RNG WORKS | THE COALITION FOR RENEWABLE NATURAL GAS

BayoTech ON-SITE HYDROGEN

The Role of Biogas & RNG in Hydrogen Production & Decarbonization

BayoTech
ON-SITE HYDROGEN

The Role of Biogas in Hydrogen Production & Decarbonization

"BayoTech's goal is to provide customers access to low-cost, lower carbon hydrogen to accelerate the global energy transition"

Mo Vargas
BayoTech CEO

Hydrogen Facts

1 kg 1 gallon

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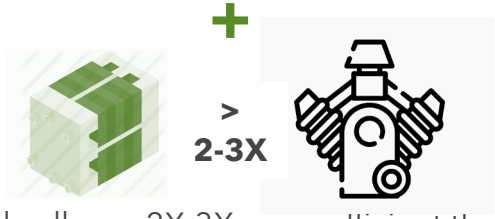

Fuel cells are 2X-3X more efficient than internal combustion engines

=

70 miles/kg H2 vs 24 miles/gal Gas

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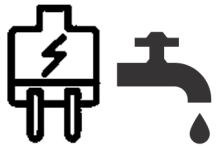
The only emissions when H2 is used in a fuel cell are water

Hydrogen should be consumed at the point of production due to low volumetric energy density

Industrial gas companies are accustomed to large onsite off-takers. **Not well suited for low price, low carbon distributed H2**

Liquification and transporting H2 from **central plants are carbon intense and are up to 2/3rd of price** at point of consumption.

H2 **pipelines cost $1MM a mile**



Electrolysis uses 2X the amount of feedstock process **water** than SMRs

50%

An electrolyzer using grid power is about 50% more carbon intensive than an onsite SMR using natural gas

4x

A large centralized electrolyzer that liquifies hydrogen has 4 times the carbon intensity versus onsite

Onsite production eliminates transportation emissions and the need for liquification

$1.69 per kg

Hydrogen produced using BayoTech has the lowest cost of production

Renewable resources such as biomethane reduce carbon intensity

-300

gCO2e / MJ
The carbon intensity of a BayoTech's onsite SMR using animal biogas

Hydrogen Applications

Fuel Cells

Agriculture

Industrial

Energy

BayoTech On-site Hydrogen Generators

The on-site generation system Includes:

- Natural gas cleanup system
- Water purification system
- Steam generator
- Furnace and Steam Methane Reformer (SMR)
- Water Gas Shift (WGS) reactor
- Hydrogen separator & cleaning system
- Process Control System including safety and shut down functions with remote monitoring capability

Intellectual Property –

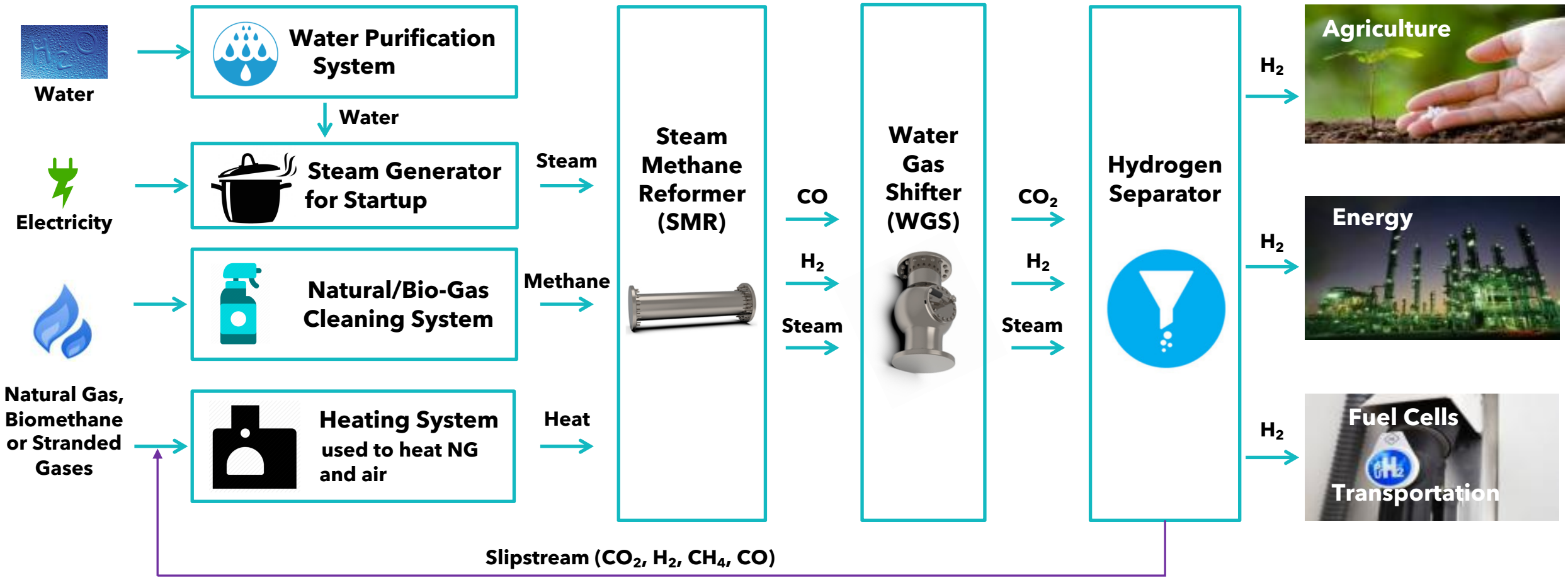
- BayoTech holds the exclusive license for the core design from Sandia National Laboratories
- Sandia spent >$50MM developing the technology
- BayoTech has filed additional patents in 2020 for key design elements

