



AIR, LAND, AND EARTH: MULTI-SECTORAL DECARBONIZATION



SEPT. 17



10:00 AM



Today's agenda

- **Welcome, Announcements, Introductions**
- **Main Presentations (20 minutes each):**
 - Decarbonizing AIR transport with green hydrogen, [Val Miftakov](#), ZeroAvia
 - Decarbonizing LAND transport with green hydrogen, [Elizabeth Fretheim](#), Nikola Motor Company
 - Decarbonizing EARTH mining with green hydrogen, [Michel Carreau](#), Hatch
- **Audience Q&A**

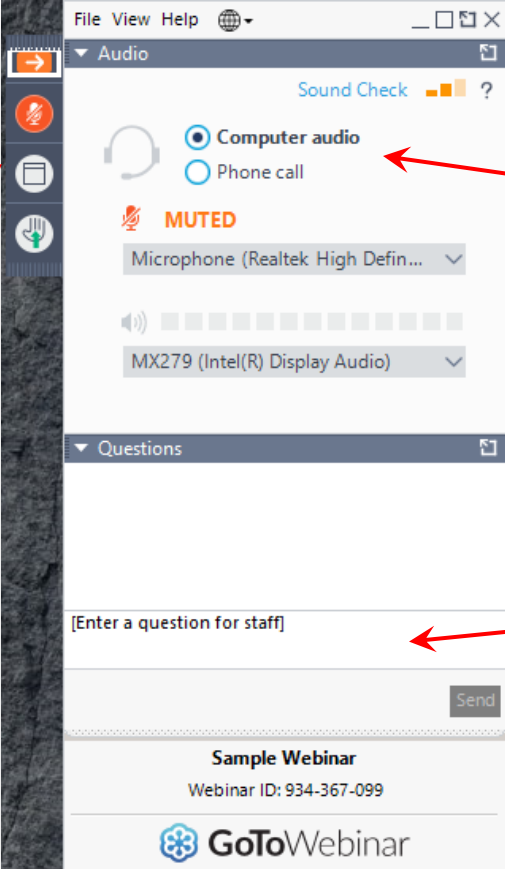


Moderator: Dr. Laura Nelson

Executive Director,
Green Hydrogen Coalition

Vice President
Strategen

Using GoToWebinar



The screenshot shows the GoToWebinar control panel with several annotations:

- Minimize control panel:** Points to the minimize button (horizontal line icon) in the top-left corner of the control panel.
- Mute microphone (all attendees are listen-only today):** Points to the microphone icon with a slash through it, indicating it is muted.
- Toggle full screen mode:** Points to the full screen icon (two overlapping rectangles) in the control panel.
- Raise hand (not used today):** Points to the hand icon with a raised arm, indicating the hand is raised.
- Audio options:** Points to the "Computer audio" and "Phone call" options in the Audio section.
- Type you questions here – questions will be answered after all panelists have presented:** Points to the text input field in the Questions section.

The control panel includes the following elements:

- Audio section:** Contains "Sound Check" with a progress indicator, "Computer audio" (selected), "Phone call", a "MUTED" status, a microphone dropdown menu, a volume slider, and an audio output dropdown menu.
- Questions section:** Contains a text input field with the placeholder "[Enter a question for staff]" and a "Send" button.
- Footer:** Displays "Sample Webinar", "Webinar ID: 934-367-099", and the GoToWebinar logo.

Today's webinar is being recorded; the recording and slides will be available after the webinar

MISSION:

Facilitate policies and practices to advance the production and use of Green Hydrogen in all sectors where it will accelerate a carbon free energy future

APPROACH:

Prioritize Green Hydrogen project deployment at scale; leverage multi-sector opportunities to simultaneously scale supply and demand

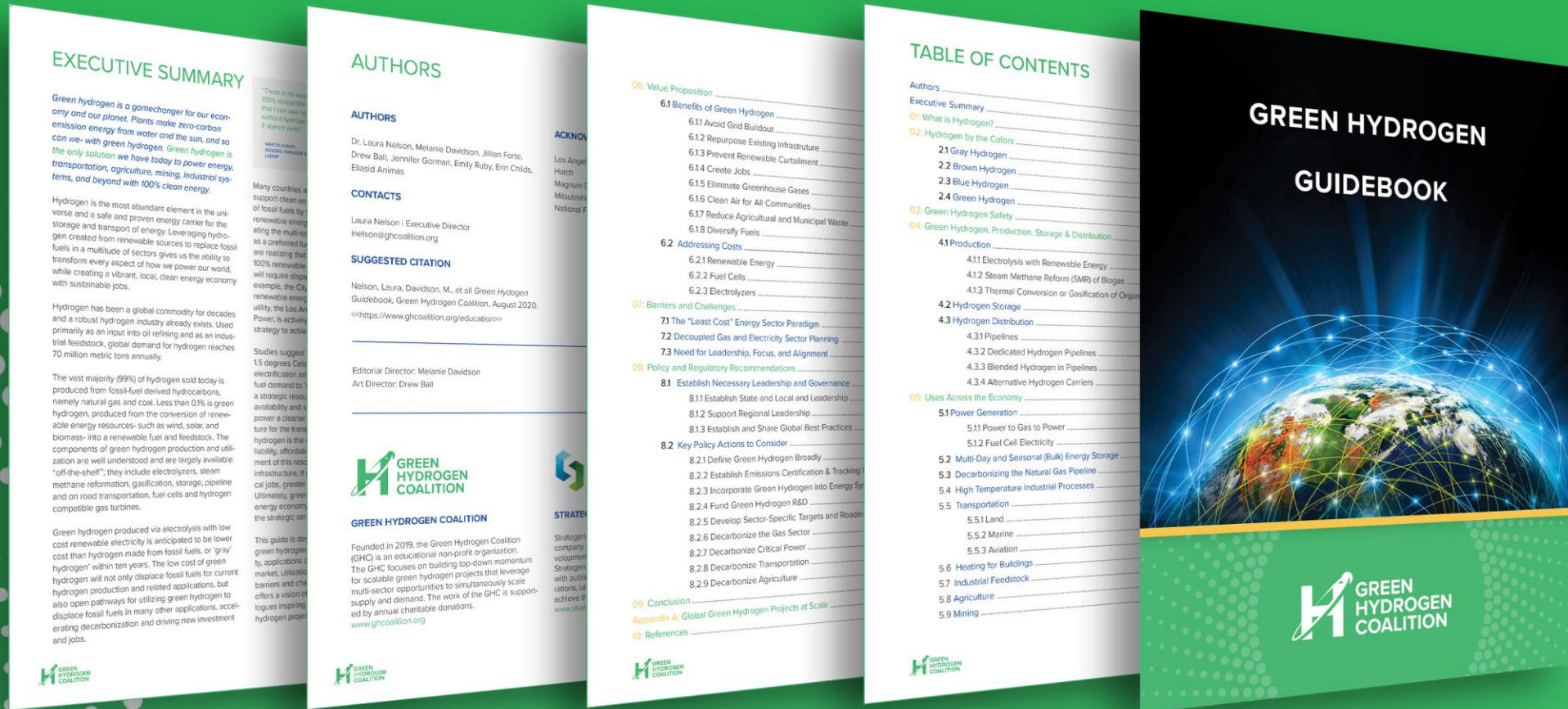


www.ghcoalition.org

GHC Supporters



Green Hydrogen Guidebook



Download today!
ghcoalition.org/guidebook



FREE WEBINAR

THE WESTERN CASE FOR **GREEN HYDROGEN**



OCT. 15



10:00 AM

GREEN HYDROGEN VISIONS FOR THE WEST

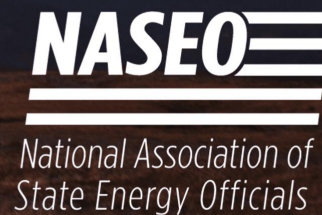
NOV 17-18, 2020 | 8:30AM-12:30PM PST
ghcoalition.org/ghvisions



VIRTUAL EVENT



SPONSORSHIP OPPORTUNITIES AVAILABLE





Strategen is a mission-driven professional services firm dedicated to decarbonizing energy systems

ASSOCIATIONS

Strategen co-founded and manages the California Energy Storage Alliance (CESA), the Vehicle-Grid Integration Council, and the Green Hydrogen Coalition. Through these organizations, Strategen policy work has been pivotal in building the energy storage industry in California, the US, and around the world.

CONSULTING

Since 2005, Strategen Consulting provides analysis and insight to governments, utilities, NGO's, and industry to help them achieve leading-edge market development and transformational clean energy strategies.

CONVENINGS

Strategen excels in stakeholder engagement, via customized small and large events. Strategen founded Energy Storage North America (ESNA), the largest grid-connected storage conference in North America. ESNA 2021 is affiliated with Intersolar North America.

Future Webinars

Green Hydrogen in the West

October 15, 2020

Today's Webinar

Air, Land, Earth: Multi-Sectoral Decarbonization with Green Hydrogen

Past Webinars

Green Hydrogen Technology 101

August 11, 2020

Global Progress & Momentum for Green Hydrogen

May 12, 2020

Perfect 50-State Storm: COVID-19 and the Utility Crisis

April 2020

Re-Imagining the Energy Ecosystem with Green Hydrogen

April 2020

V-DER Tariffs: Encouraging Good Grid Citizenship

March 2020

Energy Storage on the Move

September 2019

Energy Storage in Emerging Markets

April 2019

Recordings and slides available at <https://www.strategen.com/webinars>

Stay Tuned for More Webinars!



Val Miftakov

Founder and CEO

ZeroAvia



Elizabeth Fretheim

Head of Business Development
and National Accounts

Nikola Motor Company



Michel Carreu

Director Hybrid Power and
Green Hydrogen

Hatch



Poll



ZERO AVIA

Hydrogen in Aviation - The Only Way

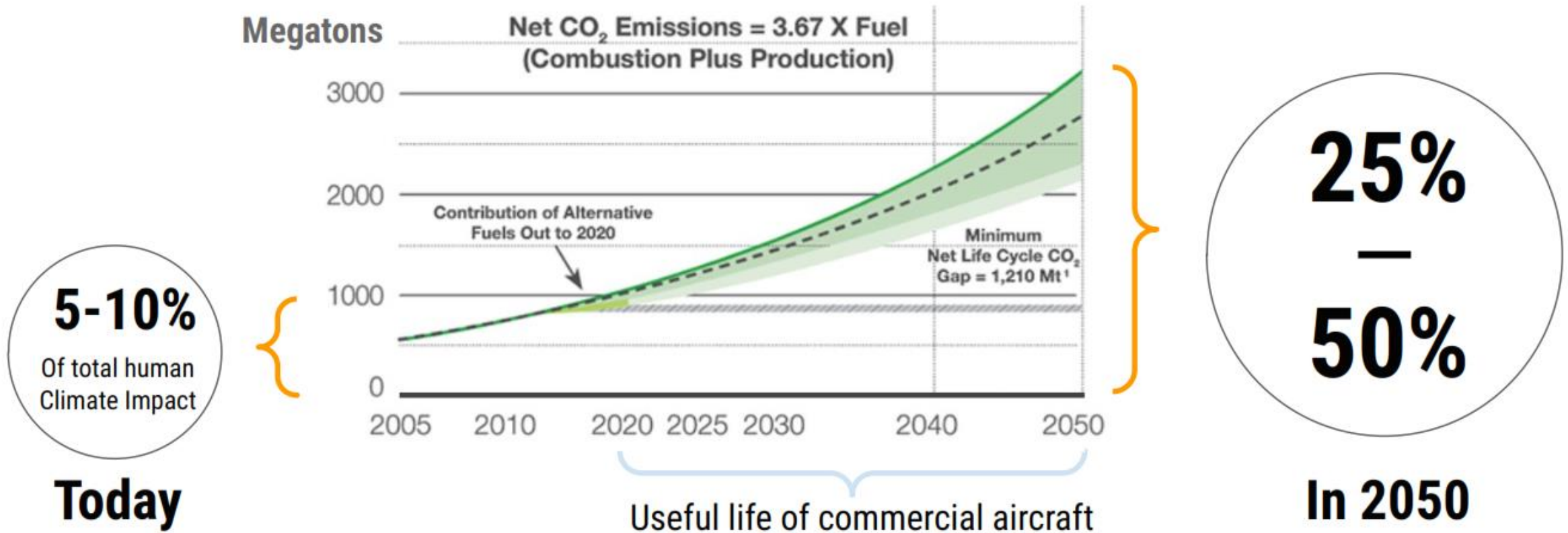
GHC Webinar
September 17 2020

“My generation won’t be able to fly other than for emergencies, in a foreseeable future if we are to be the least bit serious about the 1,5° warming limit. I will try to make it to as many places as possible without flying.”

