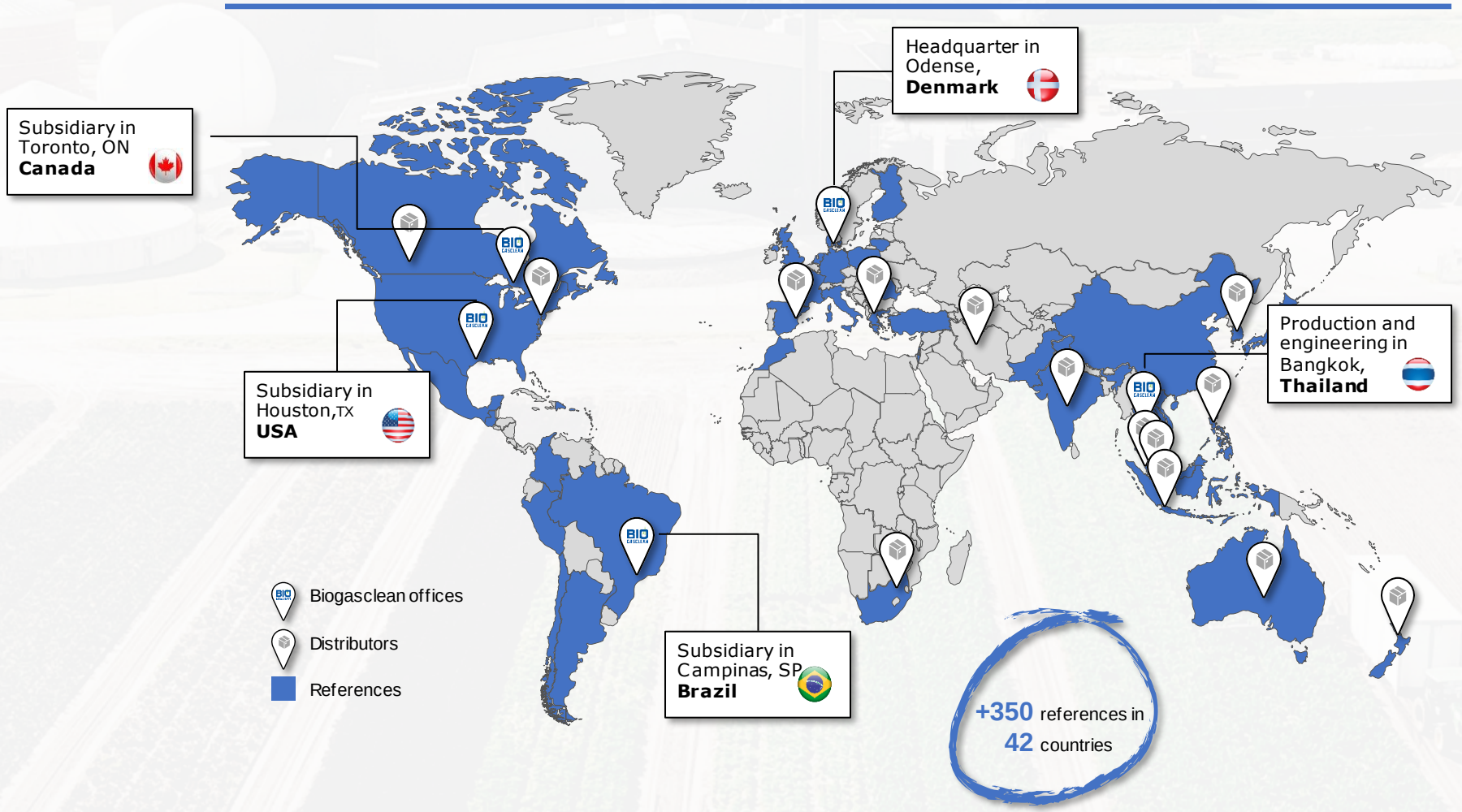
Biogasclean Americas Inc.

-Hydrogen-Enabled biofuels, MN

Biological **methanation** of biogas and CO_2

BIO GASCLEAN | Innovative solutions for efficient production of biogas and e-fuels

Biogasclean Global footprint



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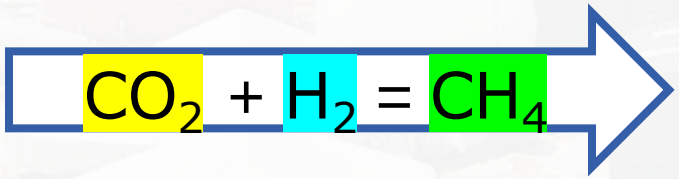
Bio E-Fuel



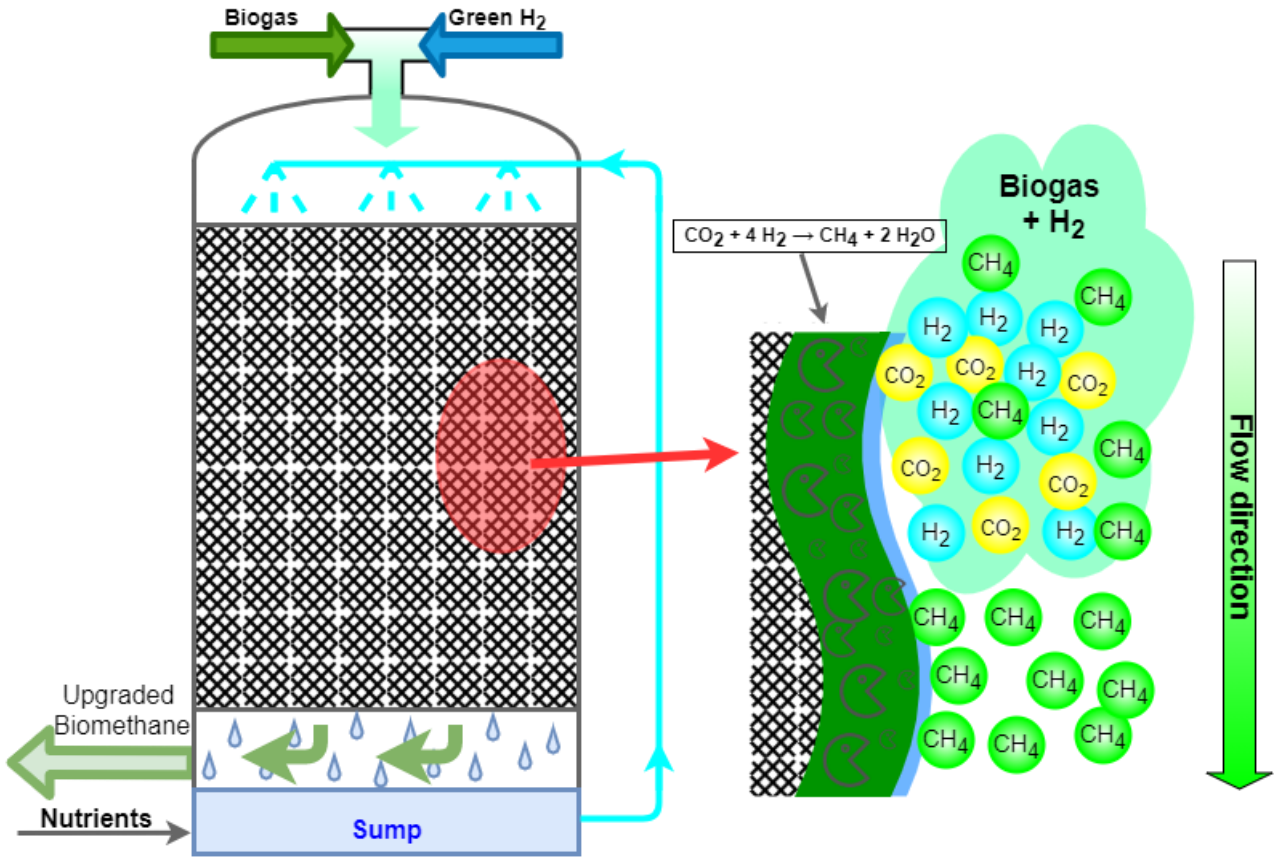
Biological Methanation of CO2

- ❑ Biological process **converting carbon dioxide (CO_2) and hydrogen (H_2) to methane (CH_4)** in a Bio Trickling Reactor.
- ✓ The lowest hanging fruit is biogas plants where the biogas typically consists of 55-60% CH_4 and 40-45% CO_2.
- ✓ Bio E-Fuel will enable biogas plants - from the same input of organic waste streams - to raise the concentration of methane in the biogas from 55-60% to +97% CH_4.
- ✓ The Bio E-Fuel technology is **not** restricted to biogas plants only; it can be applied everywhere where you have a CO_2 source.
- ❖ **Ethanol plants, Cement factories, Incineration plants, Refineries, etc.**