Sandia National Laboratories

FISH & RICHARDSON

BayoTech Technology Overview

ON-SITE HYDROGEN



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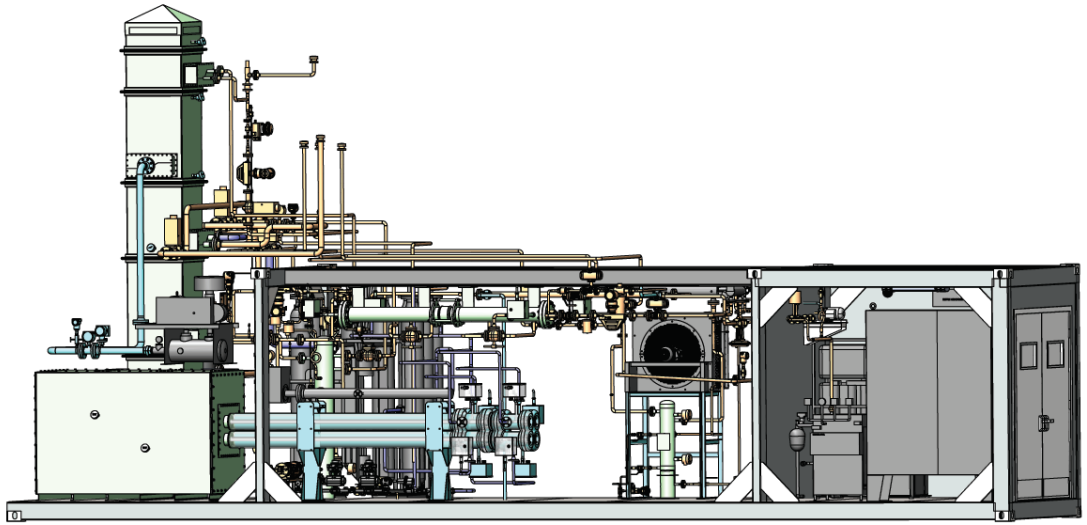
The BayoTech Solution

BayoTech provides **on-site** hydrogen production that is **more efficient, field upgradable, performance guaranteed** and **lowest cost**

Our reformers tap into the **existing network of natural gas pipelines or biogas sites**, avoiding the cost of long-haul transport

High energy efficiency, avoided liquefaction and transportation, and **biogenic feedstock** result in **lower carbon emissions**

We offer equipment **rentals**, **leases, sales** and **hydrogen Gas-as-a-Service** options



Today: 200 kg to 1 metric ton per day

2021: 5-, 10- and 30-ton units

2022: On-site ammonia

BayoTech ON-SITE HYDROGEN Sustainability Initiatives

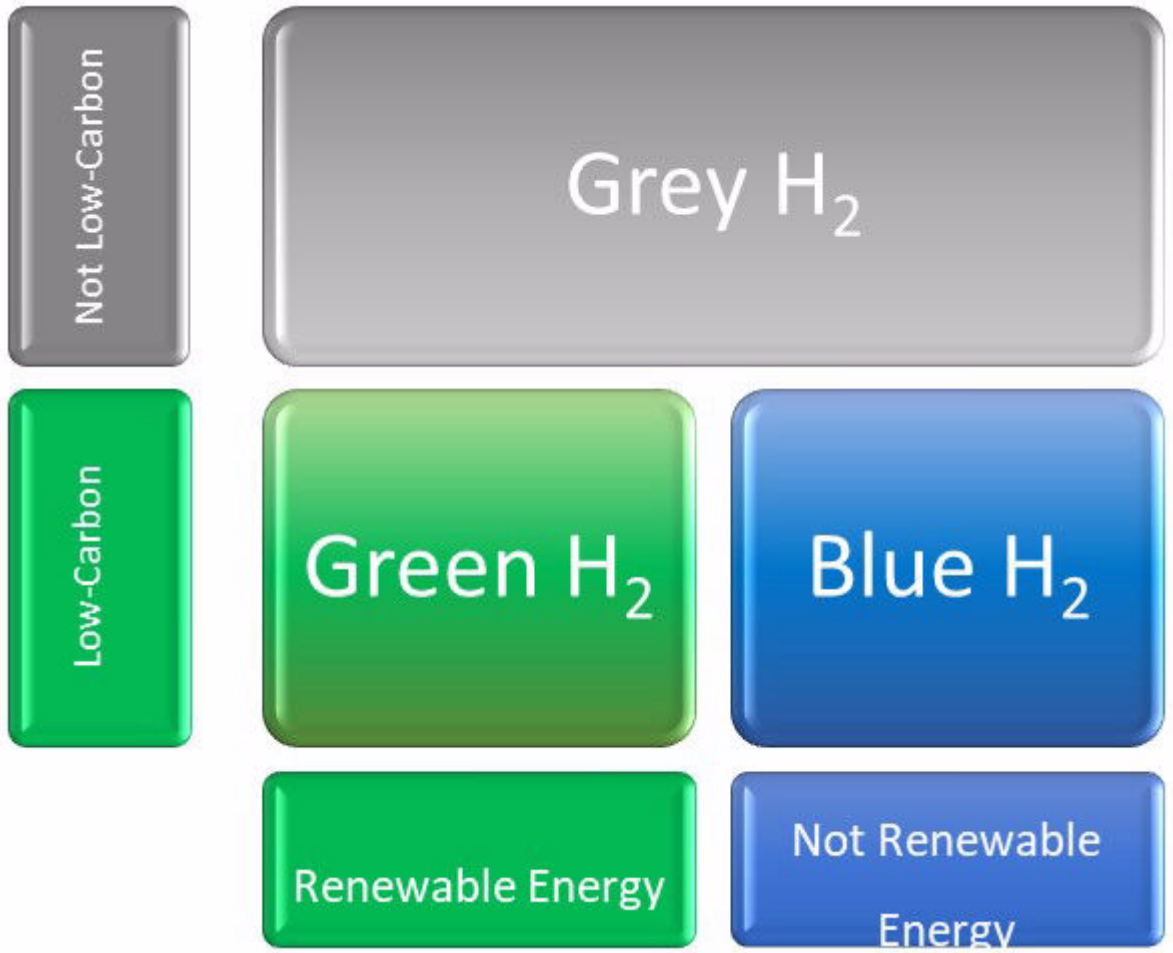
Transportation BayoTech's hydrogen solutions enable customers to produce hydrogen on-site, thereby removing the need for transportation and liquefaction and reducing carbon dioxide and other pollution resulting from typical distribution of hydrogen

Biogas & Biomethane BayoTech's hydrogen generators can use biomethane derived from biogas as a feedstock. The carbon intensity of on-site hydrogen production can be significantly reduced or even go negative by using biogas and biomethane.