SKOLSTREJK
FÖR
KLIMATET



\$1.5T Aviation Market is Flying into Sustainability Crisis



The Problem is Real and Gets Big Fast

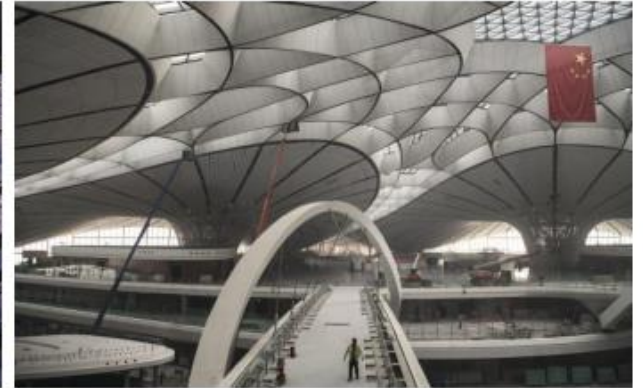
Already, everyone
wants to fly



DESTINATIONS FOOD & DRINK NEWS TODAY

Beijing is building hundreds of
airports as millions of Chinese take
to the skies

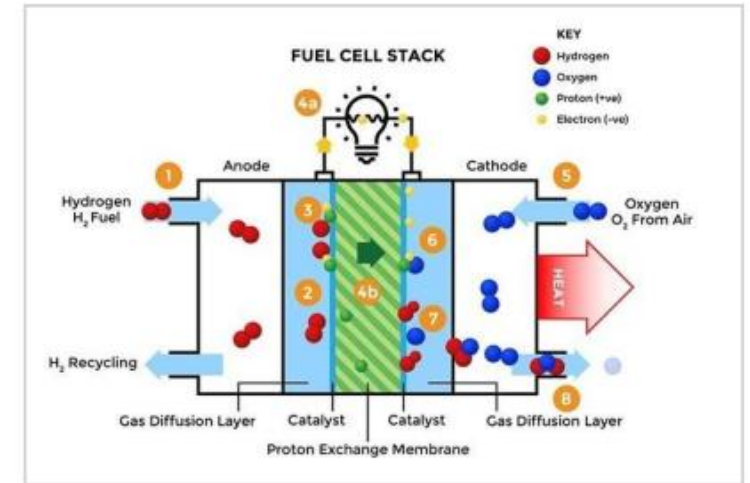
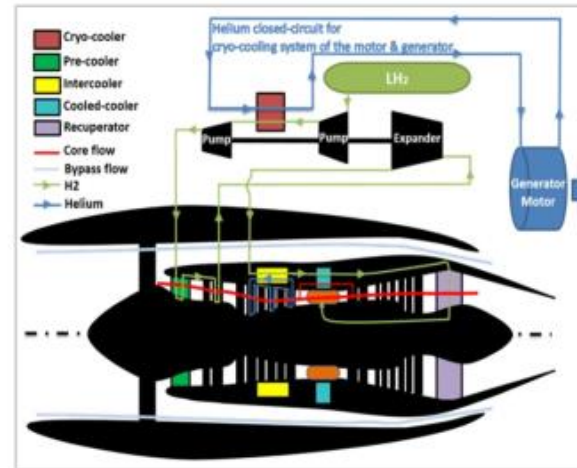
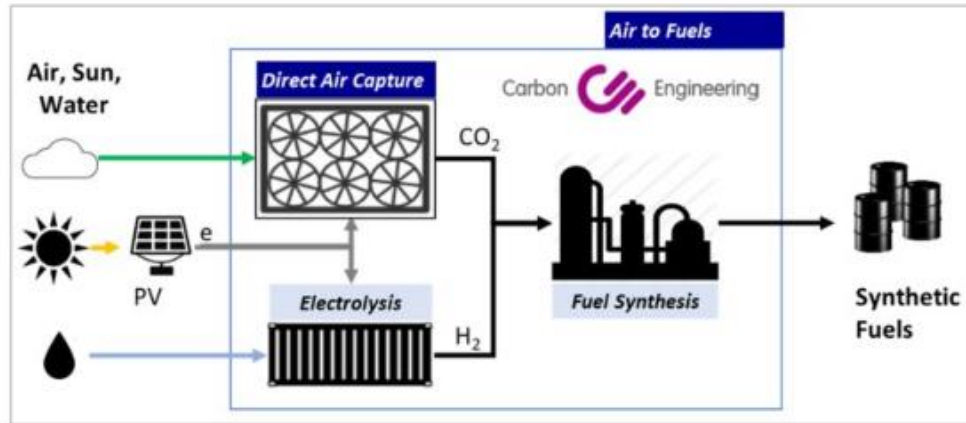
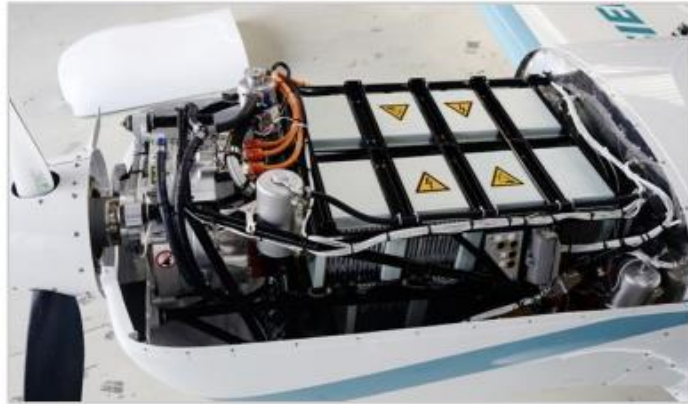
Multi-Frame and Blurred Video (2014) / Multi-Frame (2014) / Multi-Frame (2014)



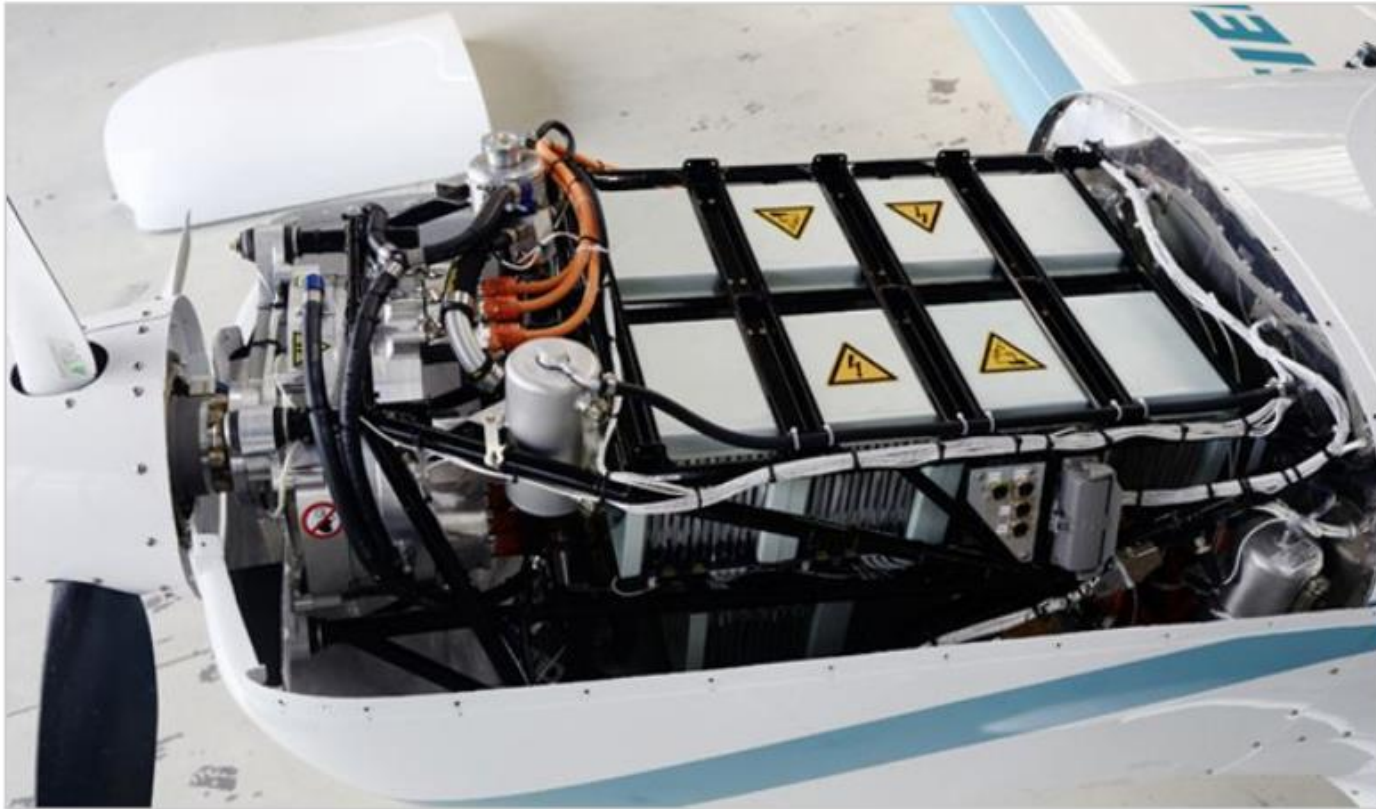
And over time, only
air transport is truly
3D scalable...



How??



Batteries?



- **50x heavier** than Jet Fuel (0.25 vs. 12 kwh / kg)
- **High cycle costs** (1,000 cycles = \$0.30 / kwh energy cost adder)
- Materials, recycling, etc.
- **New fuel infrastructure**

Turbine Hybrids?



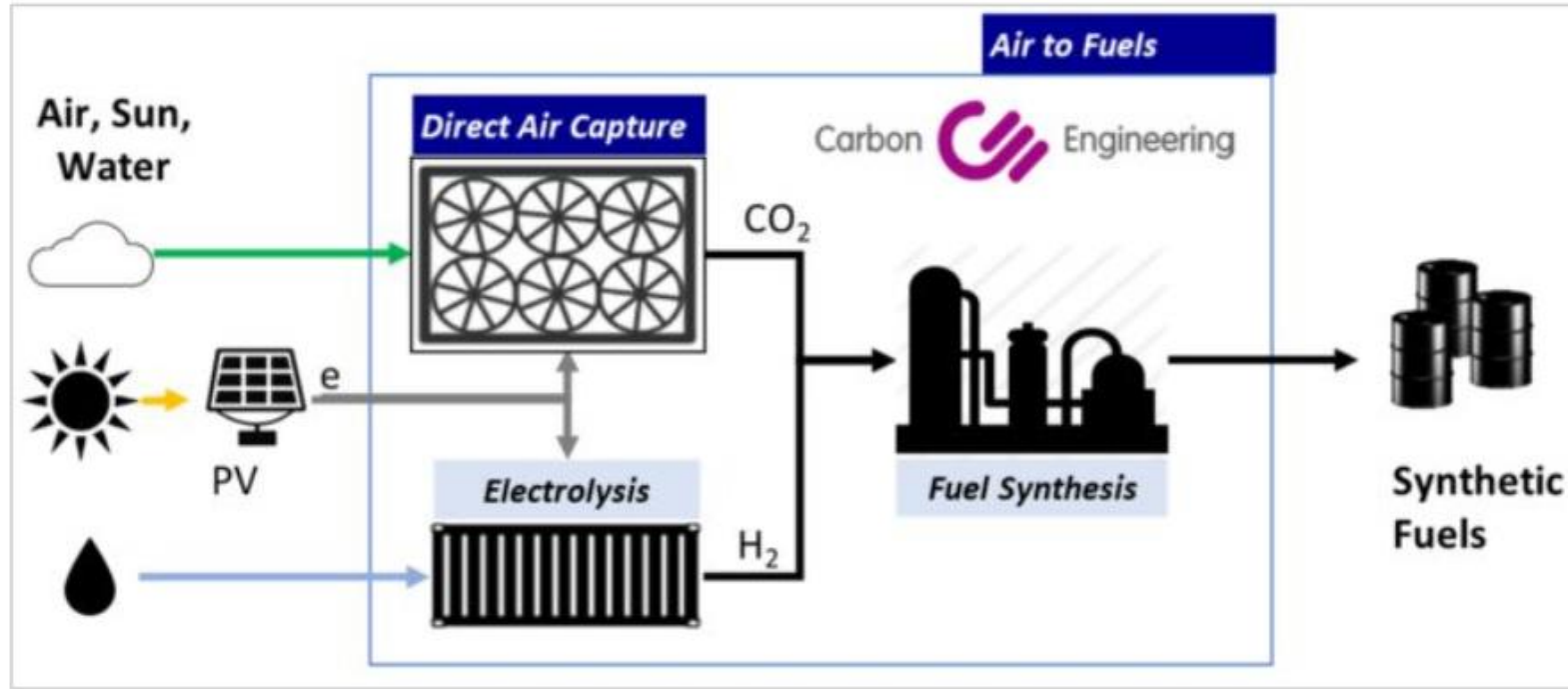
- **Higher weight & complexity**
- **Minor improvements in efficiency**
- **Retain high maintenance costs**
- **Retain NOX / Soot / SOX**

Biofuels?