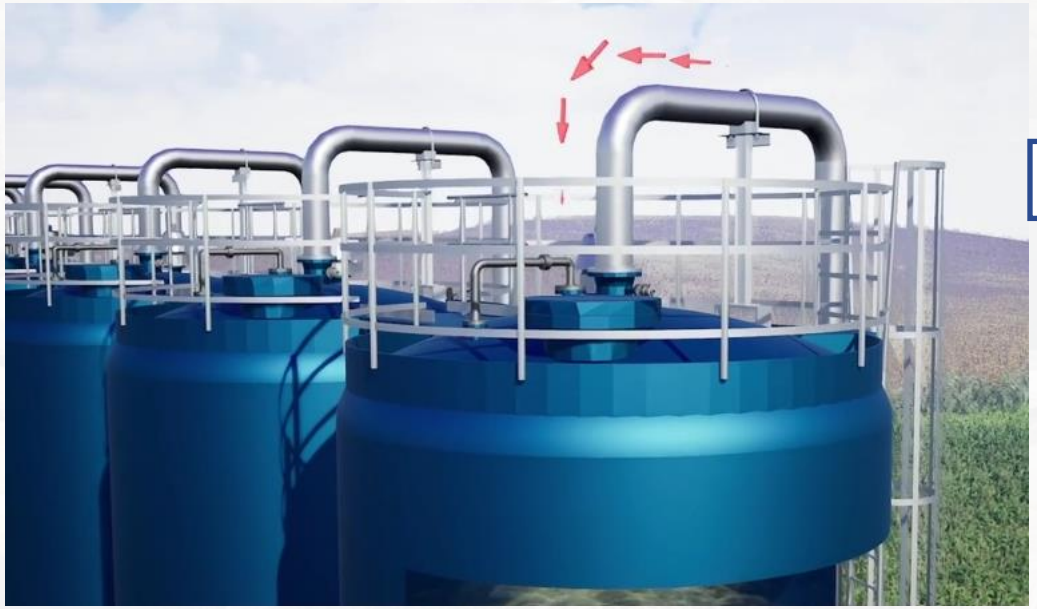
Process in Bio Trickling Reactor

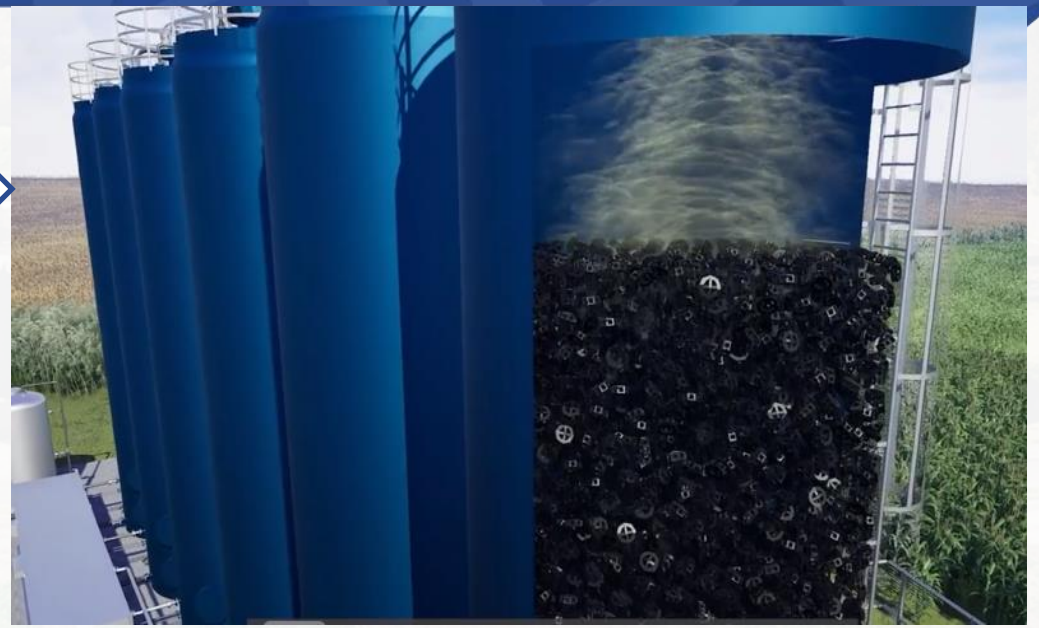
Biological Methanation

$4\ H_2 + CO_2 \rightarrow CH_4 + 2\ H_2O$



Bio E-Fuel





+97% CH4/methane

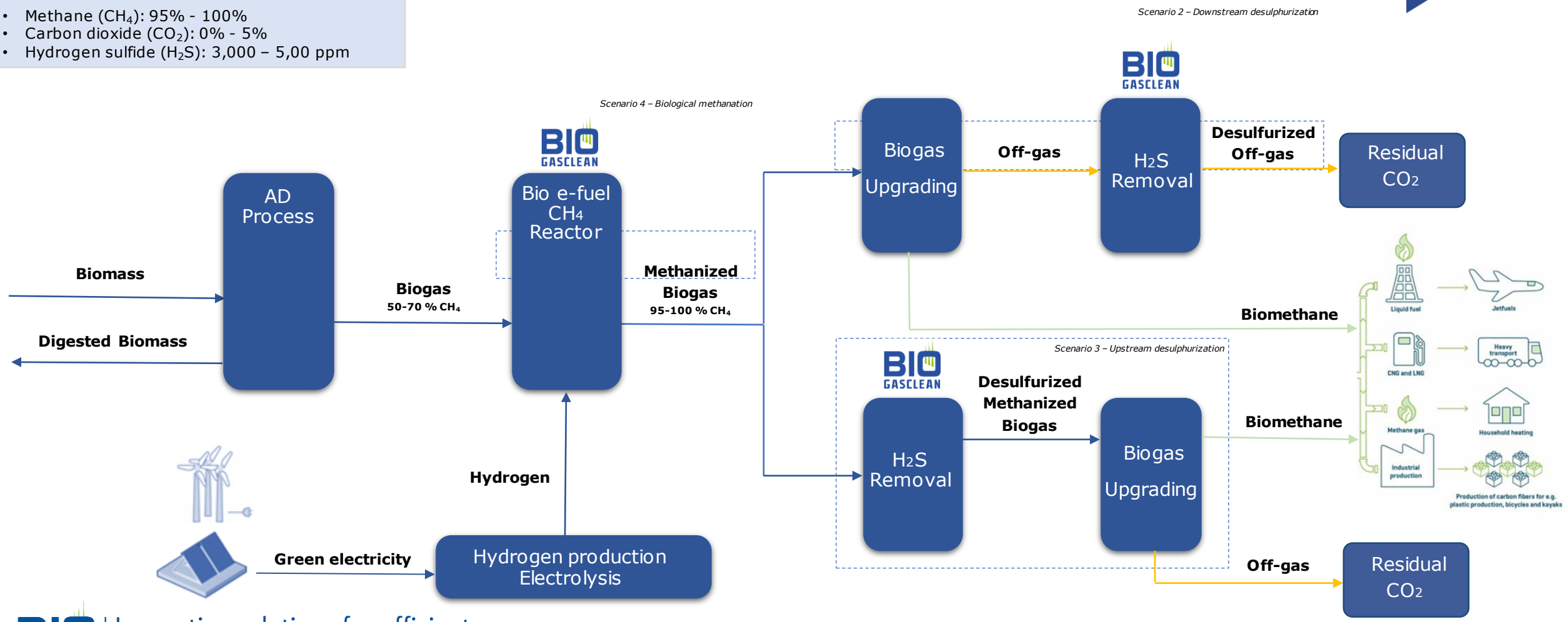
< 3% CO2, H2, etc.

BIO GASCLEAN | Innovative solutions for efficient production of biogas and e-fuels

Technologies
Biogas plants – Methanation & desulfurization

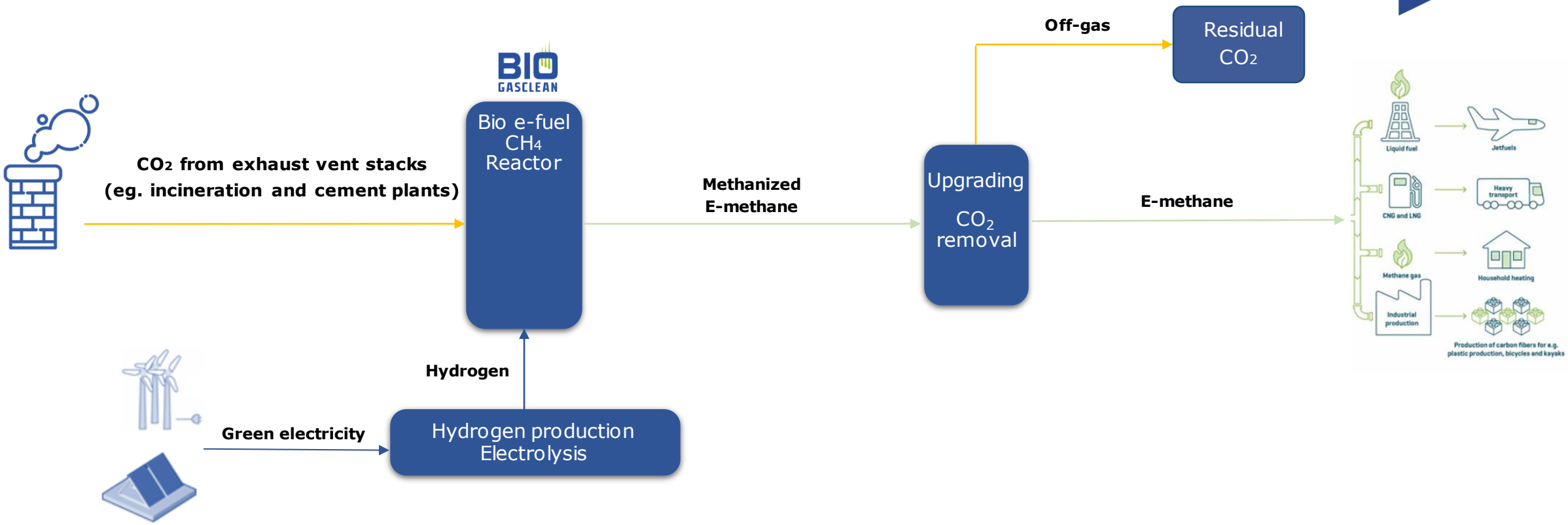
The composition of Methanized biogas is:

- Methane (CH_4): 95% - 100%
- Carbon dioxide (CO_2): 0% - 5%
- Hydrogen sulfide (H_2S): 3,000 – 5,00 ppm



BIO GASCLEAN | Innovative solutions for efficient production of biogas and e-fuels

Technologies
Carbon Capture & Utilization (CCU) – Methanation



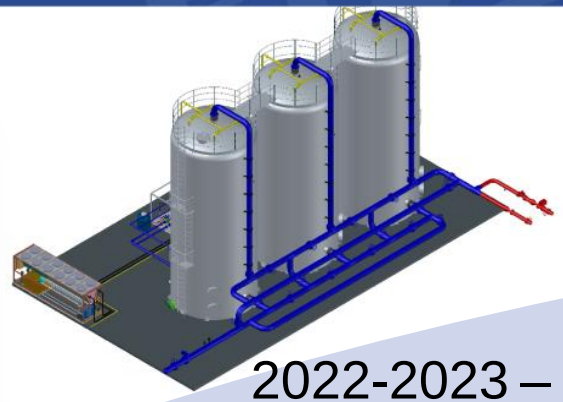
Carbon Capture and Utilization (CCU) projects aim to capture carbon dioxide (CO_2) from industrial processes or from the atmosphere and convert it into useful e-fuels, such as e-methane. Sources of captured CO_2 that can be used for CCU projects include:

I. Power plants and industrial facilities: Large sources of CO_2 emissions are power plants and industrial facilities such as cement and steel production, which release large quantities of CO_2 during their operations. Carbon capture technology can capture CO_2 from these sources and redirect it to CCU projects.

II. Direct air capture: Direct air capture (DAC) technologies use machines to capture CO_2 directly from the atmosphere. This method can be used to capture CO_2 that is not associated with an industrial process or for which there are no other sources.

III. Natural carbonates: Some natural carbonates can be mined and processed to capture CO_2, which can then be used in CCU