Efficiency BayoTech's unique SMR design uses heat more efficiently than traditional methods of hydrogen production. This translates to less feedstock used, lower carbon emissions and lower costs to produce the same amount of hydrogen.

Carbon Capture There is increasing interest in the utilization of carbon capture and storage (CCS) technologies to reduce carbon impact in hydrogen production. BayoTech is actively seeking partnerships with companies that specialize in carbon capture technology.

Hydrogen Colors

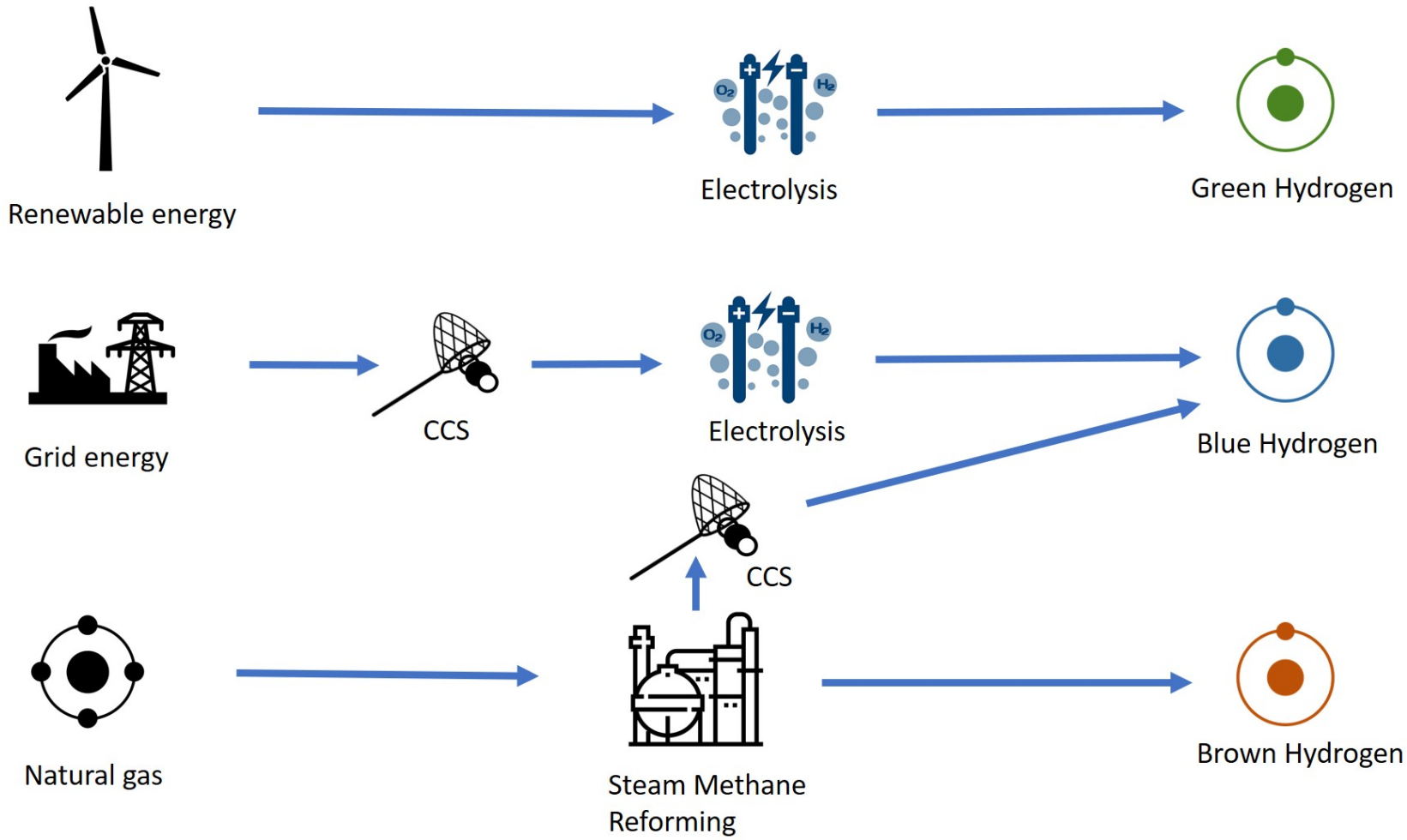


Increase to net atmospheric CO2

Does not increase atmospheric CO2

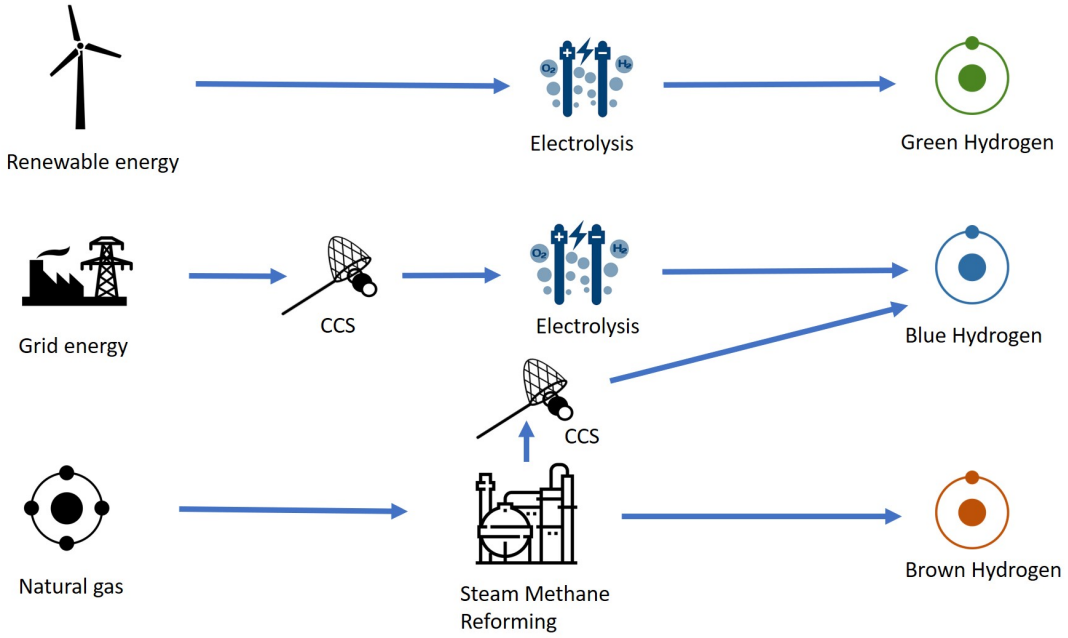
Picture credit – CertifhY Canada