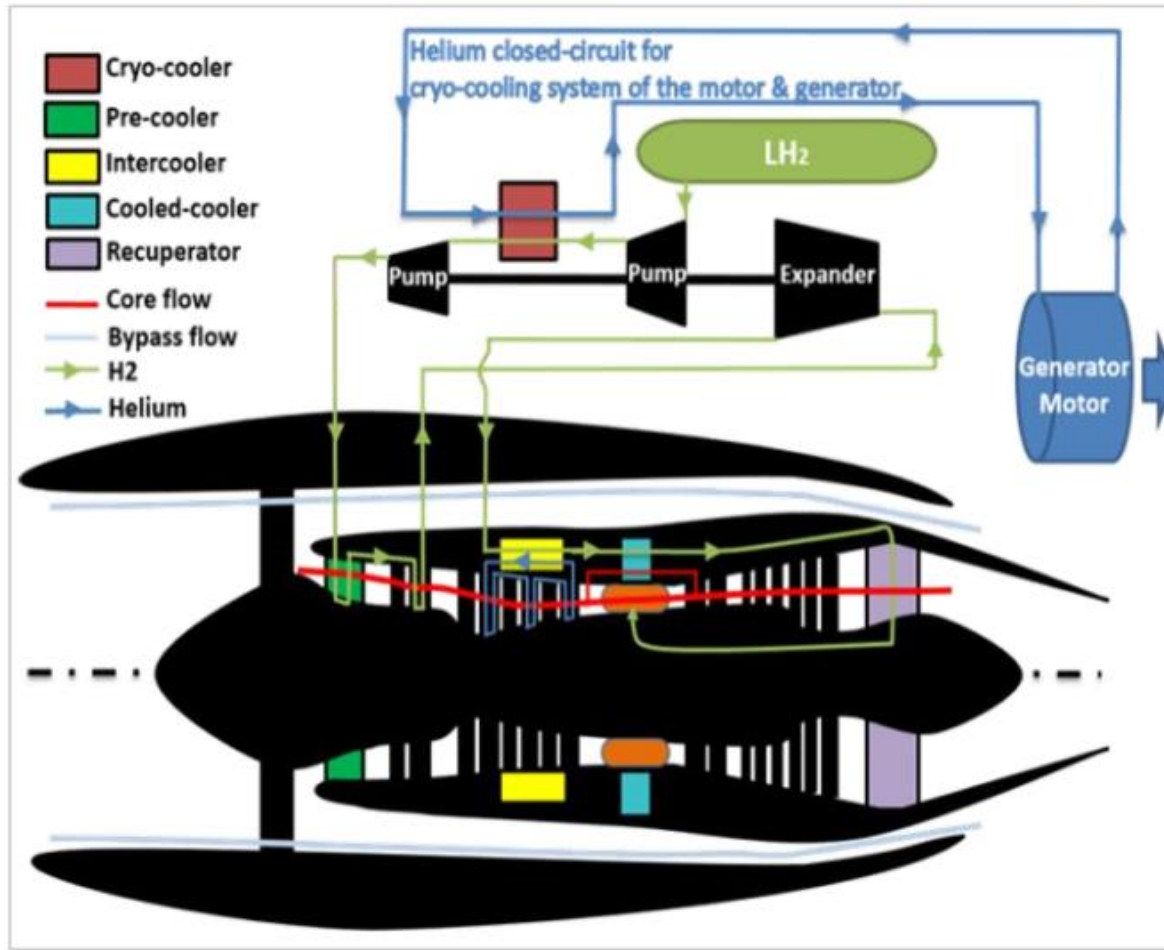
- **500x less efficient** use of land wrt Solar H2
- **Hard to scale** (40% of US ag land required to achieve 100% of fuel replacement)
- **Water use, land use issues**
- **Retain low efficiency, NOX, MX costs of turbines**

Synfuels?



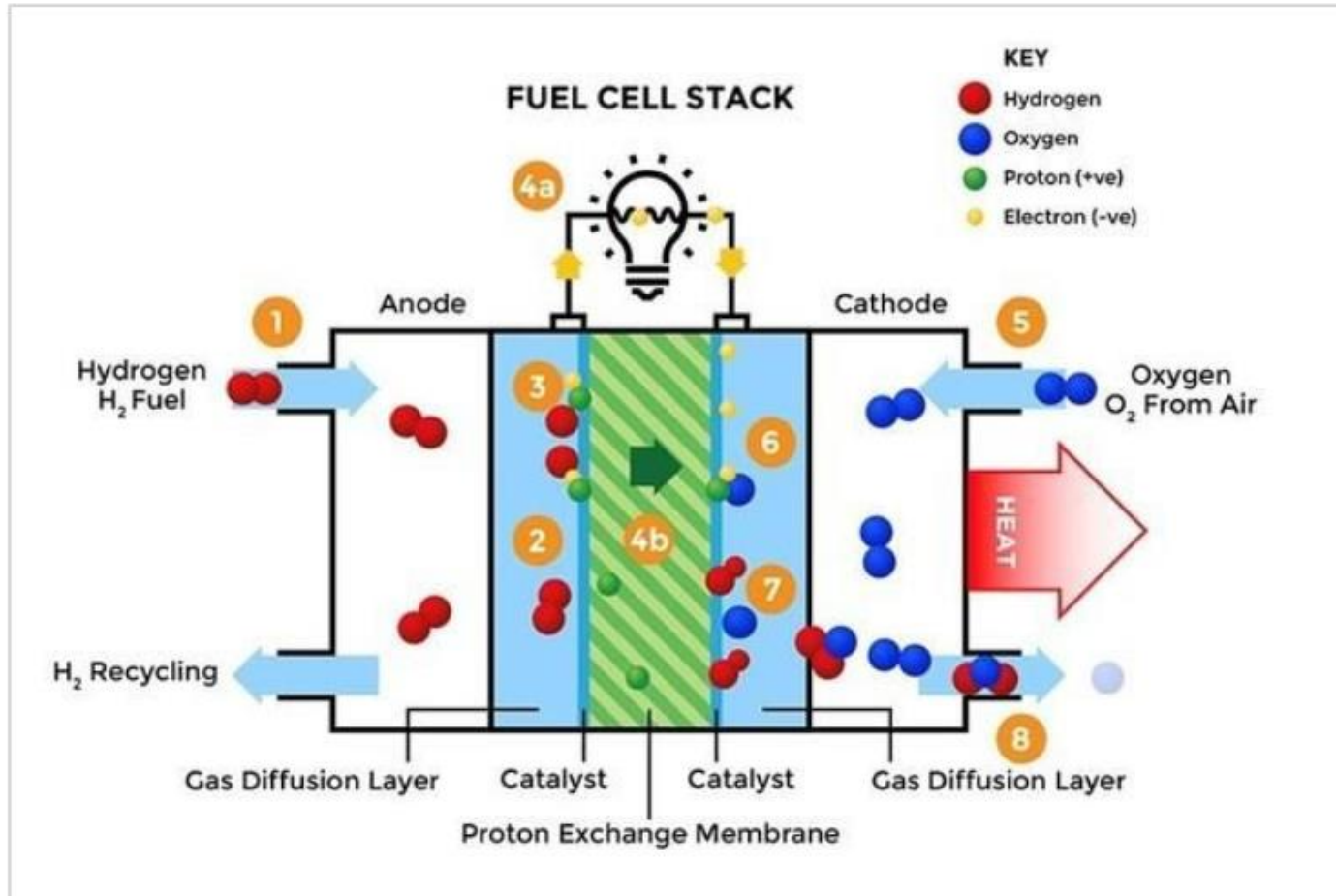
- **High cost, especially with direct air capture (4-7x fossil fuel)**
- **Retain low efficiency, high MX, NOX of turbines**

Hydrogen Turbines?



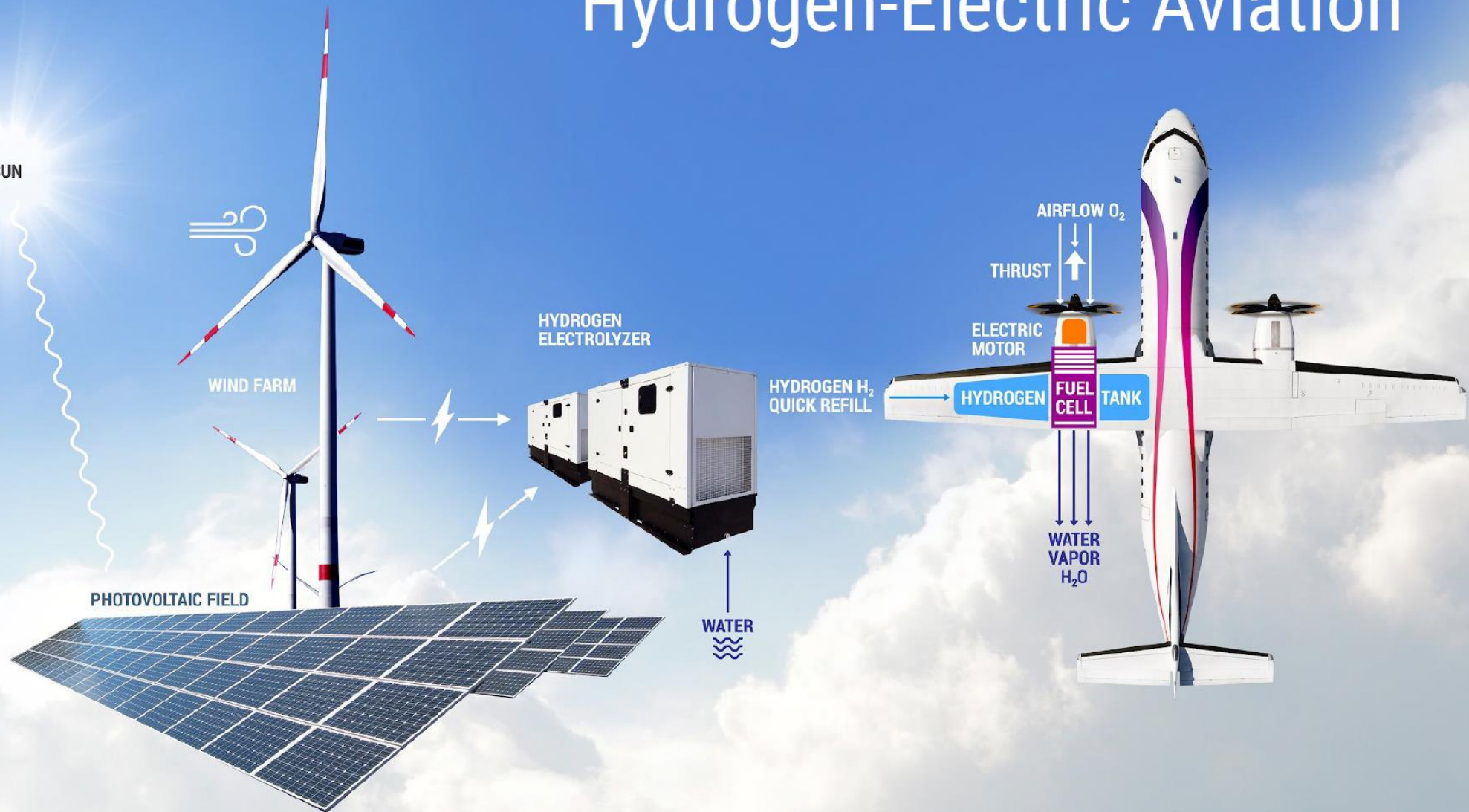
- **Retain low efficiency, high MX, NOX** of turbines
- **High volume of fuel** (H₂ 10x less dense than jet fuel)
- **New fuel infrastructure**

Hydrogen Fuel Cells?



- **High volume of fuel** (H_2 10x less dense than jet fuel)
- **Lower power density**
- **New fuel infrastructure**

Our Vision: Renewably-Powered Hydrogen-Electric Aviation



Long range, Lower costs & Zero Emission

Hydrogen Momentum Accelerating

Hydrogen is quickly rising to become one of top fuels for any serious decarbonization of aviation



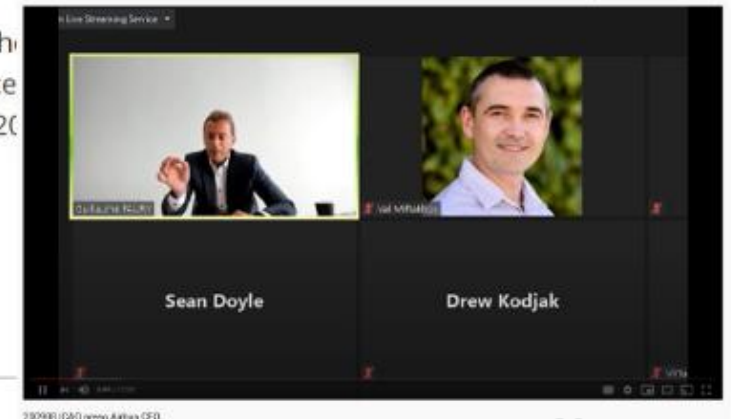
France Plans To Make Airbus A320 Successor By 2030

by **Joanna Bailey** · June 9, 2020 · 3 minute read

The French government has today revealed plans to invest heavily in developing the plane of the future. France's ambitions for a zero carbon plane include a reworking of the popular Airbus A320 product line by 2030 and the move to hydrogen fuel by 2035. Altogether, €15bn (\$17bn) will be poured into the aerospace sector over the coming years.