Bio E-Fuel Up-scale plan

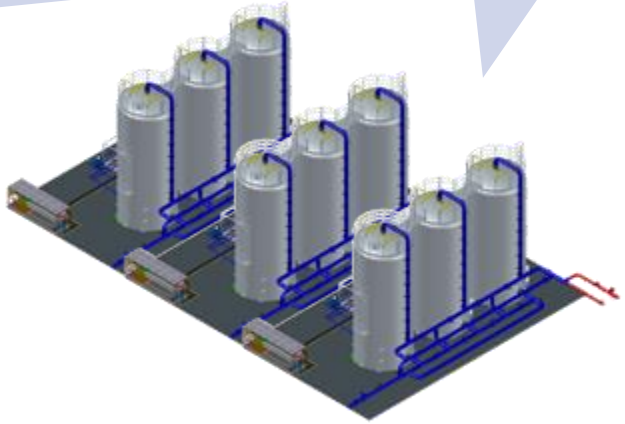


2019 - Lab scale

2021 – Pilot scale

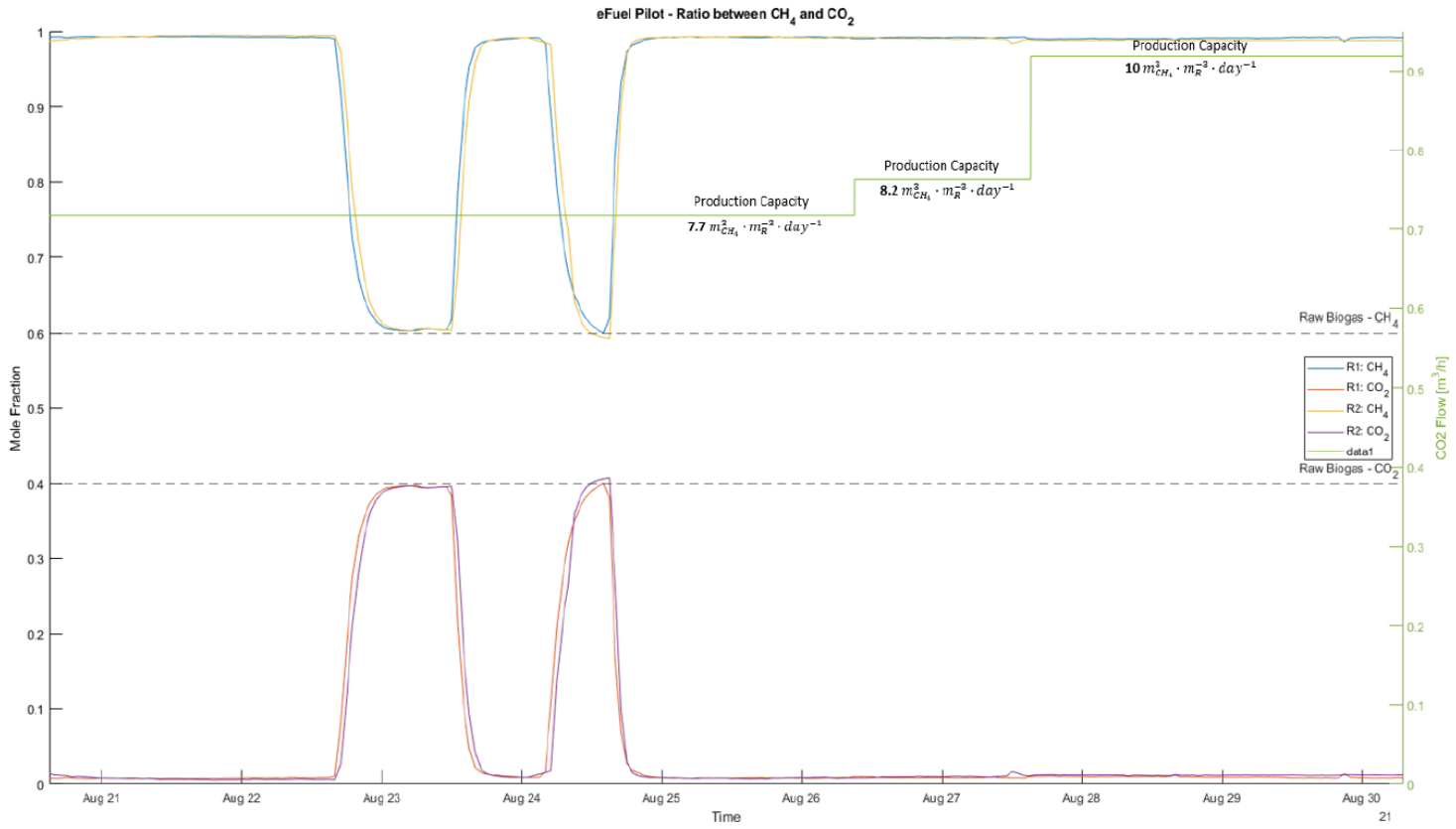
2022-2023 – Full scale

2024 – Multiple full scale



	Lab scale	Pilot scale	Full scale	Multiple Full scale
Effective reactor volume (m^3)	4 x 0.008	2 x 1	3 x 300	9 x 400
E-methane (m^3CH_4/day)	0.3	20	9,000	36,000
E-methane at full load (GWh/year)			32	130
Capacity of electrolyzer (MW)			7 MW	30 MW

Bio E-Fuel Stress Test



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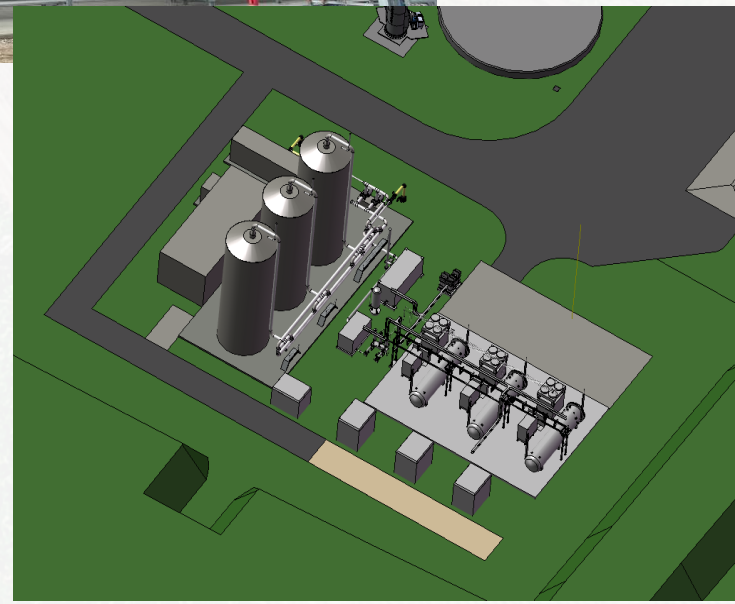
Nature Energy, Glansager - Methanation

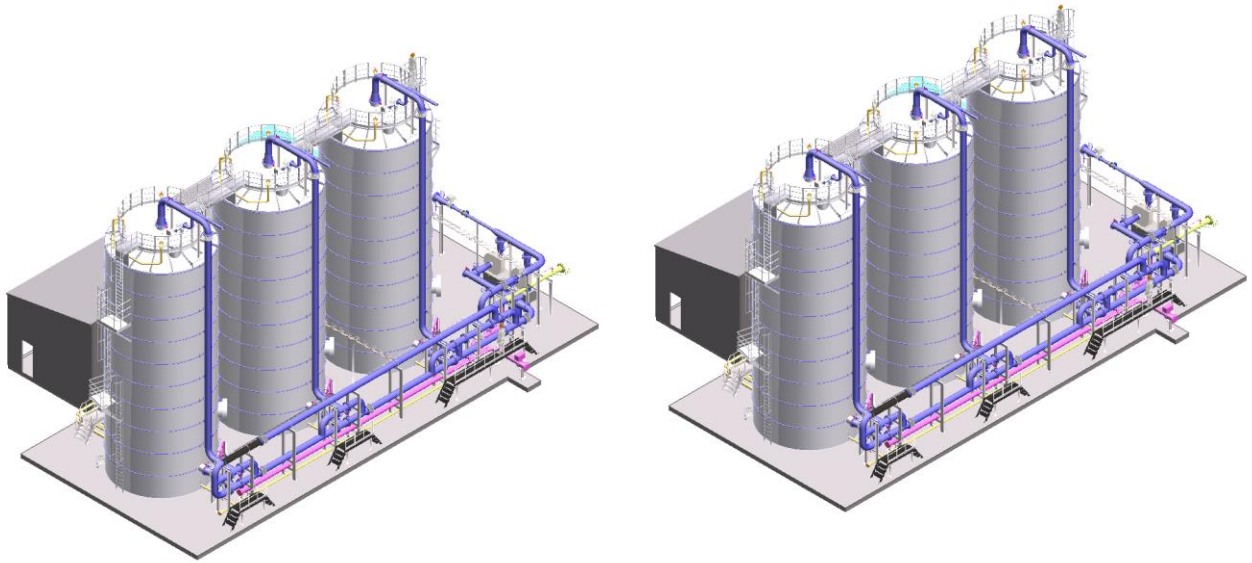
- Biogasclean's Bio E-Fuel plants are based on a scalable and modular design with one or more tanks in stainless steel or reinforced fiberglass.
- At Glansager the Bio E-Fuel plant comprises 3 pcs. insulated tanks in stainless steel filled with a random packed packing material.
- The technical equipment is skid mounted and comprise a.o. liquid supply and drain system, heating and cooling system and PLC based control system as well as gas analyzers, gas detectors, fire alarm system, etc. installed in a Technical House.
- Gas blowers and air cooler are located outside.
- The piping system for gas and liquid is made in stainless steel.



BIO GASCLEAN | Innovative solutions for efficient production of biogas and e-fuels

Key figures for Bio E-Fuel – 1,176 scfm E-methane

- CO_2 flow: 1,000 Nm^3/h → 1176 scfm
- H_2 flow: 4,000 Nm^3/h → 4704 scfm
- Electrolysis capacity: 20 MW
- Production capacity: Up to 85 GWh/y E-Methane at full load
- Power consumption: 165 kW (excl. air cooler)
- NPK and micro-nutrients costs: 16 USD/h
- pH buffer alternative 1: Decanter liquid 91 gallons/h
- pH buffer alternative 2: Bi-carbonate 2.5 USD/h
- Heat produced from the exothermic process: 3,140 kW
- Water from process: 1.6 m^3/h



BIO GASCLEAN | Innovative solutions for efficient production of biogas and e-fuels

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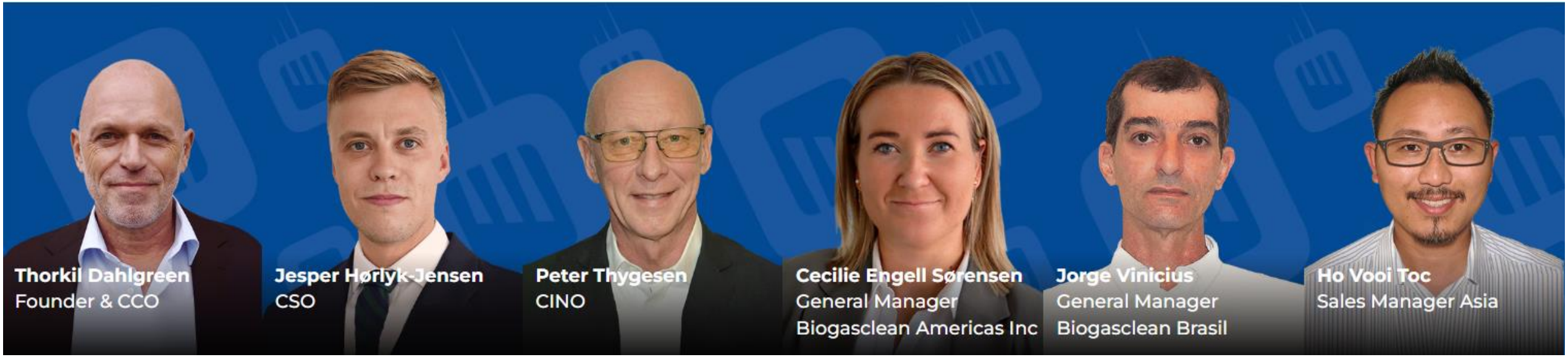
BIO GASCLEAN | Innovative solutions for efficient production of biogas and e-fuels



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Inder Pal Singh, Ph.D.

Founding President & CEO

SBI BioEnergy, Inc.

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BioEthanol - a Universal Renewable Energy Resource

December 06, 2023

2023 Minnesota Renewable Energy Roundtable

SBI Group

- Cleantech. Development & Commercialization

Gölu Hydrogen Technologies Inc.

SBI BIOENERGY INC.

SBI Fine Chemicals Inc.

WHO WE ARE

SBI Group

SBI Group of Companies, commercialize innovative clean fuels technologies, including Renewable Jet Fuel, Biodiesel, Renewable Diesel, and modular, on - site Carbon Negative Hydrogen Production at the point ofuse

25 years in cutting edge technologies development business

Invested heavily in technology and Product Development

25,000 SF fully equipped state of the art facility with modern analytical, quality assurance, and fabrication facilities.

Technologies protected by Global Patents

Successfully licensed green diesel and SAF technology to Royal Dutch Shell

Leaders in

- Catalyst development
- Process development & optimization
- Processor design
- Automation & controls

Technology Commercialization SBI Group

SBI BioEnergy Inc. - Renewable Liquid Fuels Technology Licenses

1.	Renewable Diesel & SAF:	Shell Petroleum International
2.	Low Temp. Biodiesel:	Alberta Petroleum Refinery (under NDA)
3.	Renewable Diesel:	Alberta Petroleum Refinery (under NDA)
4.	SAF (Sustainable Aviation Fuel):	European Multinational Technology Supplier (under NDA)

Golu Hydrogen Technologies Inc.