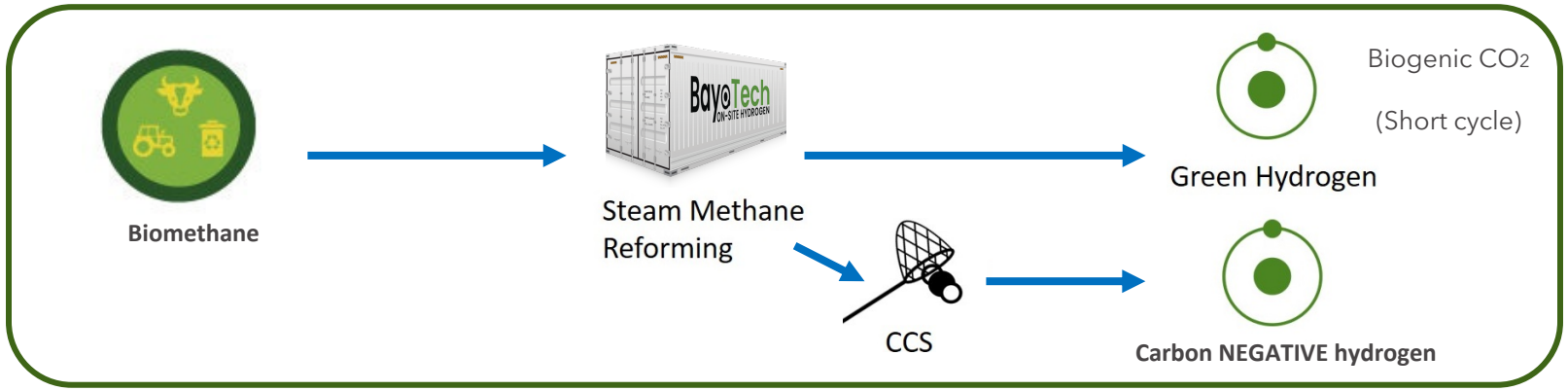
Pathways to Hydrogen



Picture credit – MIDC

Pathways to Hydrogen





Biomethane to hydrogen with CCS is the ONLY way to generate carbon negative H_2

Hydrogen by Color Does Not Tell the Whole Story

"Renewable" Hydrogen is characterized by source of the molecule

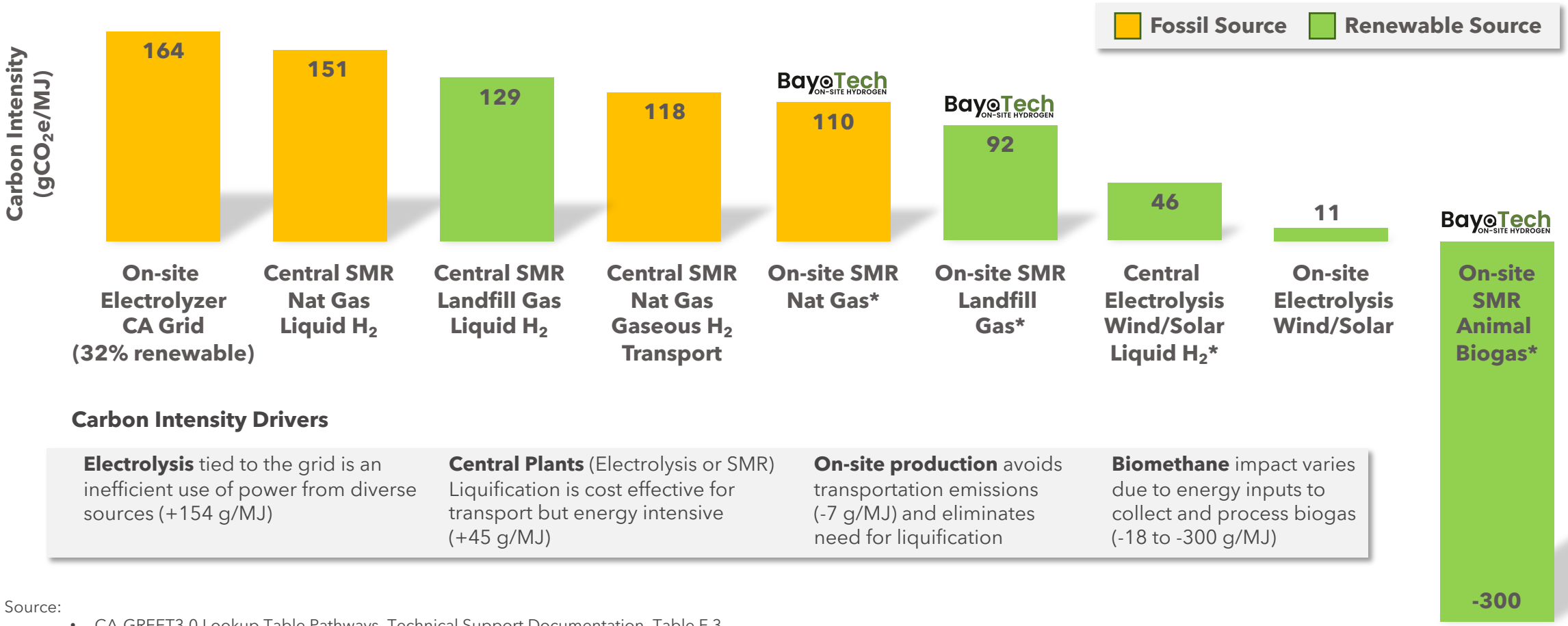
- Methane-derived hydrogen is renewable if the gas comes from biogenic source
  - Landfill
  - Animal waste
  - Wastewater treatment plants
- Electrolytic hydrogen is renewable if the power comes from a renewable source
  - Wind, Solar, Hydro…
- Generally ignores energy for related processes (e.g., to liquify/compress H2 and gather/prepare feedstock)