To work towards the development of the zero emissions plane, France has planned a roadmap for development, as detailed by Minister of Energy Transition and Transport, Elisabeth Borne. This includes developing the [successor to the Airbus A320](#) to be ready by around 2030.

Simultaneously, research is planned to develop the switch the new aircraft to this clean energy source the new A320 would be revealed around 2026 - 2028 and be designed before the end of the decade.

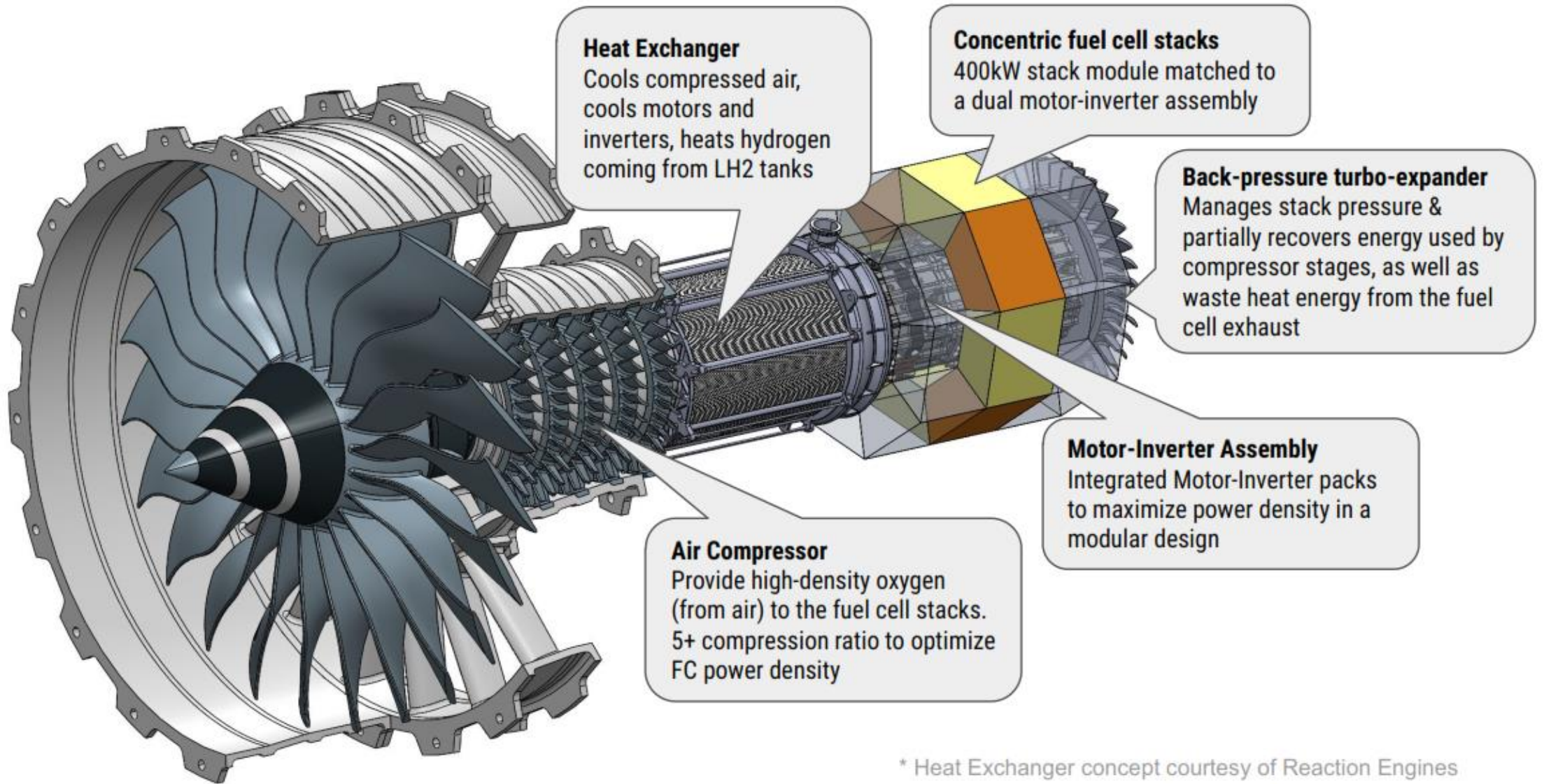


H2-Electric - Better Than Jet Turbines?

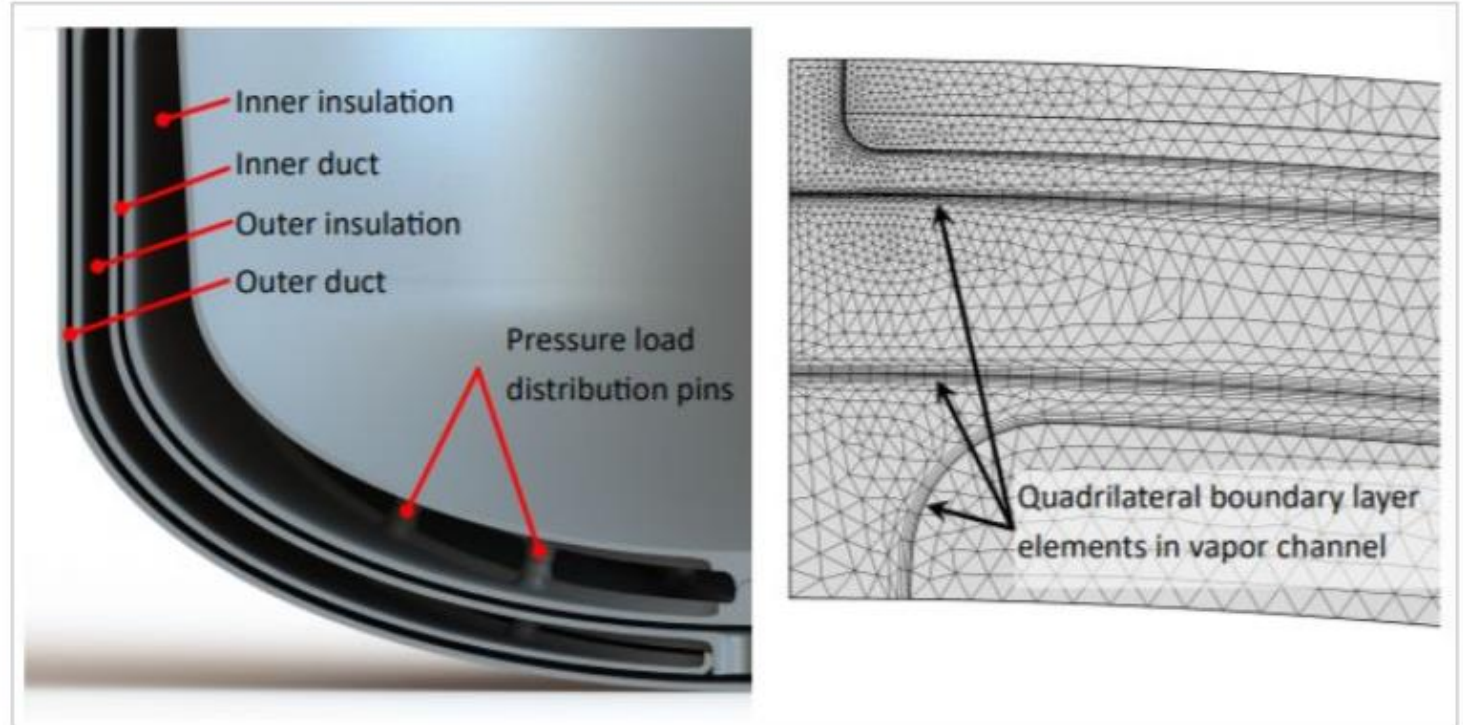
H2-electric powertrains will not only be clean but also a fundamentally better product for everyone

	Jet Turbine	H2-Electric
Lower & stable fuel costs	\$2 / gallon for large operators, up to \$4 / gallon for small; hedging is a big cost item	Green H2 projects are at \$3 / kg today, equivalent to \$1.5 / gallon jet fuel for small planes, with path to <\$1 / gallon for large planes in 15-20 years; fuel source much more secure (e.g., PV), stable prices
Lower maintenance costs	Small turbines: 1,800 - 3,600 hours to major MX / overhaul; large: 4,000 - 7,000	Electric side of the powertrain can have 10x lower MX cost; Fuel cells already at 10,000+ hours, 20,000+ achievable for HTPEM
Lower noise levels	High-speed jet exhaust major source of noise	Only propulsor noise remains; can be further tuned exploiting wider power bands of e-motors
More efficient airframes	Thermodynamics drives need for smallest number of large engines - not aero-efficient	Much lower efficiency penalty for smaller engines allows more distributed propulsion & higher aero-efficiency

TurboCell H2-Electric Engine Platform



Onboard H2 Tanks



70% mass fractions possible, resulting in longer ranges than jet fuel (assuming volume is available)

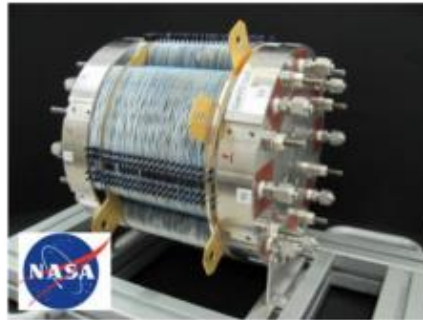
Green H2 SuperChargers

Quickly deployable solar arrays



LiFePo4 buffer battery

Advanced scalable electrolysis systems



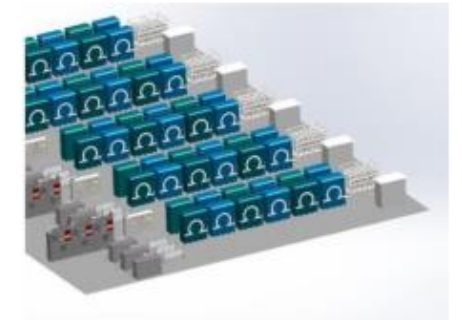
Exceptional PEM Stack

- Selected for lunar missions
- 10^5 hours life
- Rapid cycling



UPS Power Electronics

- Proven, low-cost
- High-volume ready now
- Vertically integrated IP



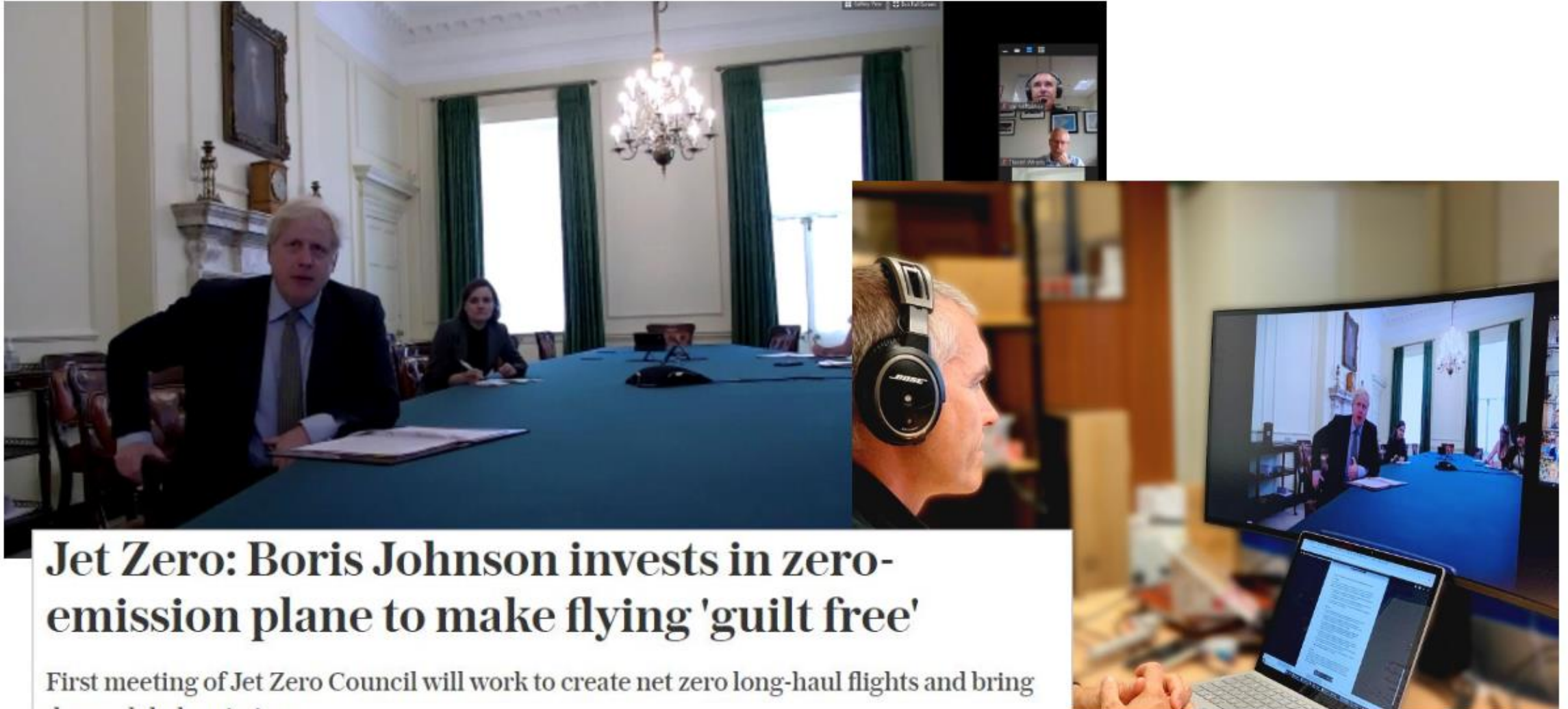
Modular Design

- Scale 0.3 MW to 300+ MW
- UL Certification ready
- Many markets, one core

Plan: All Aviation, Starting @500-mile 19-Seat



JetZero - Zero Emission 100+ Seat Jet by 2030



Jet Zero: Boris Johnson invests in zero-emission plane to make flying 'guilt free'

First meeting of Jet Zero Council will work to create net zero long-haul flights and bring down global emissions

Thank You!

val@zeroavia.com

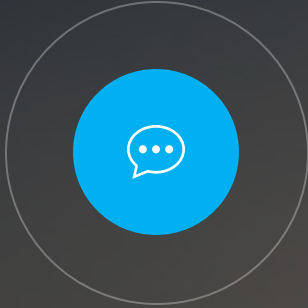


NIKOLA™

TRANSPORTING THE
FUTURE TO NOW.