On Site H_2, Power and Heat Generation and CO_2 Capture:

1. Edmonton International Airport (public Info)
2. Others in various stages of negotiations:

a)	Data Centers :	Continuous Power Heat and CPU Cooling
b)	Microgrid Communities & Green Houses:	Combined Power, Heat, Hydrogen, Airconditioning and CO_2 Capture
c)	Bus & Truck Fleet Owners:	FCEVs refueling, Co-injection and Level 3 EV Charging
d)	Sea Ports:	Hydrogen and Power for tug boats and Drayage Trucks
e)	Utilities:	Hydrogen blending with Natural Gas, Decentralized Power and District heat
f)	US Fruit Orchards:	Hydrogen for equipment and Power, Heat and CO2 for Green houses and fruit dehydration
g)	Heavy Duty Transport:	Supplying Fuel Cell grade Hydrogen Produced using Demo Plant on SBI site

BARRIERS TO HYDROGEN ADOPTION

gölu-H_2

C O S T

CARBON FOOTPRINT

ON-SITE INFRASTRUCTURE Cost

SAFETY

TRANSPORT

Gölu Hydrogen Technologies Inc.

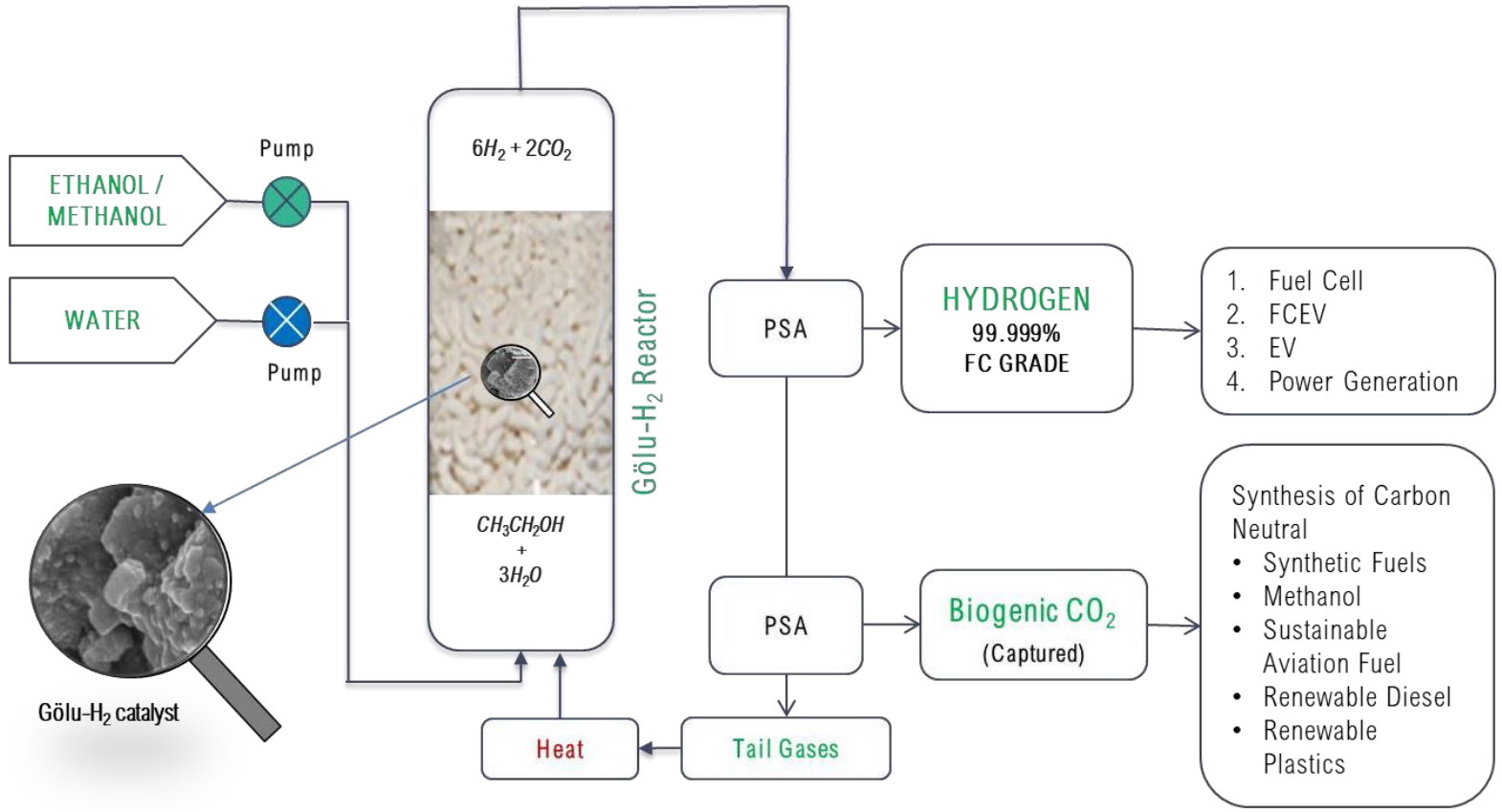
gölu-H_2

BioEthanol
for
Decentralized Clean Hydrogen and Power Generation

Gölu-H_2 PROCESS FLOW

gölu-H_2

- Thermo-Catalytic Process
- 85% less water compared Electrolysis and SMR
- Takes Wet Ethanol
- No SOx
- No NOx
- No external heat required
- Zero carbon intensity process
- 99.999% purity renewable hydrogen
- Additional Revenues from Biogenic CO_2

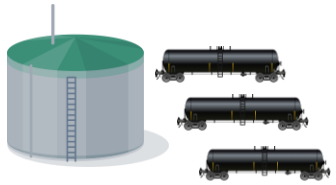


PSA– Pressure Swing Adsorption unit to purify hydrogen to 99.999% purity

RENEWABLE ENERGY STORAGE COMPARISON

gölu-H_2

1 GWH STORAGE CAPACTIY



Ethanol Tank

Capacity	90,000 gal.
Cost	~$80,000 USD

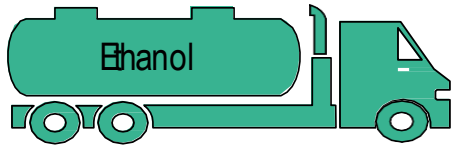
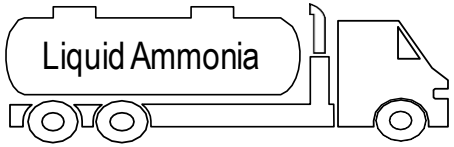
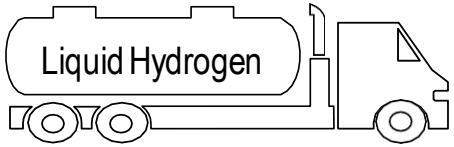
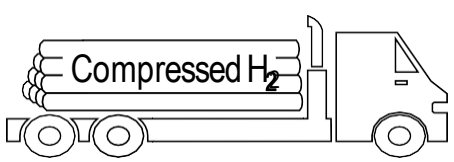
H_2 Tanks

Capacity	50 Tons
Cost	~$50Million USD

Batteries

Capacity	2,470 Acres
Cost	~$1Bn. USD

MORE HYDROGEN PER DELIVERY

Delivery Method	Total Hydrogen per Delivery	Advantage/Disadvantage
	7,700 kg	Existing infrastructure
	4,700 kg	Toxic carrier
	3,000 kg	Cryogenic form
	800 kg	High compression

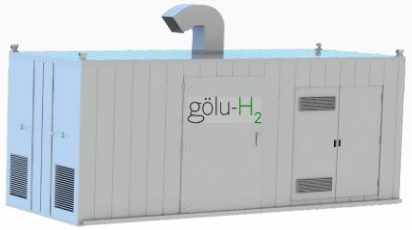
MODULAR Gölu- H_2 CLEAN HYDROGEN DEMO UNIT

- 50 kg daily on-site hydrogen production
- Deployable at site-specific capacities
- 99.999% pure Hydrogen generated
- Only water and ethanol inputs