Carbon Intensity factors both feedstock and processing

- Reflects impact of entire value chain in carbon equivalent through life cycle analysis
- Includes energy inputs from related functions like compression, liquification, and transportation
- More relevant for sustainability & decarbonization initiatives

Hydrogen Production Carbon Intensity by Source

Based on California Air Resources Board Methodology



Carbon Intensity Drivers

Electrolysis tied to the grid is an inefficient use of power from diverse sources (+154 g/MJ)

Central Plants (Electrolysis or SMR) Liquification is cost effective for transport but energy intensive (+45 g/MJ)

On-site production avoids transportation emissions (-7 g/MJ) and eliminates need for liquification

Biomethane impact varies due to energy inputs to collect and process biogas (-18 to -300 g/MJ)

Source:

- CA-GREET3.0 Lookup Table Pathways, Technical Support Documentation, Table F.3
- https://ww3.arb.ca.gov/fuels/lcfs/ca-greet/lut-doc.pdf
- Calculated values (*) estimated from existing pathways using CARB methodology

Hydrogen Production Carbon Footprint

Based on California Air Resources Board Methodology

Fuel Pathway Code:	HYEG	HYFL	HYBL	HYF	EFP*	HYB	EFP*	EFP*	HYER	EFP*
Process Description:	CA grid Electrolyzer gas H2	NG Central SMR liquid	LFG Central SMR liquid	NG On-site SMR gas H2	NG On-site SMR gas H2	LFG Central SMR gas H2	LFG On-site SMR gas H2	wind/sun Electrolyzer liquid	wind/sun Electrolyzer gas H2	dairy/swine On-site SMR gas H2
Natural Gas Recovery		6.07		6.07	6.07					
Natural Gas Processing		3.31		3.31	3.31					
NG or RNG Transport		5.50	9.47	5.50	5.50	9.47	9.47			
Landfill Gas Recovery			0.79			0.79	0.79			
Landfill Gas Processing			42.74			42.74	42.74			
H2 Production (energy)	153.95	21.79	21.79	20.46	20.46	20.46	20.46	0.00	0.00	
H2 Production (non-combustion)		68.26	8.29	64.09	64.09	7.78	7.78			
Liquifaction		45.28	45.28					45.28		
H2 Transport		0.74	0.74	7.21		7.21		0.74		
Gaseous H2 Compression & Precooling	10.51			11.04	10.51	11.04	10.51		10.51	
Carbon Intensity (gCO2e/MJ)	164	151	129	118	110	99	92	46	11	-300

* -- Estimated from established pathways

Source:

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Biogas: Sources & Composition