Elizabeth Fretheim
Head of Business Development
elizabeth.fretheim@nikolamotor.com





“The **light bulb** did not come from the continuous improvement of **candles.**”

OREN HARARI

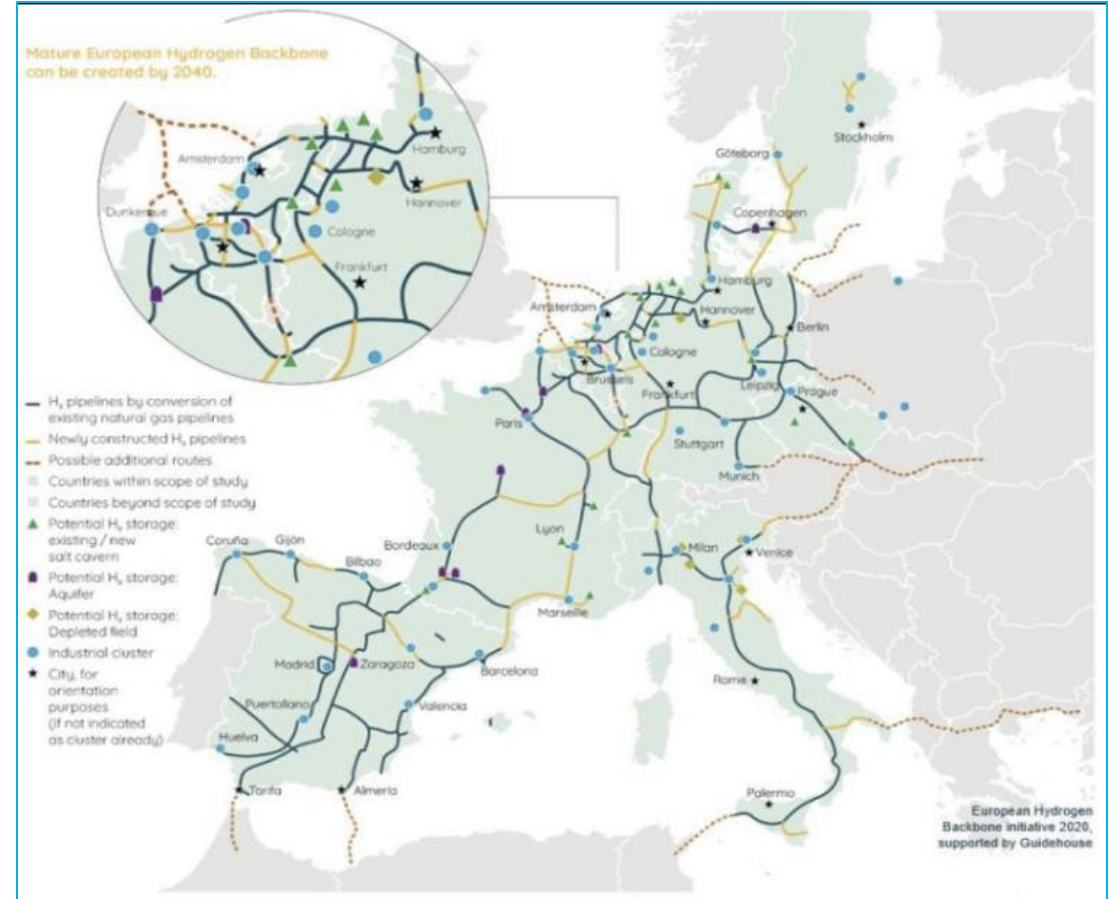


A blue-tinted photograph of a truck driving on a road next to a lake, with mountains in the background. The truck is in the foreground, moving towards the viewer. The road curves to the right, and a guardrail is visible on the right side. The background shows a large body of water and distant mountains under a clear sky.

MARKET DRIVERS, OPPORTUNITY & POLICY PRIORITIES

MARKET DRIVERS

- Government and private-sector activity
 - Federal agency commitment and interest in innovative vehicle technologies, fuel cells, electrification
 - Growing number of global hydrogen players - investment and deployment strategies
 - U.S., Canada, Japan, China, South Korea, Australia, European Union
 - Expanding state-level zero emission policies and grid energy security needs
 - Private-sector carbon reduction and sustainability operational goals
- Market demand and cost competitiveness
 - Market acceptance of Nikola is strong and growing
 - Cost of hydrogen anticipated to drop by 50% by 2030 with future global investment/scaling



Ontras Gastransport, A Proposed European Hydrogen Highway System (2020)

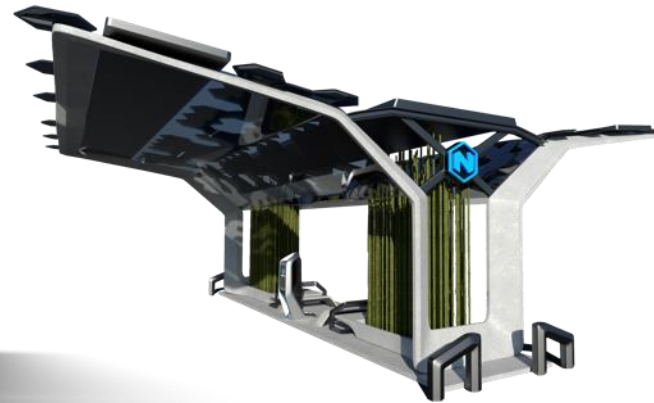


WHAT WE DO:



ELECTRIC TRUCKS

Design and manufacture battery-electric and fuel cell hydrogen-electric vehicles.



HYDROGEN STATIONS

8-32 ton hydrogen generation & filling stations & chargers.
700 planned in North America,
70 planned in Europe.



POWERSPORTS

Design and manufacture electric Off-Highway Vehicles and personal watercraft for commercial & military markets.



PRIVILEGED &
CONFIDENTIAL

WORLD-CLASS PARTNERS.

Nikola has partnered with some of the greatest industry leaders in the world. These partnerships enabled Nikola to come to market quickly and make its' vision become reality.



IVECO



WABCO

MAHLE

nel•



PRATT & MILLER

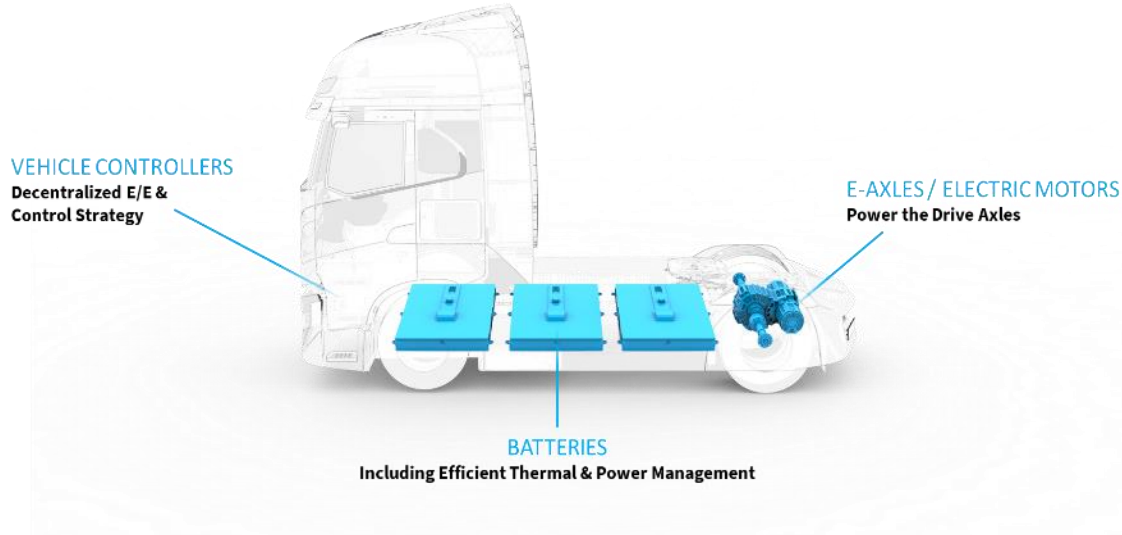


A blue-tinted photograph of a Nikola truck driving on a winding road. The truck is in the foreground, moving towards the viewer. The road curves to the right, with a guardrail on the edge. In the background, there is a large body of water (a lake or reservoir) and a range of mountains under a clear sky. The entire image has a monochromatic blue color scheme.

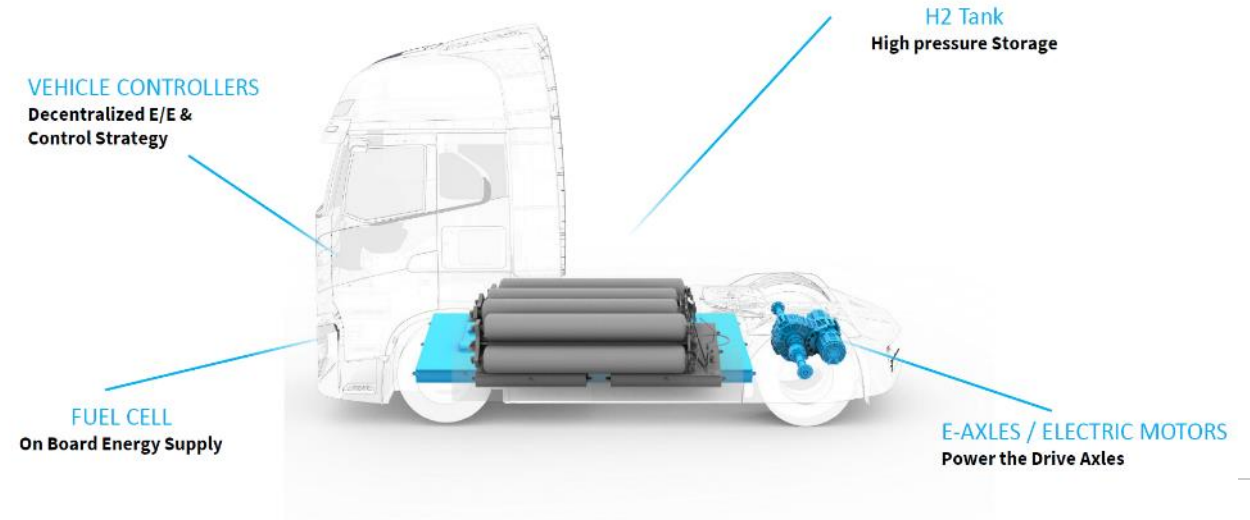
TRUCK PORTFOLIO

Zero emission VEHICLES - battery or hydrogen?