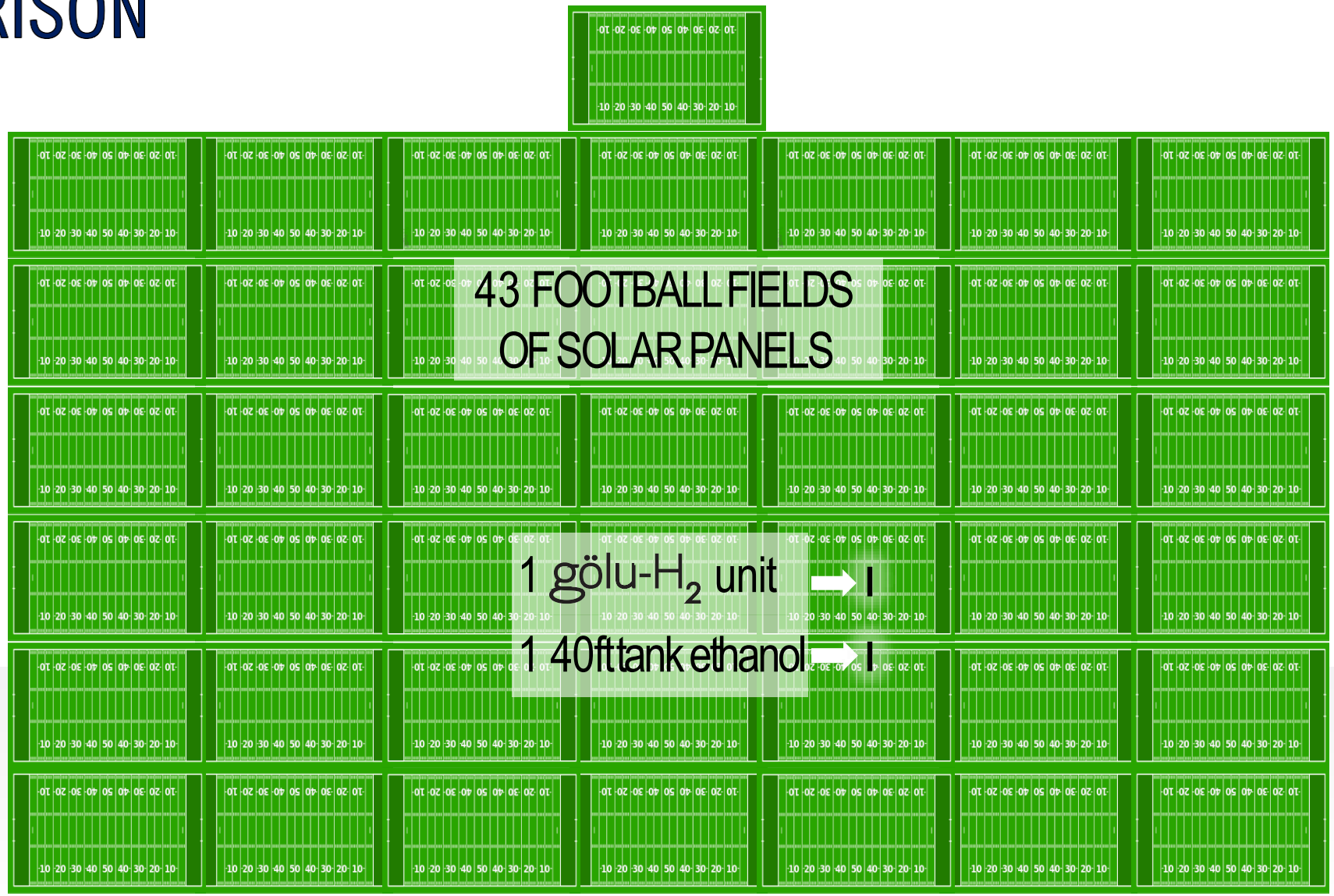
FOOTPRINT COMPARISON

57 acre solar farm

1.5 acre electrolyzer

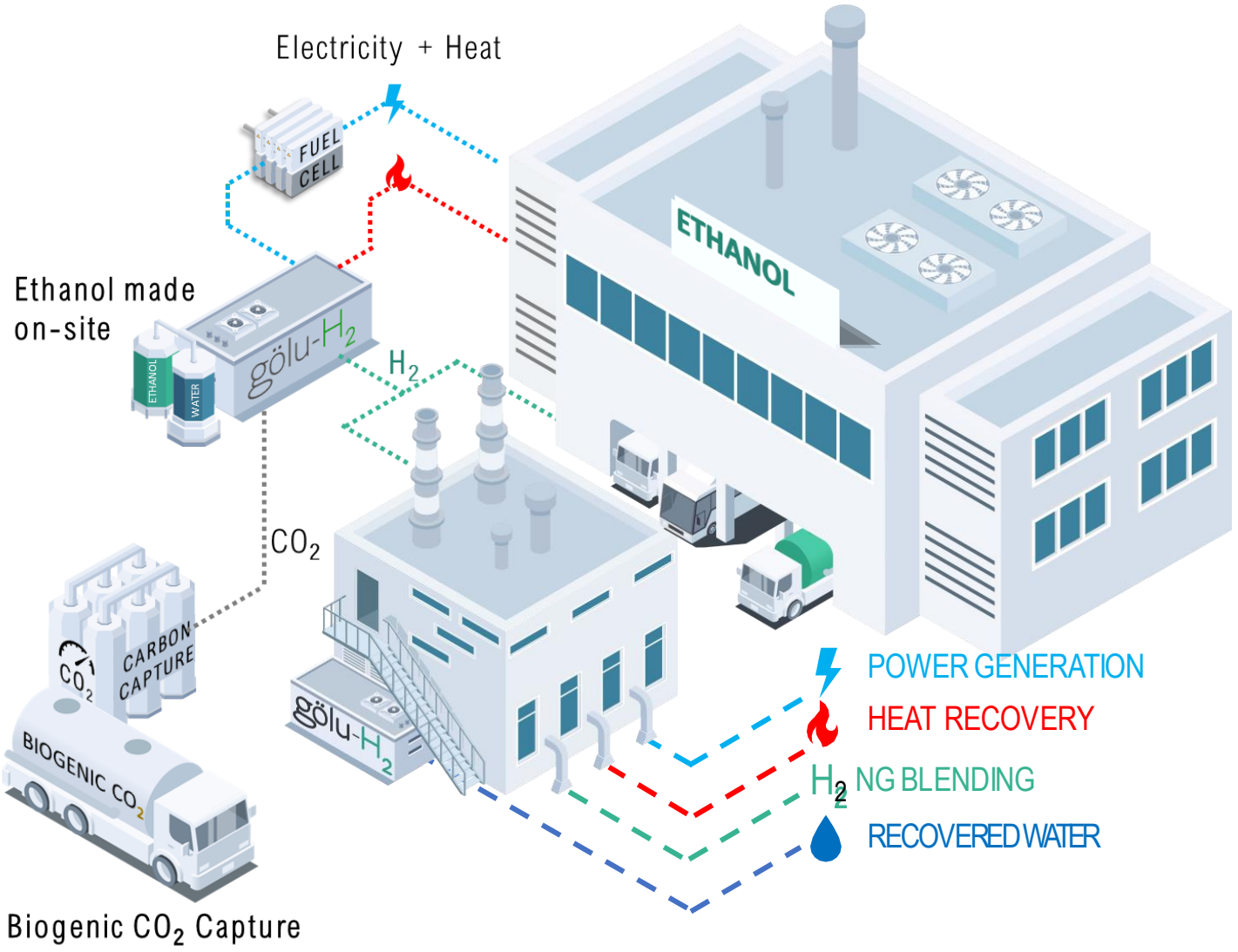


40’ x 8’ = 1,250 kg/day



1250 kg/day Hydrogen production from solar power requires 57 acres of solar cells = 43 football fields and an additional 1.5 acres electrolyzer footprint

A COMPLETE LOW CARBON ETHANOL PLANT



Module Information

Generate your own energy

20% Ethanol* (off the beer column)

Co-feed Hydrogen for process heat

Recharge EV forklift

10 MWh of heat

Standard Unit Information

1250 kg daily on-site hydrogen production

Only Ethanol and Water required

Deployable atsite-specific capacities

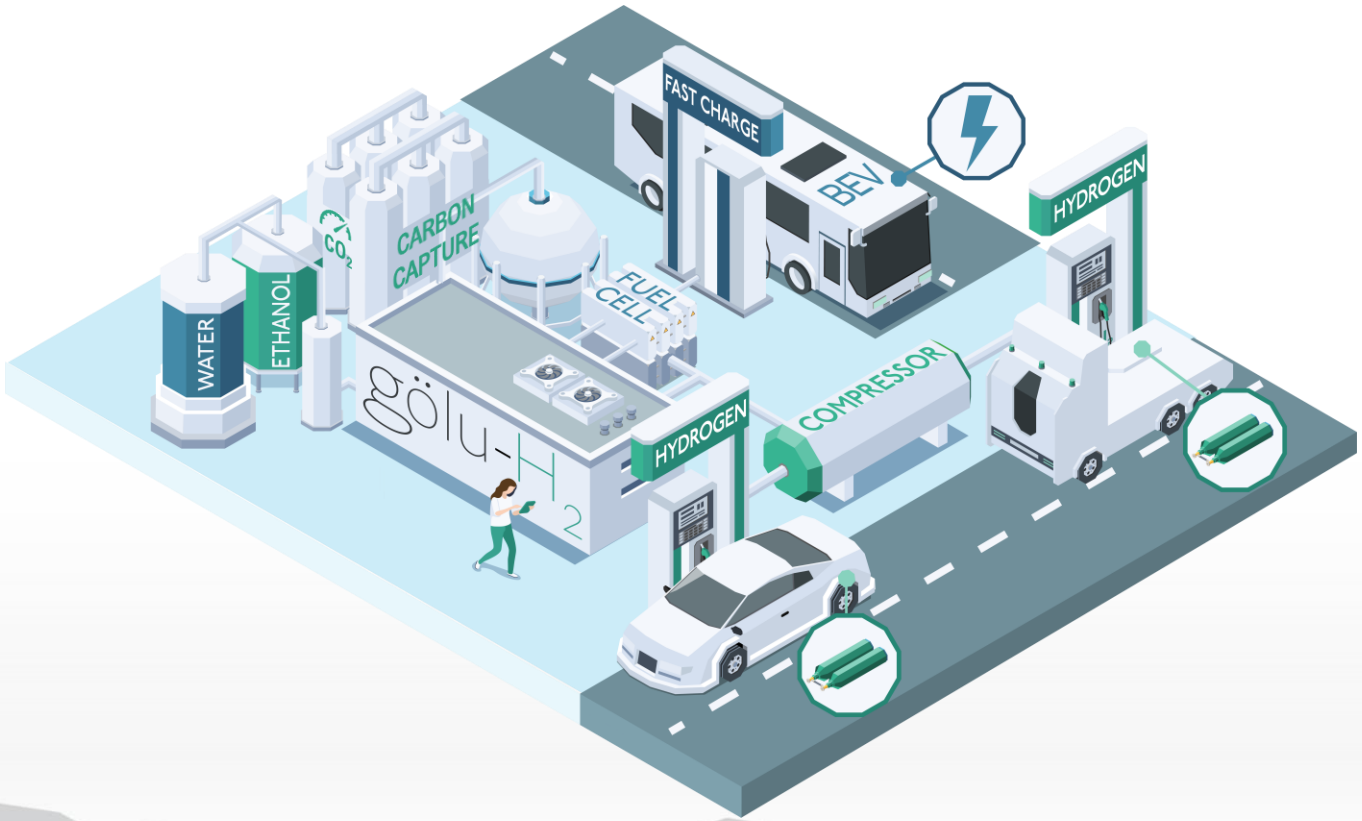
Stand-alone source of Green Hydrogen

Additional Revenues from Biogenic CO_2

Eliminates >3 thousand Tons CO_2 from the environment/yr.

Recycle water and recover heat

FLEX ENERGY STATION – IMMEDIATE & FUTURE DEMAND








Hydrogen Generation | Compression | Storage | EV Charging | H_2 Refueling | Power Generation

Hydrogen Output	
Flow	1,250 kg/day
Purity	Fuel Cell Grade (99.999%)

Dimensions (L X W)
Gölu H_2 unit 40′ X 8′

Fueling Capability
FCEV Buses – 50/day
EV Buses – approx. 240/day

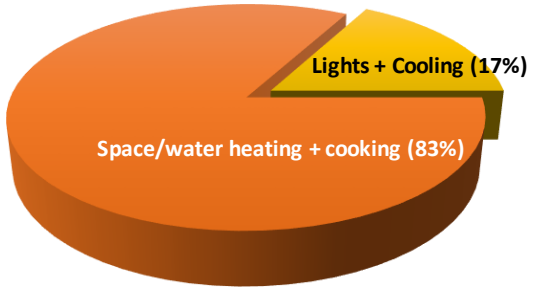
Emissions	
Fossil CO_2	Negative
NOx	Zero

gölu-H_2 A COMPLETE ENERGY INDEPENDENT COMMUNITY

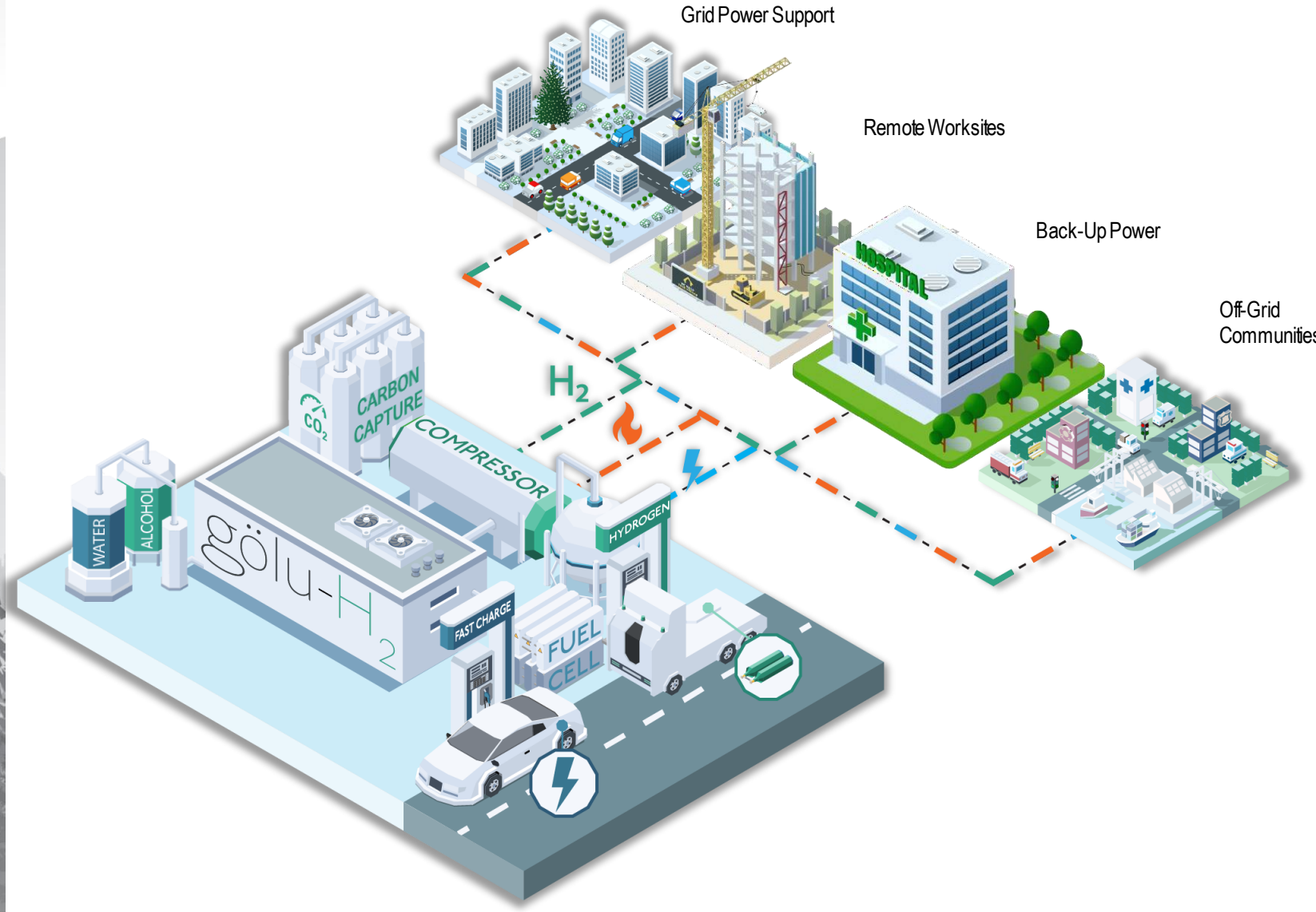
One Golu-H2 Unit + 650kW Fuel Cell will support