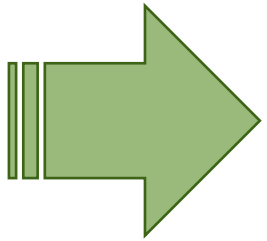
Landfill Gas

Animal waste

Food waste

Crop residue

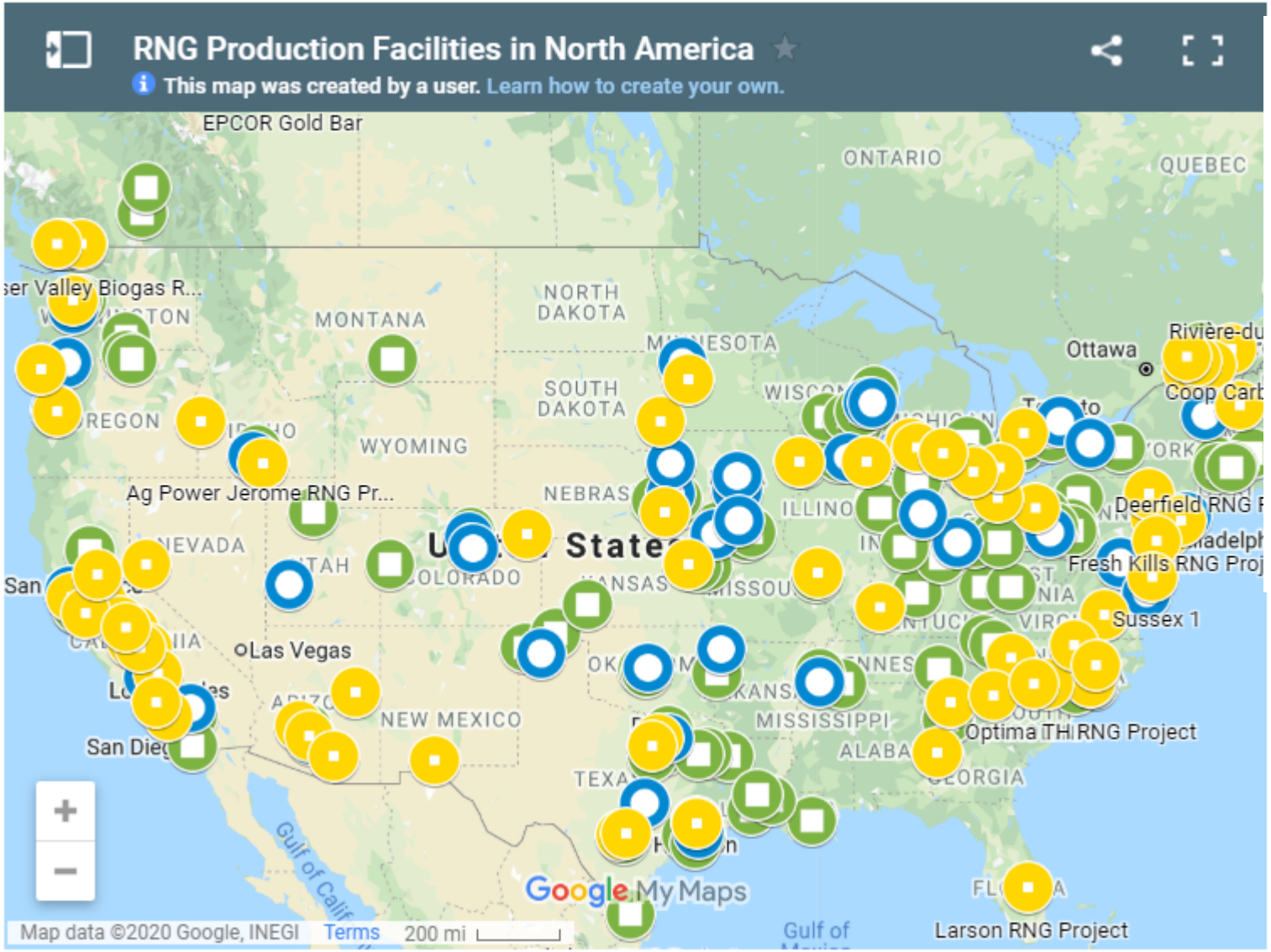
Wastewater Treatment



Gas mixture from biological decomposition of organic matter in absence of oxygen

- Methane: 50% - 70%
- CO_2: 30% - 40%
- Sulfur compounds
- Ammonia
- Siloxanes
- Water vapor

RENEWABLE NATURAL GAS PRODUCTION FACILITIES IN NORTH AMERICA



RNG PRODUCTION FACILITY COUNTER

129 OPERATIONAL/ONLINE (U.S. - 118, CANADA - 11)

37 UNDER CONSTRUCTION (U.S. - 36, CANADA - 1)

74 IN SUBSTANTIAL DEVELOPMENT (U.S. - 63, CANADA - 11)

MAP KEY

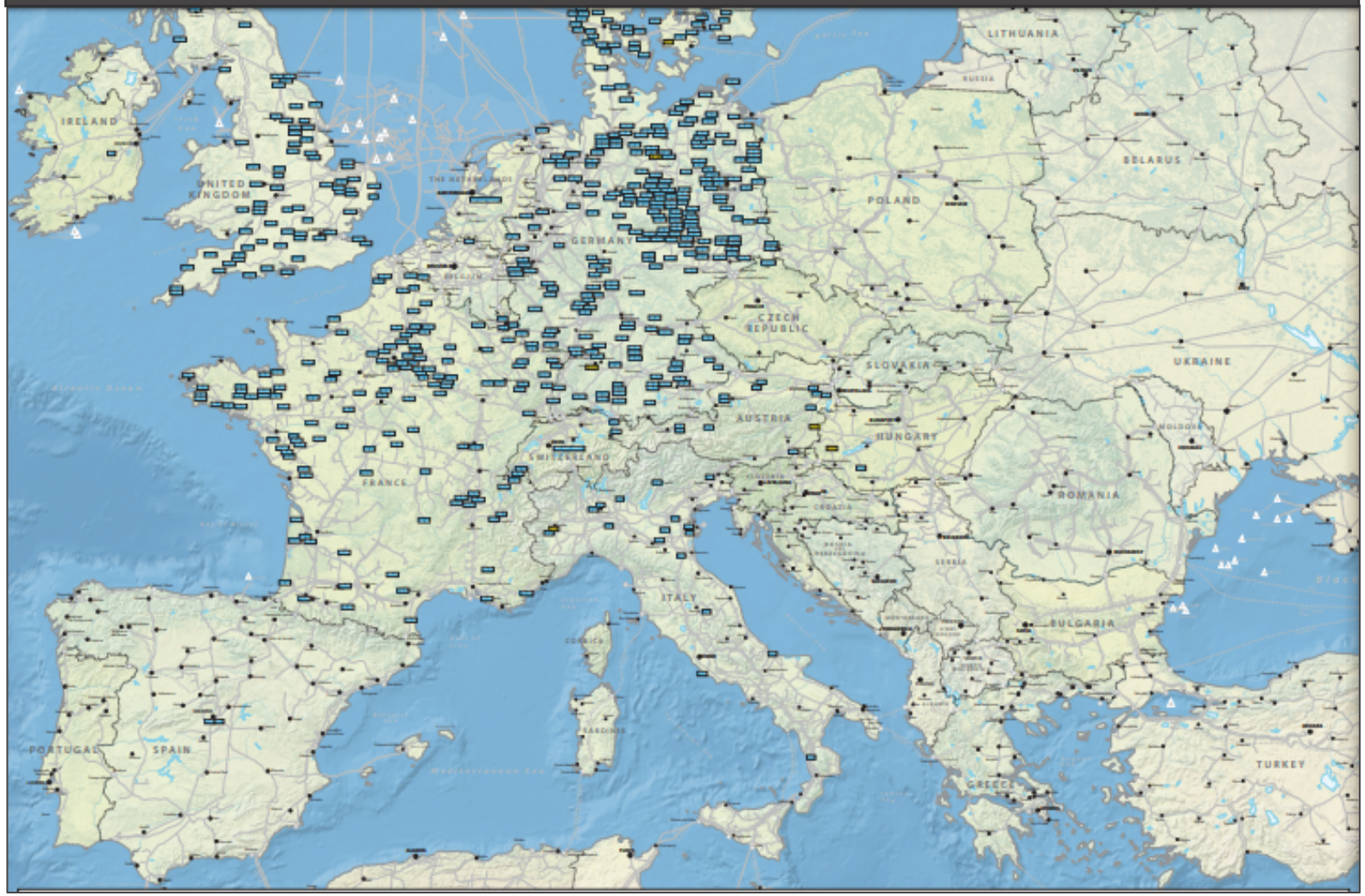
- Operational / Online
- Under Construction
- Substantial Development

The US Market has 43,000+ organic waste sites in North America that can be developed to capture methane

Source: RNG Coalition North America

RENEWABLE NATURAL GAS PRODUCTION FACILITIES IN EUROPE

European Biomethane Production Facilities in 2020



18 countries are currently producing biomethane in Europe

729 active biomethane production facilities in Europe

232 production facilities in Germany, **131** in France & **80** in the UK

European Biogas Association (EBA) analysis shows that the number of biomethane plants in Europe has increased by **51%** in 2 years, from **483** in 2018 to **729** in 2020.