Battery Electric vehicle (BEV)



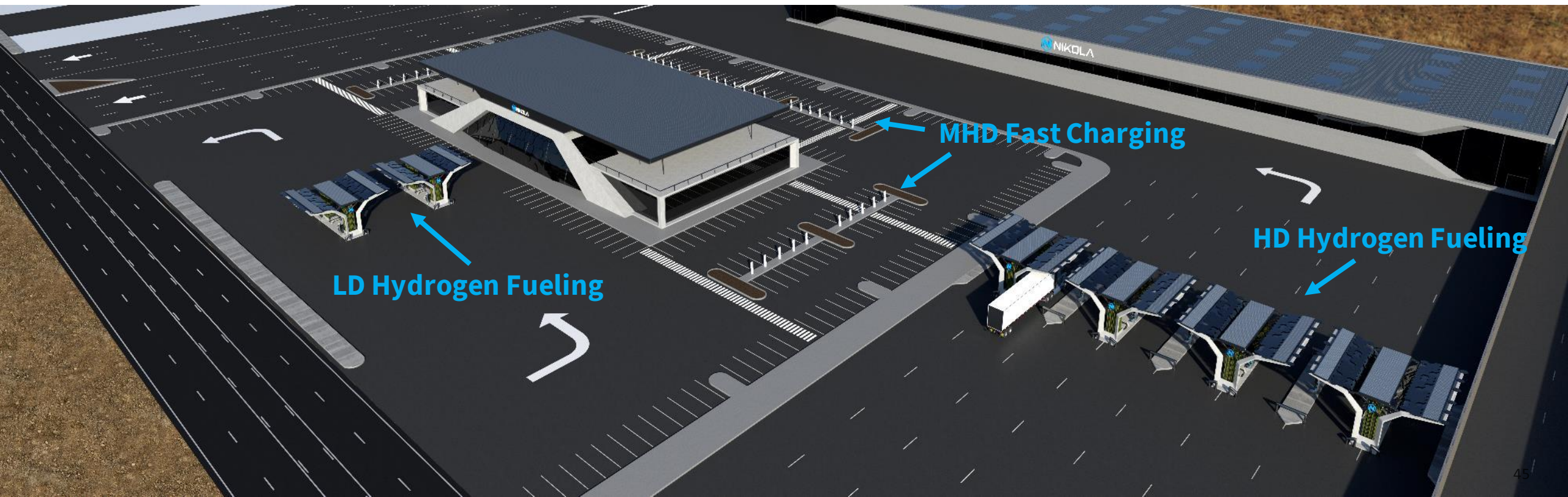
Fuel cell electric vehicle (Fcev)



A blue-tinted photograph showing a close-up of hands holding a fuel nozzle. The nozzle is black with a blue handle and a white label that includes the number 'E0036'. The background is blurred, showing other people and parts of the fueling station. The text 'fueling INFRASTRUCTURE' is overlaid in white, with 'fueling' in lowercase and 'INFRASTRUCTURE' in uppercase.

fueling INFRASTRUCTURE

ZERO EMISSIONS: FROM ENERGY CREATION, TO ENERGY CONSUMPTION.



Station Specs:

8_T

STANDARD

Expandable to 32 T/day

20

gallons OF WATER
PER DAY

K

22.5

MW OF
POWER

8-10

acres OF LAND



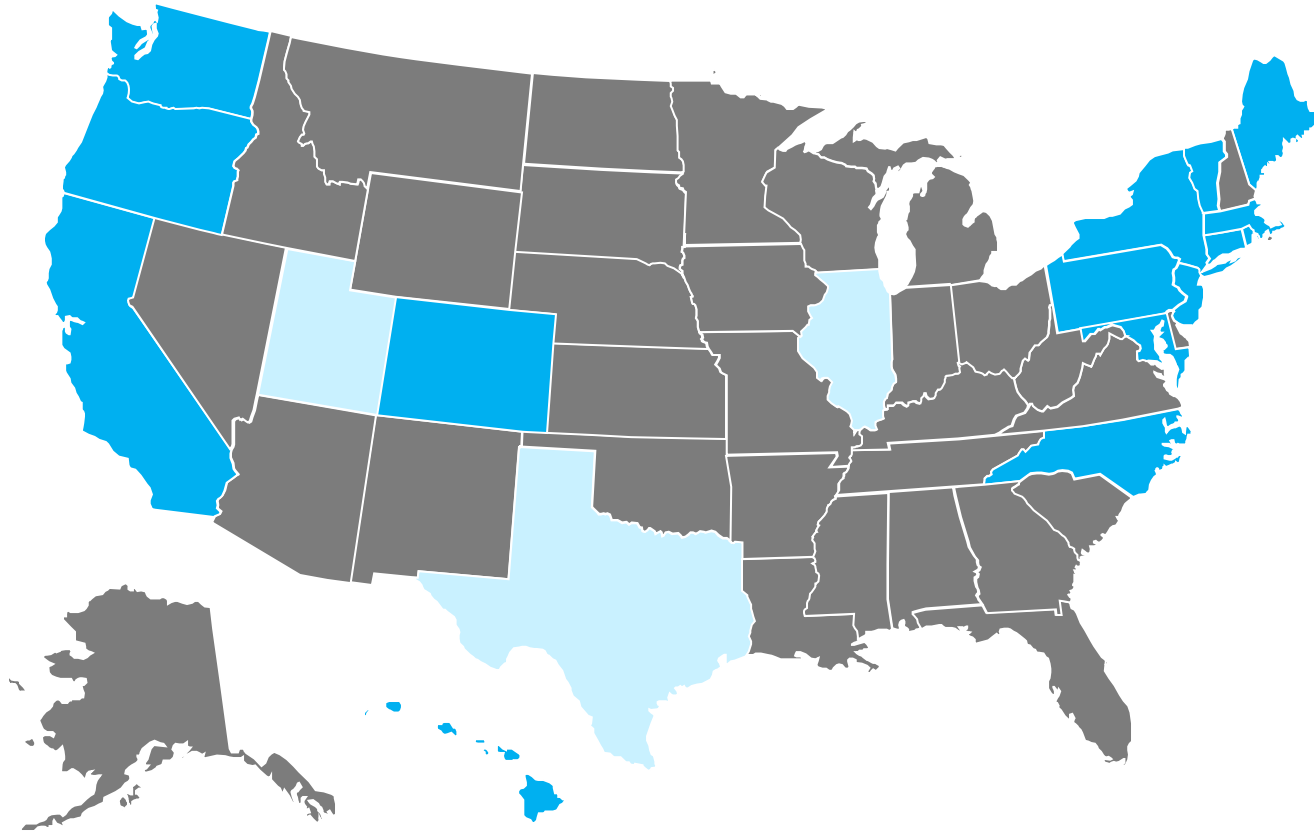
PRIVILEGED &
CONFIDENTIAL

A map of North America, including parts of Canada, the United States, and Mexico, is shown in a dark grey tone. Overlaid on the map are numerous small, teal-colored icons, each consisting of a shield shape with the chemical formula 'H₂' inside. These icons are distributed across the continent, with a higher density in the eastern and southern United States. The text '700 HYDROGEN & charging STATIONS IN NORTH AMERICA BY 2028' is superimposed in large, white, sans-serif font across the center of the map.

700 HYDROGEN & charging
STATIONS
IN NORTH AMERICA BY 2028

GEOGRAPHIC PRIORITIES

USA GOVERNMENT INCENTIVES



MOU Participants:

California, Connecticut, Colorado, DC, Hawaii, Maine, Maryland, Massachusetts, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, Vermont, Washington

California HVIP

Zero-Emission Truck Voucher Amounts

GVWR (lbs)	Base Vehicle Incentive	
	Outside Disadvantaged Community	In Disadvantaged Community
5,001 – 8,500	\$20,000	\$25,000
8,501 – 10,000	\$25,000	\$30,000
10,001 – 14,000	\$50,000	\$55,000
14,001 – 19,500	\$80,000	\$90,000
19,501 – 26,000	\$90,000	\$100,000
26,001 – 33,000	\$95,000	\$110,000
>33,000	\$150,000	\$165,000
>33,000 Hydrogen Fuel Cell Truck	\$300,000	\$315,000

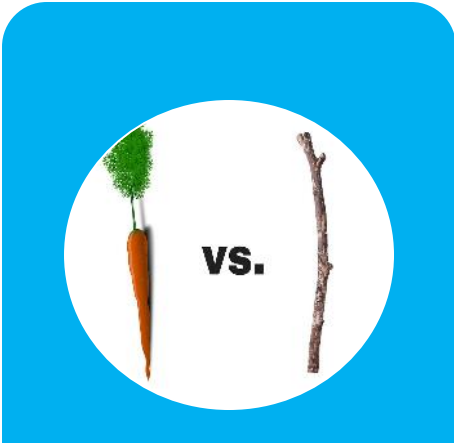
New York Truck Voucher Incentive Program

		Voucher Amounts and Caps by Vehicle Technology and Weight Class					
Vehicle Technology	Incremental Cost %	Vehicle Weight Class (GVWR)					
		3	4	5	6	7	8
BEV	80-95%*	\$60,000	\$100,000	\$110,000	\$125,000	\$150,000	\$185,000
PHEV	85-90% [^]	-	\$55,000	\$60,000	\$70,000	\$100,000	\$120,000
HEV	85-90% [^]	-	\$25,000	\$35,000	\$45,000	\$50,000	\$55,000
CNG	85-90% [#]	-	\$25,000	\$35,000	\$45,000	\$50,000	\$55,000
Propane	85-90% [#]	-	\$25,000	\$35,000	\$45,000	\$50,000	\$55,000

Puzzle pieces



Customers



Incentives



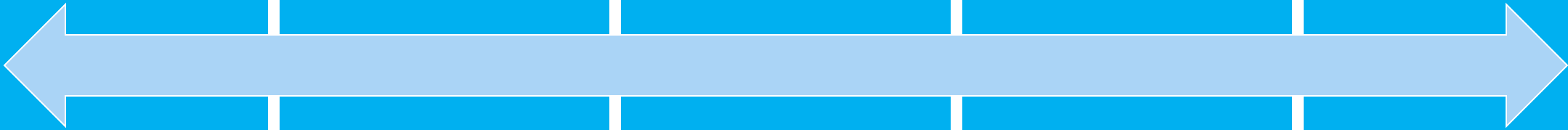
Regulations



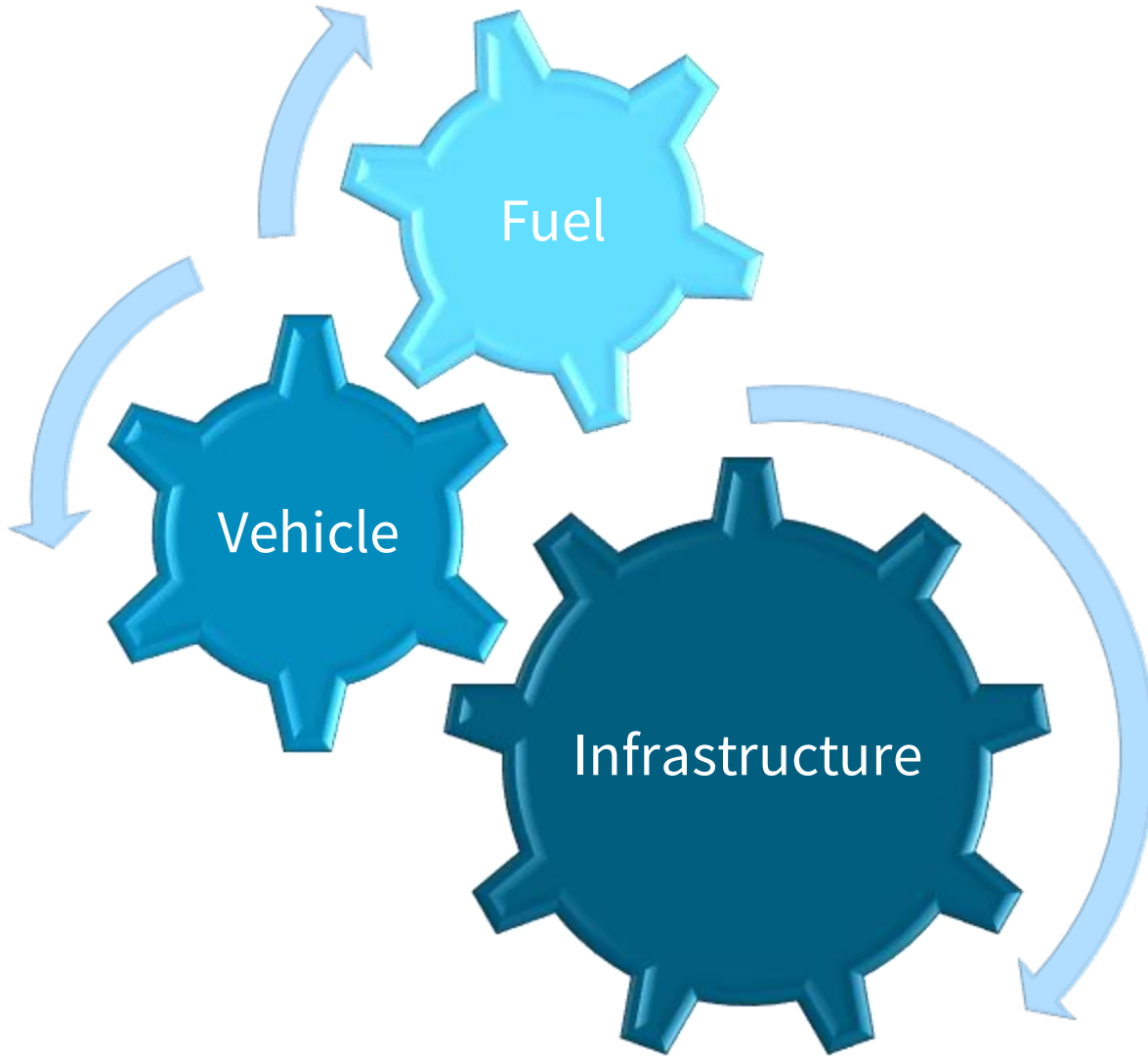
Electricity



Infrastructure



POLICY PRIORITIES



- Expansion of Federal Weight Exemption
- Alternative Fuel Vehicle Corridors
- Tax Credits/Production Incentives/Funding Mechanisms
- Implementation vs R&D Funding
- Competitive Electricity Pricing
- Streamlined Permitting and Inspections



commercialization



ROADMAP TO COMMERCIALIZATION.