- ~1000 household with heat & electricity needs
- ~2,000 EV residential FastCharge points
- Additional revenues from food-grade biogenic CO_2

Daily European Household Energy Consumption

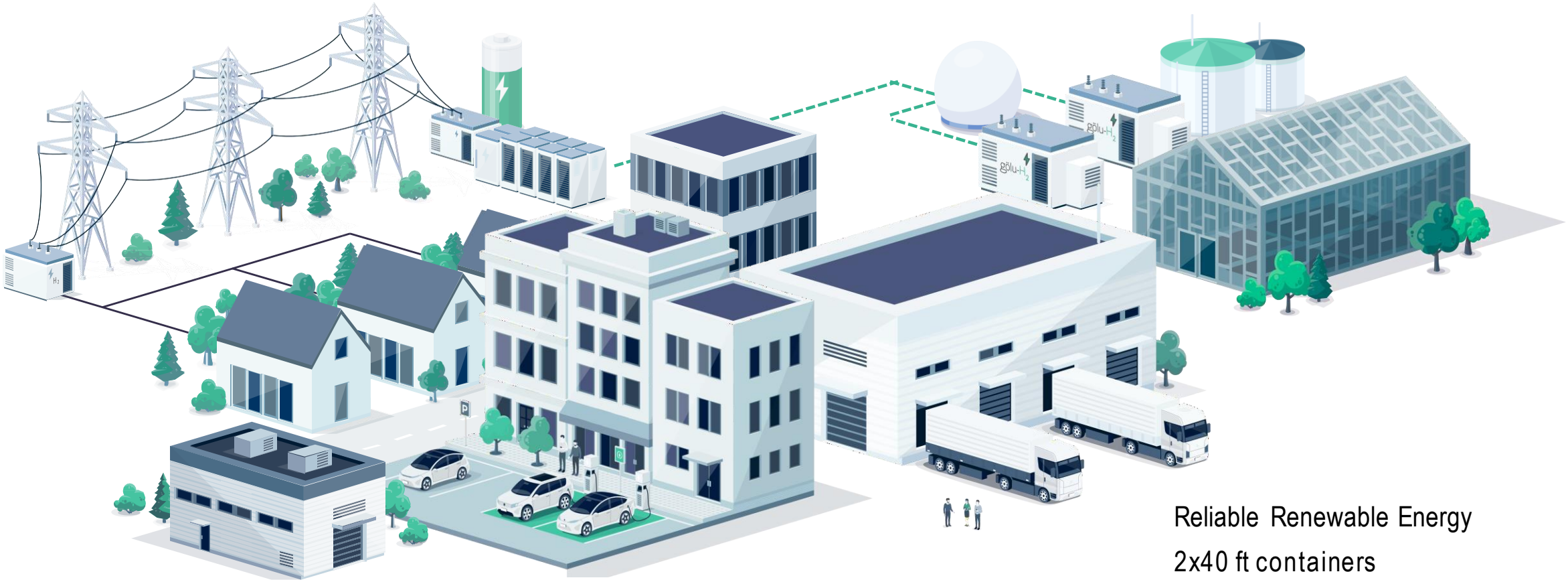


H2 for Space and Water Heating	625 Kg
Spare heat from the process	10 MWh
H2 for Power generation	625 Kg
Power Generation Capacity	12.5 MWh



A COMPLETELY OFF-GRID COMMUNITY

gölu-H_2



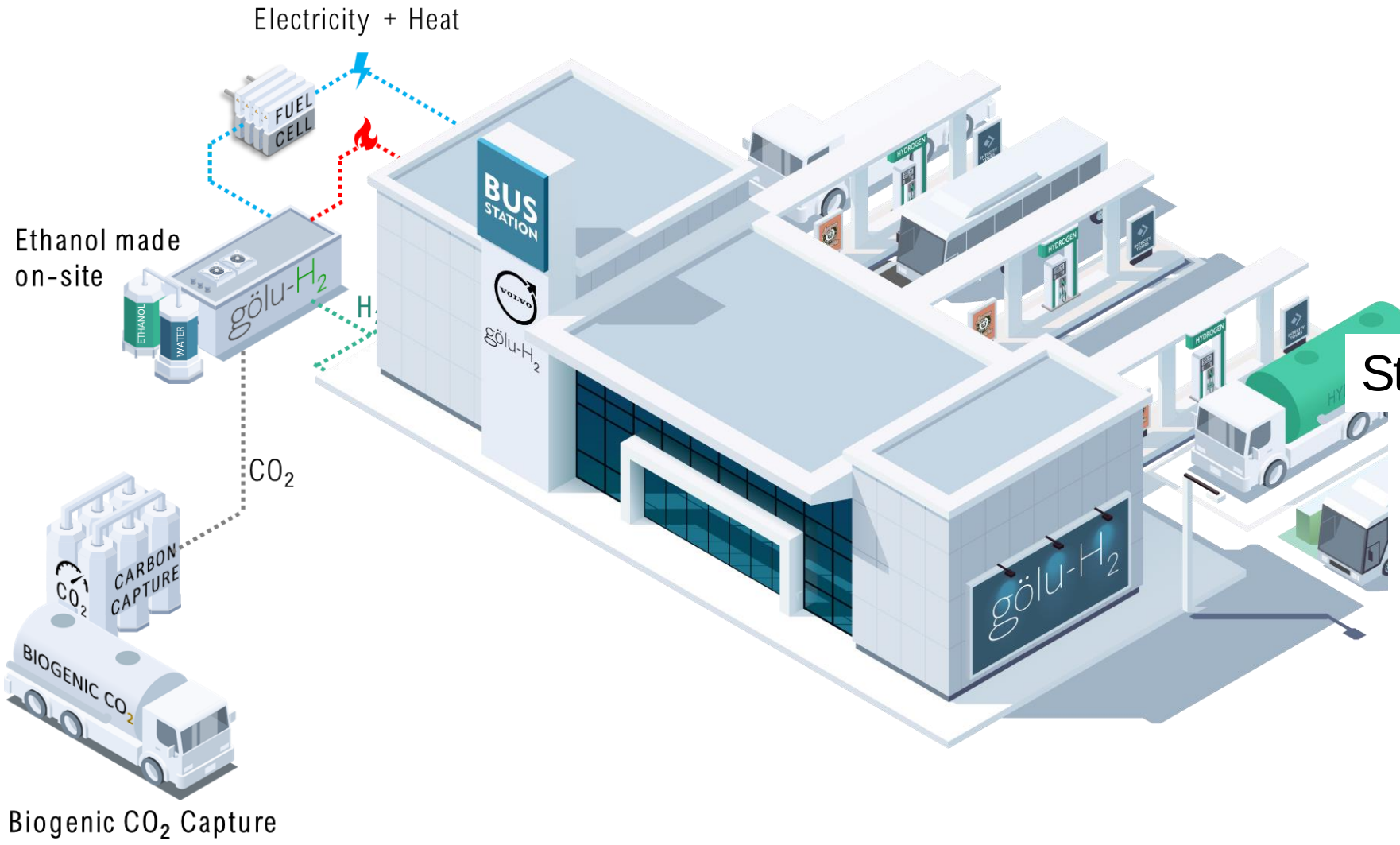
Reliable Renewable Energy

2x40 ft containers

2 MW or 50MWh/day

Greenhouse for all CO_2 Sequestration

A COMPLETE LOW CARBON BUS FACILITY



Module Information

- Refuel 50 FCEV Buses
- Charge up to 240 EV Buses (requires Fuel Cell)
- Refuel 250 FCEV Cars
- Heat for the Bus Barn

Standard Unit Information

- 1250 kg daily on-site hydrogen production
- Only Ethanol and Water required
- Deployable at site-specific capacities
- Stand-alone source of Green Hydrogen
- Additional Revenues from Biogenic CO_2
- Eliminates >3 thousand Tons CO_2 from the atmosphere annually

FUEL COST* COMPARISON based on 60,000-mile average

Diesel @ $5/gal.

Fuel Cost
$86,000/yr.

High Emissions

Ethanol @ $ 2.16/gal

Fuel Cost
$30,000/yr.

Carbon Negative

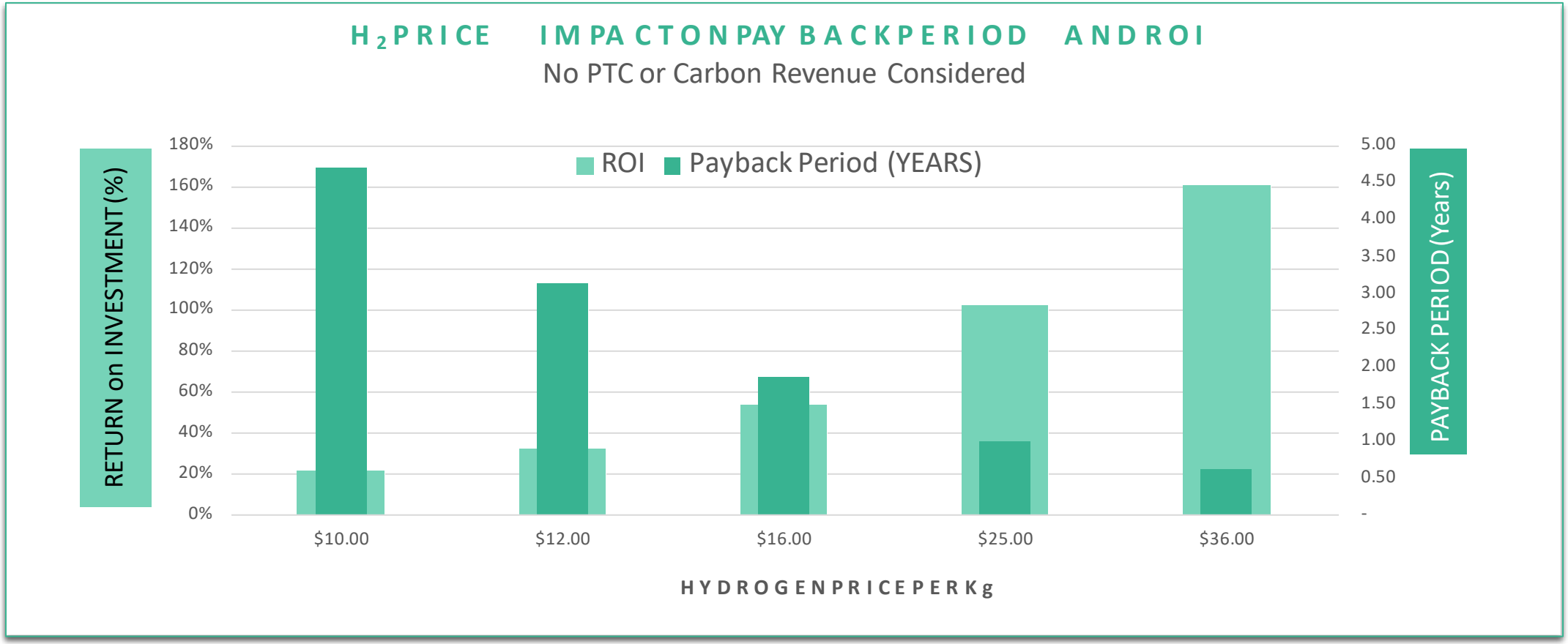
H_2 @$36/Kg

Fuel Cost
$258,000/yr.