Source: European Biogas Association

Low/No Carbon Hydrogen from Waste

Why not just use biomethane directly?

1. Hydrogen vehicles have ZERO tailpipe emissions improving local air quality
   Local air quality linked with many health issues and healthcare costs

2. Hydrogen vehicles are 2x more efficient than RNG engine vehicles = more miles travelled
   More miles travelled = better use of biomethane resource

3. Hydrogen vehicles are much quieter than RNG vehicles reducing noise pollution

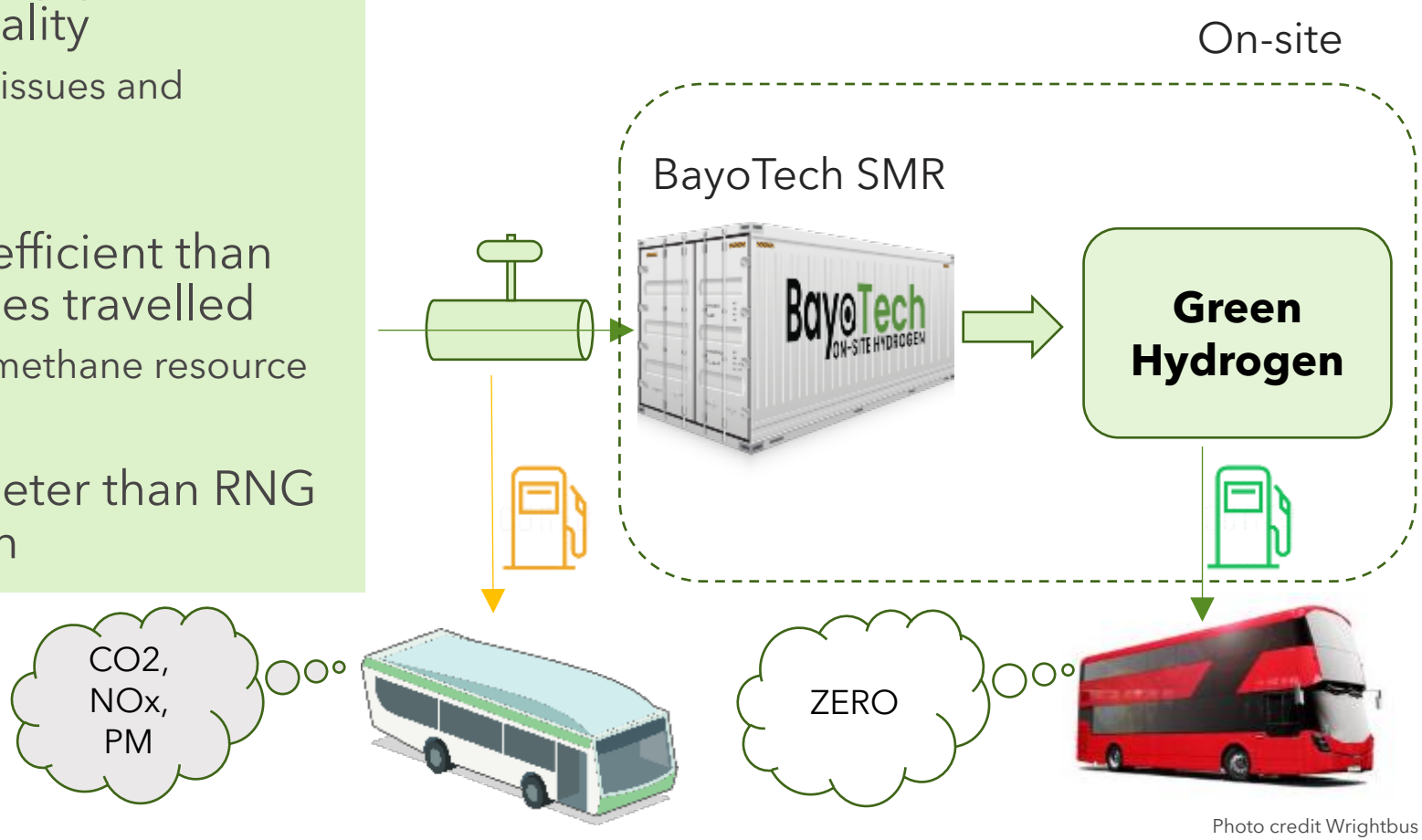
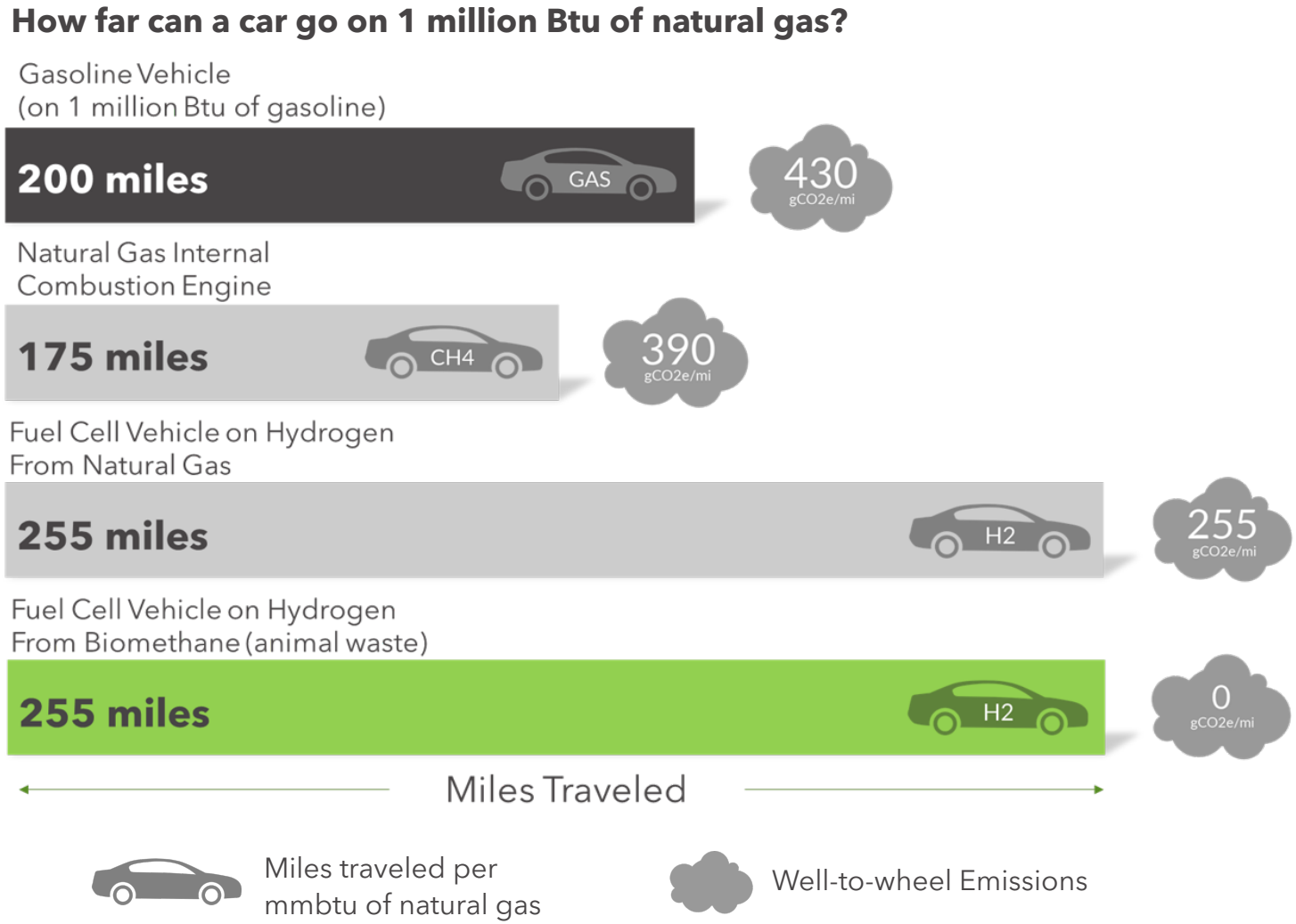