**ALPHA
BUILDS**

2019



**ALPHA 2.0
BEV BETA BUILDS**

2020

**PRODUCTION
BEV**

2021



**FCEV B/G
BUILDS**

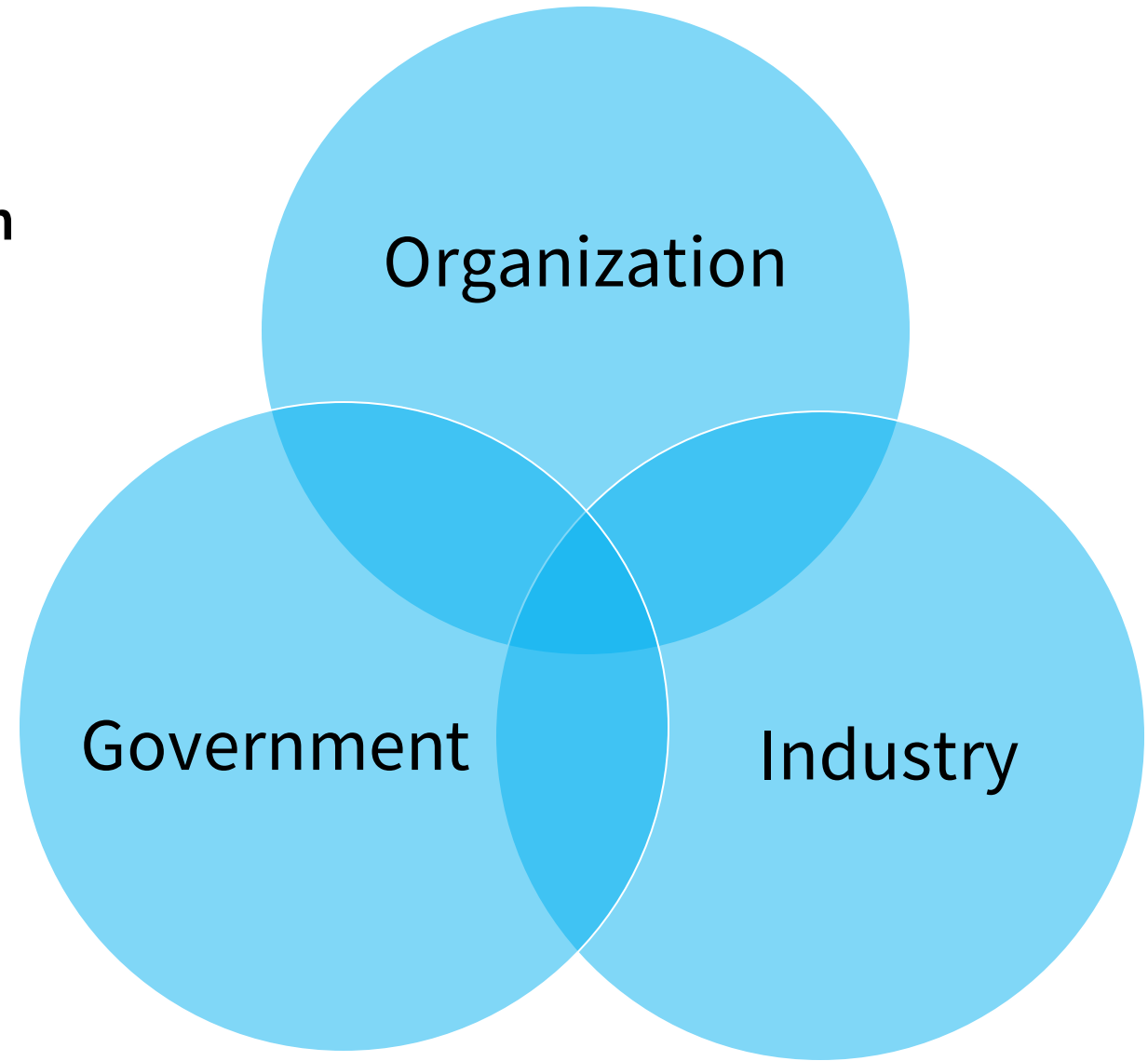
2021 - 2022

**IN-HOUSE
PRODUCTION**

2023

Collaboration.

- Shipper / Supplier Collaboration
- Lobbying
- Longer contract terms
- Acceptance of higher rates
- Co-investment
- Onsite charging



Benefits.

- Increased productivity
- Decreased costs
- Improved performance & safety
- Improved stakeholder relations
- Meet sustainability goals





*TRANSPORTING THE FUTURE
TO NOW.*

Elizabeth Fretheim
Head of Business Development
elizabeth.fretheim@nikolamotor.com



Green Hydrogen for Mining



Michel Carreau, Ph.D, September 17 2020

Hatch approach to zero carbon emissions

- **Alternative Power, Microgrid**
 - Wind, Solar, Biomass Power to reduce diesel or natural gas consumptions
 - At remote locations (off-grid) or
 - Behind the meter (grid connected to brown electricity)
- **Alternative Fuel (Hydrogen, Electricity) : for steam and heat**
- **Alternative Equipment & Vehicles (Hydrogen, Electric)**
- **Low-Carbon Technology Solutions (Reduce direct emission with technologies, Carbon Capture Storage and Utilisation)**
- **Combining these options to achieve lowest cost solution**

Green Hydrogen Activities

- **Green Hydrogen Consortium** composed also of BHP, Anglo American and FMG, each member developing Green Hydrogen Project in mining plant, members share lesson learned
- Hatch provides Engineering Support, Project & Construction Management of 20 MW PEM Electrolyser in Canada for Air Liquide – World largest PEM Electrolyser set the trend of large mining electrolysers
- 100% Renewable Mining with Anglo/De Beers at planned Diamond mine (wind, solar, battery and Hydrogen with Variable mining)

+ Green Hydrogen Project in the Mining Industry

+ Wind power at remote mining sites – + Tugliq/Glencore project at Raglan Mine



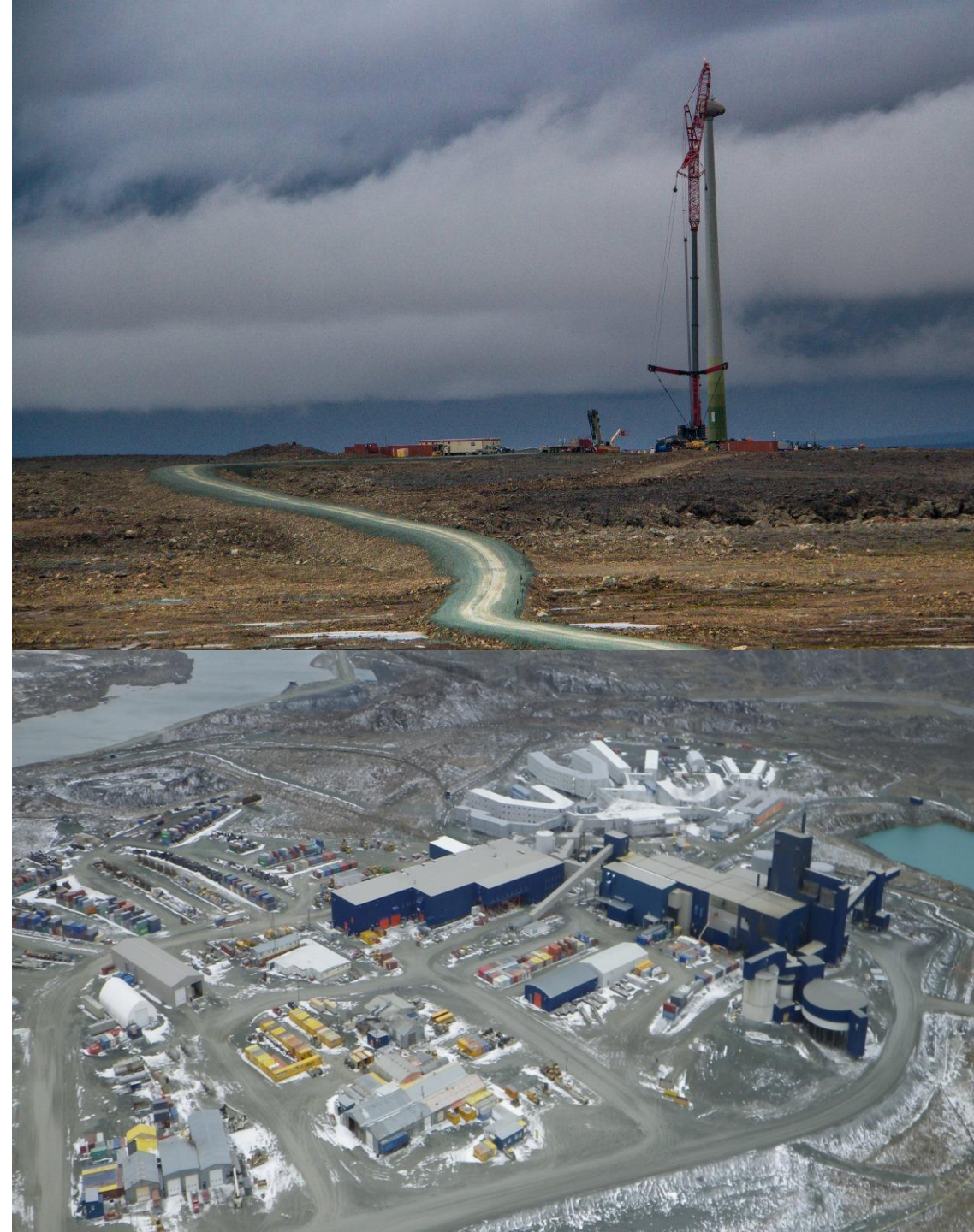
Courtesy of Tugliq – Photographer Justin Bulota – Raglan Project

Glencore – Raglan Mine



Glencore Raglan Mine Hybrid Power

- Access by plane or by sea
- Autonomous Micro-Grid
- 10 Diesel Generator – 2nd largest cost center at the mine
- Mine Raglan Lifetime – additional +20 years
- Wind Power Since 2014

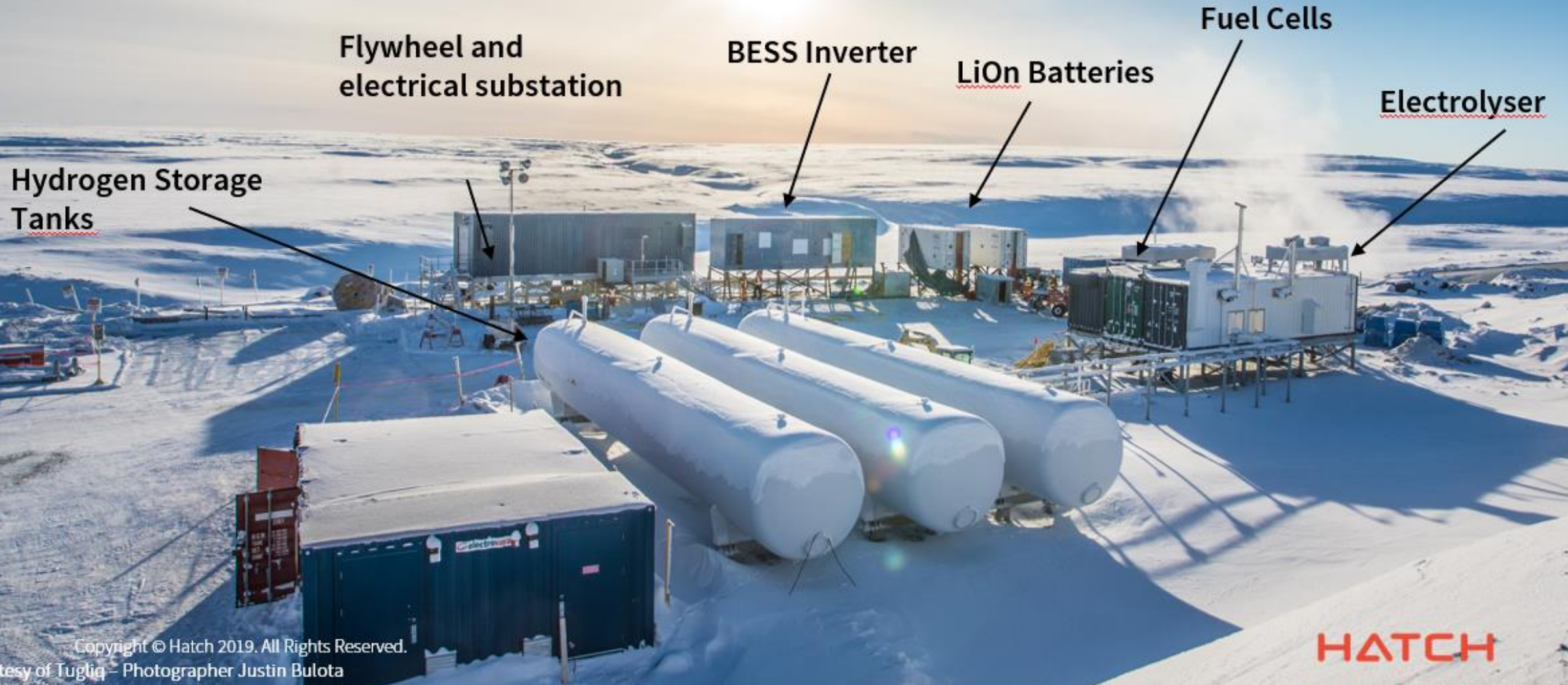


Raglan Mine, Glencore: Wind-Energy Storage Project

- 6 MW Wind Power + 3 MW Lithium Ion Battery Installed and in operation – Hatch full EPCM - 2018
- Hatch Microgrid Controller to manage battery and wind power dispatch.
- Electrolyser + Fuel Cell + H2 Storage EPCM, installed
- 97% availability of the wind turbines
- Diesel displaced today: 12+ ML