Reduced Emissions

*cost based on ethanol, H2 pricing 02/2023

MODULAR UNITS: Pay Back Period and ROI



H_2 Price Per Kg	$10.00	$12.00	$16.00	$25.00	$36.00
Payback Period (YEARS)	4.71	3.13	1.87	0.98	0.62
ROI	21%	32%	53%	102%	161%

*Depends on ethanol price and other local factors etc.

Audience Q & A

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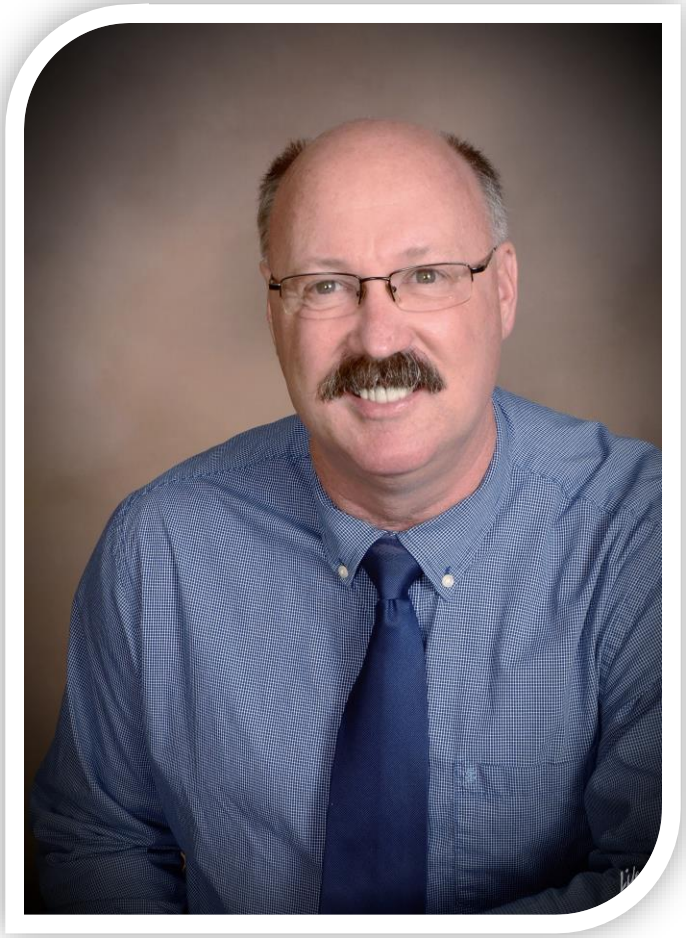

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THE GEVO CLIMATE-SMART FARM-TO-FLIGHT PROGRAM

USDA

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OVERVIEW OF GEVO, INC. (NASDAQ: GEVO)

- Founded in 2005
- Rebooted in 2007 to pursue alcohols to hydrocarbons
- Number of employees: 97

Gevo, Inc. has a mission to transform carbon captured from the atmosphere into energy-dense liquid hydrocarbons.

Net-Zero Fuels and Chemicals

- **Drop-in Products for Jet fuel, Gasoline, Diesel, Chemicals and Nutritional Products**
- **Develop Projects, Invest in Capacity, License, Enable, Monetize Carbon Value**

1

Corporate Headquarters
Englewood, CO

2

R&D, Demo Facility
Luverne, MN

3

Jet Fuel & Gasoline Plant
Silsbee, TX(1)

4

Net-Zero 1
In financing phase, Lake Preston, SD

5

Gevo RNG Facility
Operating in NW Iowa

Sources: US EIA, Statista.
(1) Owned by South Hampton Resources, Inc. and operated in partnership with Gevo.
(2) Sources: US EIA short term energy outlook May 2023. BNEF "Decarbonizing Petrochemicals", January 2022.

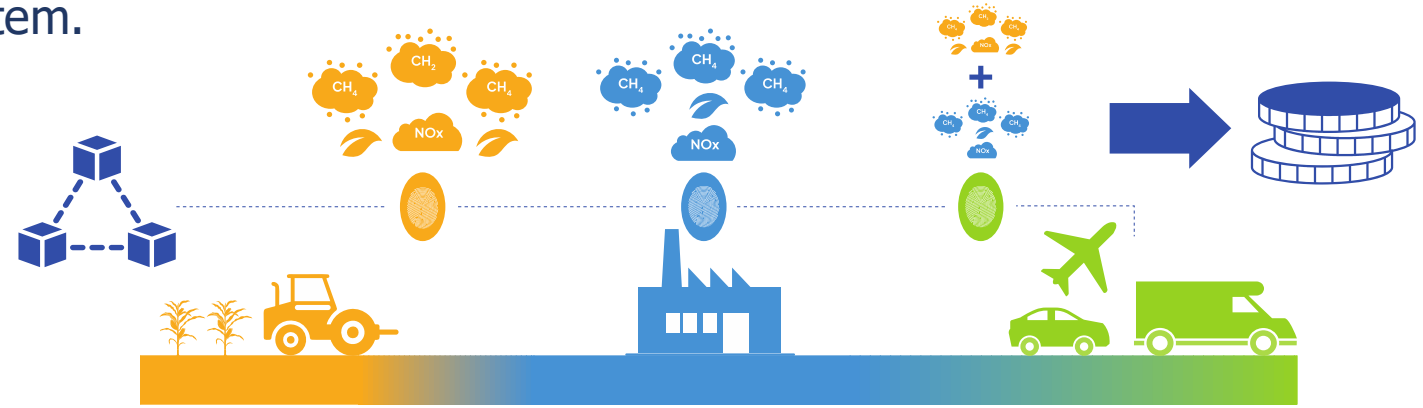
GEVO CLIMATE-SMART COMMODITIES DETAILS

Gevo has received a grant of up to $30 million from the USDA's Partnerships for Climate-Smart Commodities and has partnered with 15 businesses and university programs to improve and share climate-smart growing techniques with partner farmers.

Gevo believes that the Argonne National Laboratory GREET model is the best available standard of scientific-based measurement for life cycle inventory or LCI, and its subsidiary Verity uses the adaptability of GREET to measure CI and track it.

VERITY CARBON SOLUTIONS

Verity Carbon Solutions (Verity) currently offers full-service carbon project development via a proprietary digital MRV (Measure, Report, Verify) platform which is enabled by distributed ledger technology. Verity will provide carbon accounting and services to maximize the value of all environmental benefits throughout the entire business system.



Value creation through proprietary digital MRV platform and full carbon accounting for tax, compliance and voluntary incentives.

Sustainability Consulting

- Regulatory Analysis & Strategy Development
- Life Cycle Analysis
- Compliance Management / Audit Readiness

Verity Tracking

- Digital Measurement / Reporting / Verification
- Minting / Tokenization
- Carbon Accounting
- Upstream & Downstream Supply Chain

Marketing

- Utilization & Retirement Services
- Scope 1, 2, 3
- Trading / Marketing
- Voluntary, Compliance & Tax

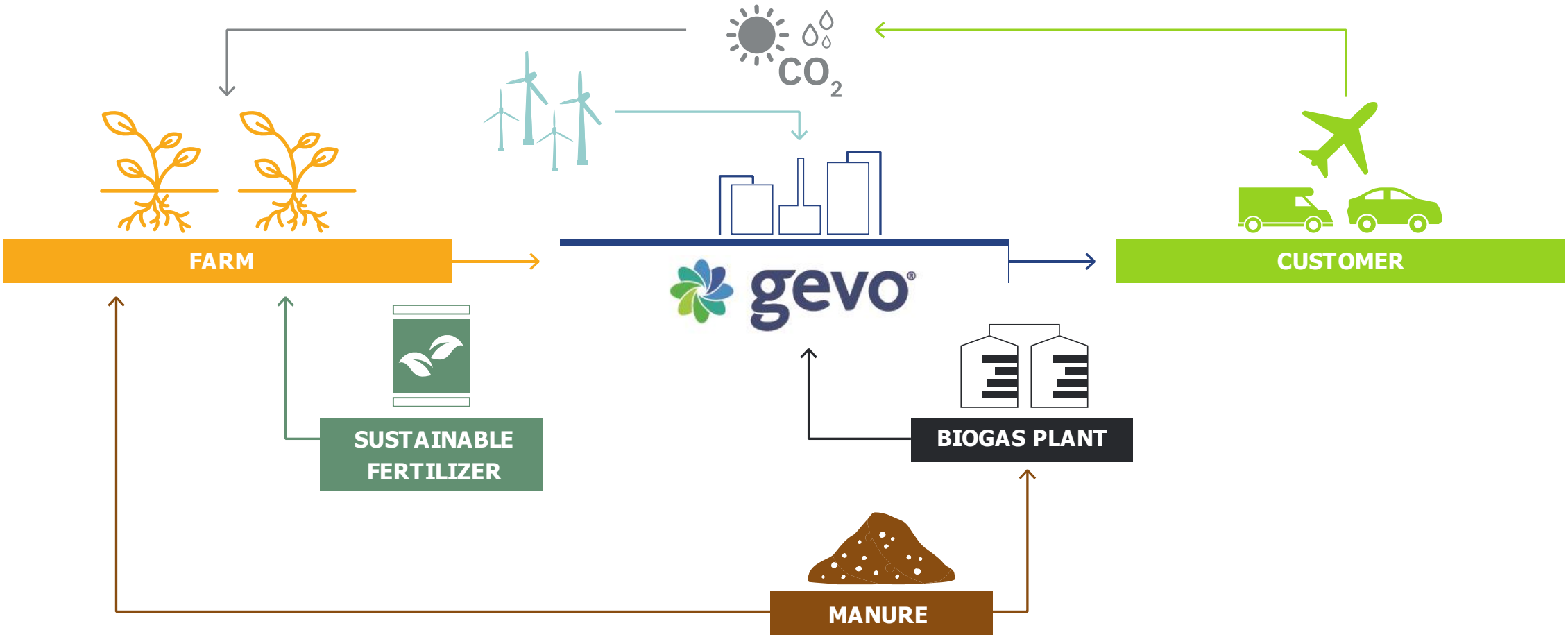
PROJECT OVERVIEW

- Total project cost is expected to be $46.3 million funded by $30 million USDA grant and $16.3 million non-federal funds.
- Includes $18.4 million in direct payments to producers.
- Four-year project to track and study soil health and carbon-intensity levels through soil tests and yield monitoring across four complete growing seasons.
- An estimated 435,000 corn acres to be enrolled.
- Utilizes a carbon-inset model through proprietary Verity Tracking technology to measure, record, and verify greenhouse gas attributes and monetization of carbon reduction.
- Allows Gevo to incentivize farmers for production and delivery of low carbon intensity corn.