Photo credit Wrightbus

Hydrogen Advantage in Mobility



Source: NREL

Low/No Carbon hydrogen from waste

Low Carbon credit revenue is significant – Example from California

Potential LCFS Credit Revenue for Hydrogen

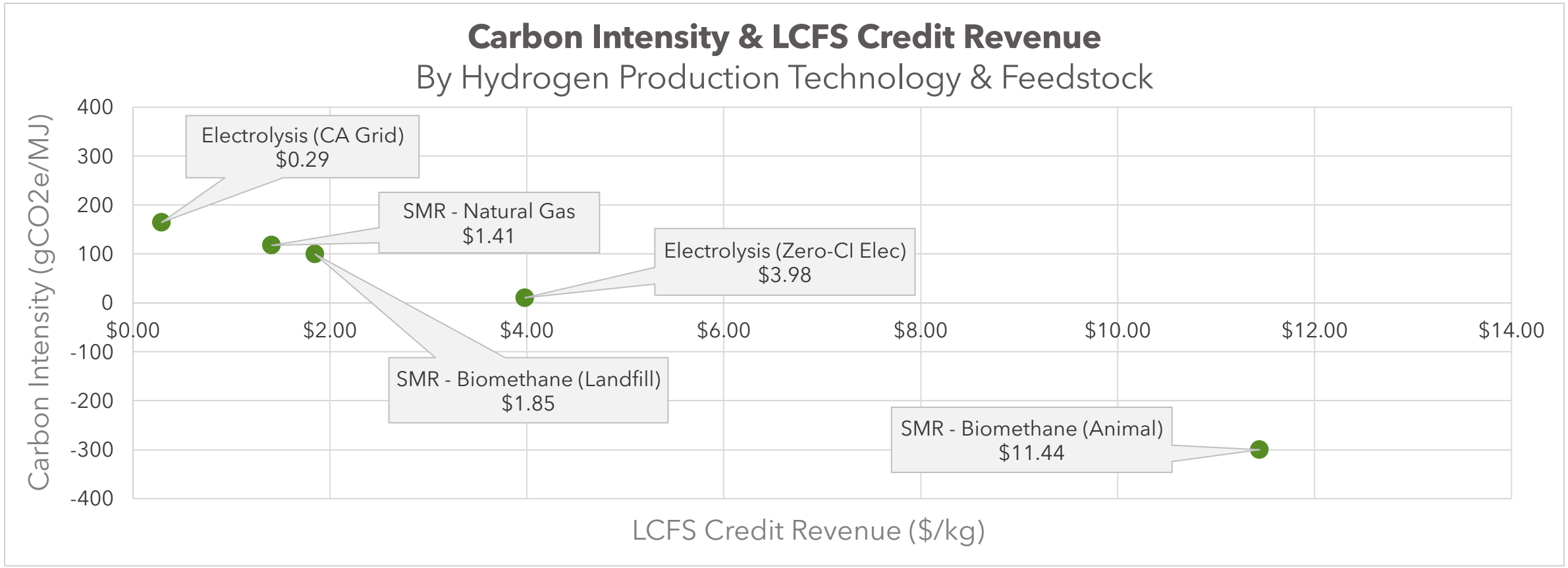
Fuel Production Technology	Feedstock	Example Carbon Intensity	Fuel Displacement Multiplier (EER)	Potential LCFS Credit Revenue
Steam Methane Reformation	Fossil natural gas	117.67 gCO2e/MJ	1.9	$1.41/kg
	Biomethane from landfills	99.48 gCO2e/MJ	1.9	$1.85/kg
	Biomethane from dairy/swine manure	-300 gCO2e/MJ	1.9	$11.44/kg
Electrolysis	CA grid electricity	164.46 gCO2e/MJ	1.9	$0.29/kg
	Zero-CI electricity	10.51 gCO2e/MJ	1.9	$3.98/kg

Assumptions:

- Hydrogen is dispensed to heavy-duty fuel cell electric vehicles (EER = 1.9)
- Credit price of $200/credit, roughly the average for April 2020

Source - ARB

Potential LCFS Credit Revenue for Hydrogen



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