- The feedstock is expected to help Gevo produce low-carbon-intensity ethanol to creates SAF to decarbonize portions of the transportation sector that cannot be easily abated through electrification or hydrogen.

SYSTEM – NOT REDUCTIONIST - SOLUTIONS

Gevo's Circular Economy Concept realizes **Low Carbon** fuel, chemicals, and by-products.



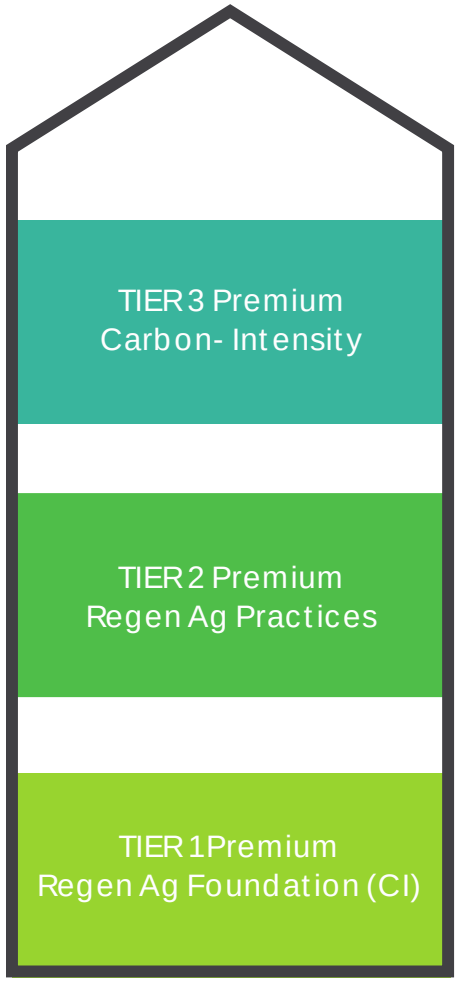
GEVO FARM-TO-FLIGHT GOALS

This project has two goals:

1. Create critical climate-smart market incentives for low carbon-intensity corn.
2. Accelerate the production of sustainable fuel to reduce the dependence on fossil-based fuels.

Gevo plans to provide incentives to accelerate the production of sustainable fuels, such as ethanol and sustainable aviation fuel (SAF). By continuing practices farmers are already doing today and establish new practices, farmers can receive additional pay via a 3-tiered structure of incentives.

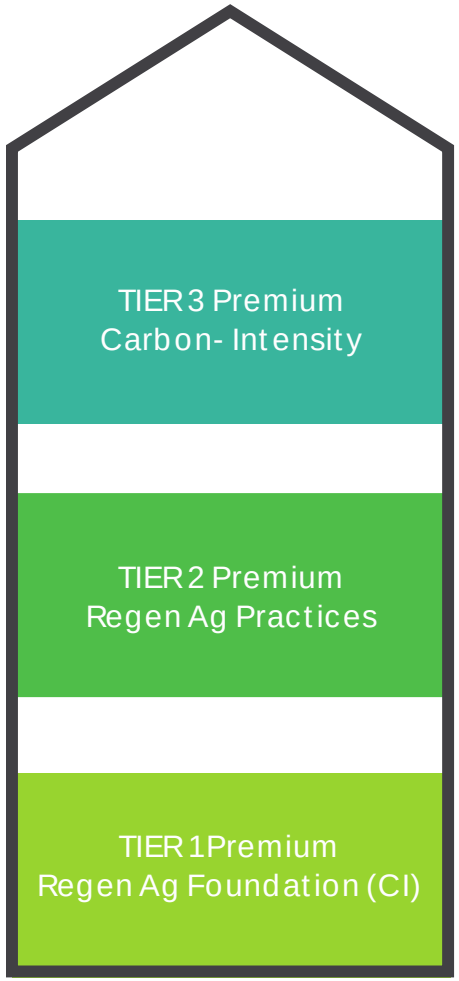
GEVO FARM-TO-FUEL PREMIUMS



TIER 1: Regen Ag Foundation (CI)

- Soil Biological Microbials ($10/acre): Build soil health and soil organic matter by increasing soil microbial activity
- Carbon Soil Amendments ($50/acre): Feed microbials in soil to create a more robust build soil organic matter
- Soil Genomics Testing ($6.50/acre): Reduce synthetic nitrogen applications and reduce carbon intensity
- GIS Data Collection ($4/acre): Collect and transfer data more seamlessly to calculate carbon intensity

GEVO FARM-TO-FUEL PREMIUMS

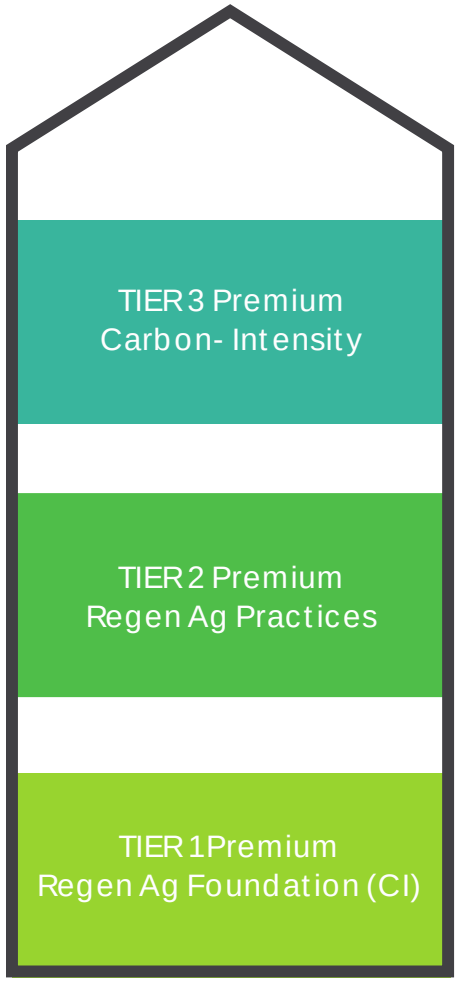


Using Regenerative Ag Practices can augment per-bushel price premiums for corn.

TIER 2: Regen AG Practices (to gain additional $/bu)

- Reduced Tillage – leaves crop residue on the soil surface allowing root structure to maintain the soil health
- No-Tillage – conserve soil from wind and water erosion and increases soil organic matter content
- Carbon Soil Amendments – adds Greenhouse Gas (GHG) benefits and encourages natural production of soil organic matter
- Nutrient Management – best management practices that optimize the efficiency of fertilizer use
- Prescribed Grazing – managing intensity, frequency, duration, timing, and number of animals in accordance with site
- Cover Cropping – cover crops hold nutrients in their roots and stalks

GEVO FARM-TO-FUEL PREMIUMS

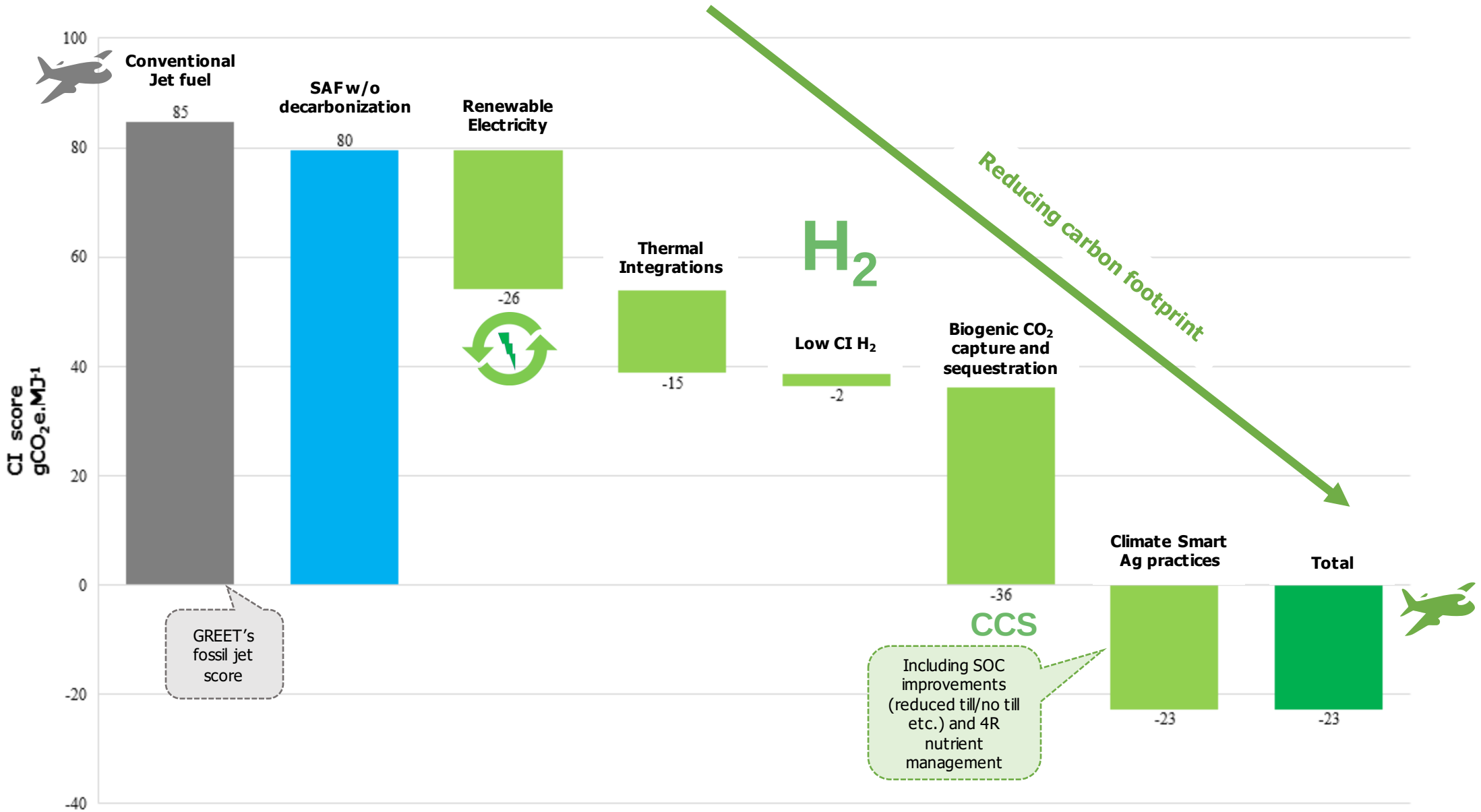


Carbon intensity reductions yield payments per bushel of corn

TIER 3: Carbon Intensity Reductions Below Midwest Average

- 0–5 CI Reduction average for all bushels of the crop-type: $0.08/bu
- 5–10 CI Reduction average for all bushels of the crop-type: $0.10/bu
- 10–15 CI Reduction average for all bushels of the crop-type: $0.20/bu
- >15 CI Reduction average for all bushels of the crop-type: $0.22/bu

HOW WE PLAN TO DRIVE CI DOWN: DECARBONIZATION DEMONSTRATED THROUGH HIGH-QUALITY MODELING WITH ARGONNE GREET



iLUC – Indirect Land Use. CCS – Carbon Capture Sequestration. CI – Carbon Intensity. LCA- Life Cycle Assessment

https://doi.org/10.2172/1046913; https://greet.es.anl.gov/; https://publications.anl.gov/anlpubs/2012/07/73815.pdf

Any Questions?

Thank you

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