Energy Storage Systems





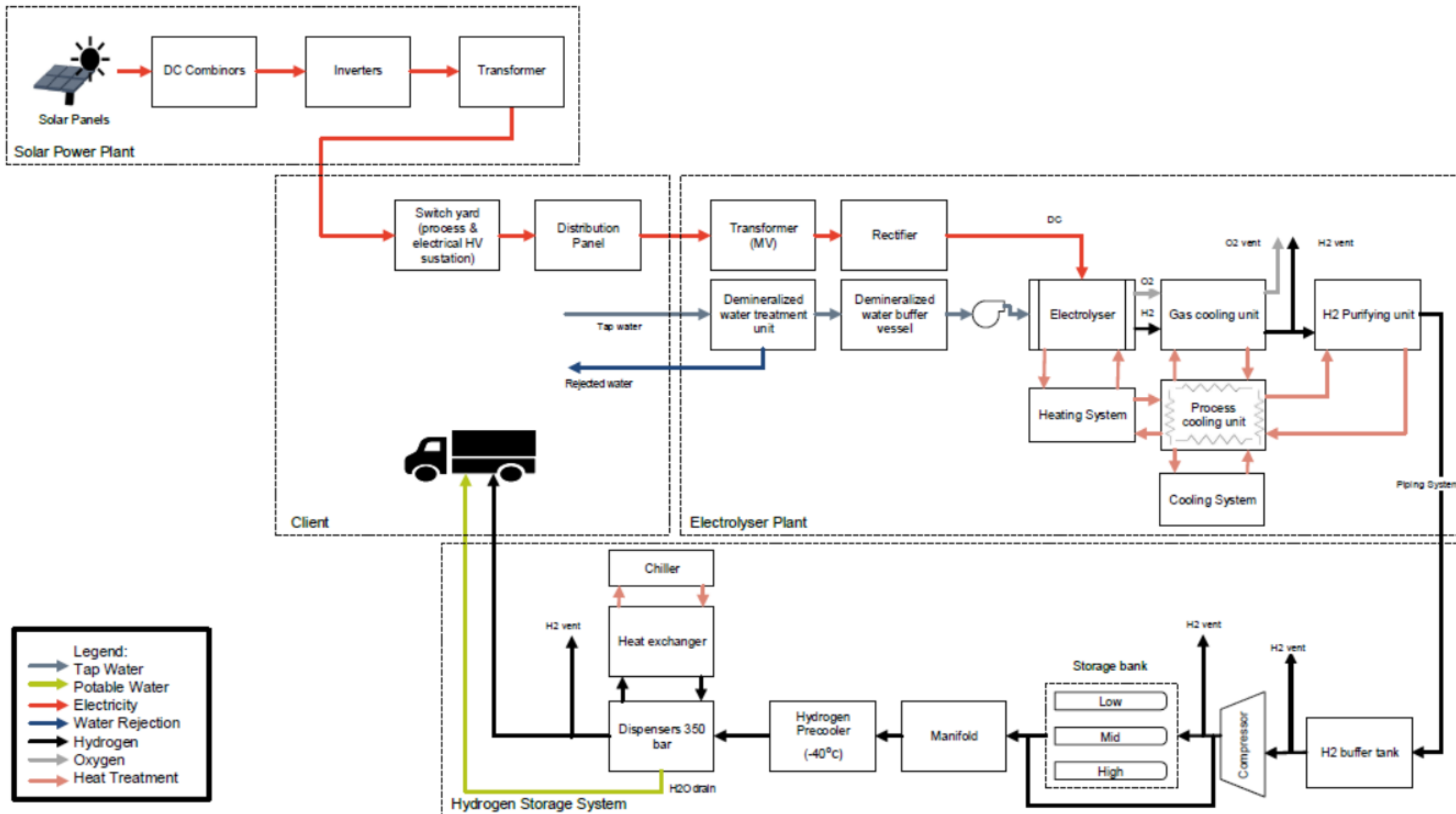
Hydrogen Mining Trucks

Hydrogen-Electric Mining Trucks (Anglo American – 300 T to be converted)

- Solar Power provide Green Electricity to production hydrogen
- Hydrogen used by 900 kW fuel cell to energy the mining truck
- Hatch optimized Hydrogen project compressors and storage pressure

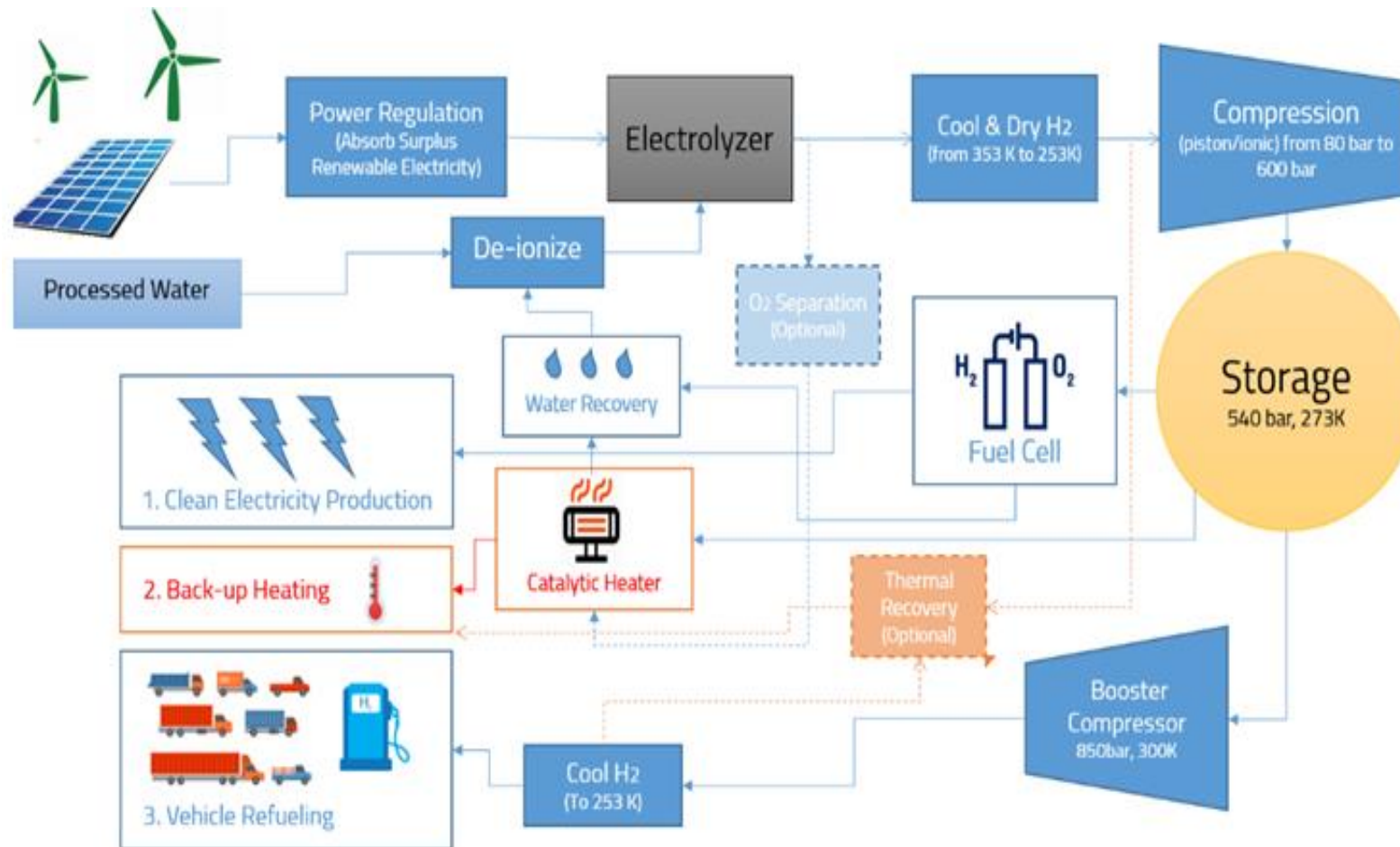


Block Flow Diagram Hydrogen Generation & Distribution



+ Achieve 100% Renewable Power at Remote Mine with Green Hydrogen

100% Renewable Power at Remote Site



+ Direct Reduction of Iron using Hydrogen from Grey to Green

Hydrogen Application – Iron & Steel (ArcelorMittal – Contrecoeur use SMR)

– Current approach
extract Iron using CO
and generates CO₂
emissions

– With Hydrogen, Iron
extracted with Zero
emissions

Reduction by CO

- $\text{Fe}_3\text{O}_4 + \text{CO} = 3\text{FeO} + \text{CO}_2$
- $\text{FeO} + \text{CO} = \text{Fe} + \text{CO}_2$
Consumes 500 Nm³/t_{iron} of CO

Reduction by H₂

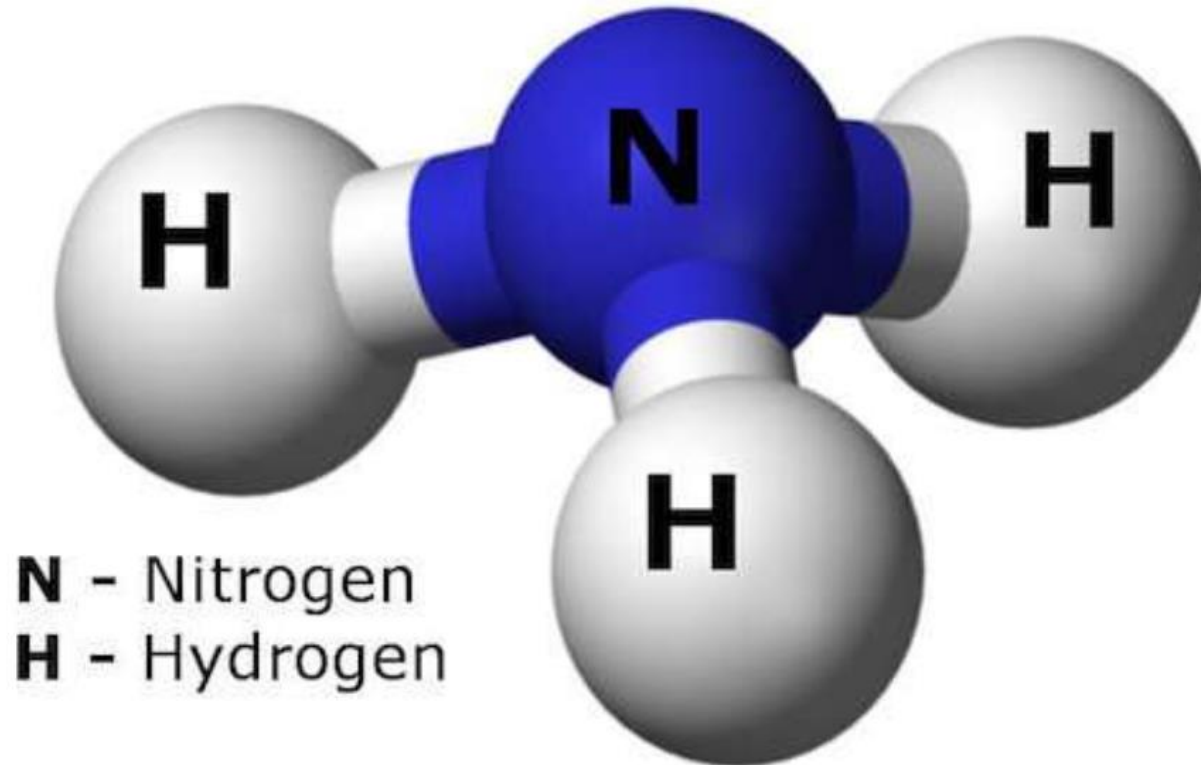
- $\text{Fe}_3\text{O}_4 + \text{H}_2 = 3\text{FeO} + \text{H}_2\text{O}$
- $\text{FeO} + \text{H}_2 = \text{Fe} + \text{H}_2\text{O}$
Consumes 500 Nm³/t_{iron} of H₂



Green Hydrogen to Green Ammonia
(Ammonia is used in production of
Nickel Production at BHP Nickel West
Refinery and Fertilizer at Yara Pilbara
Mine in Australia)

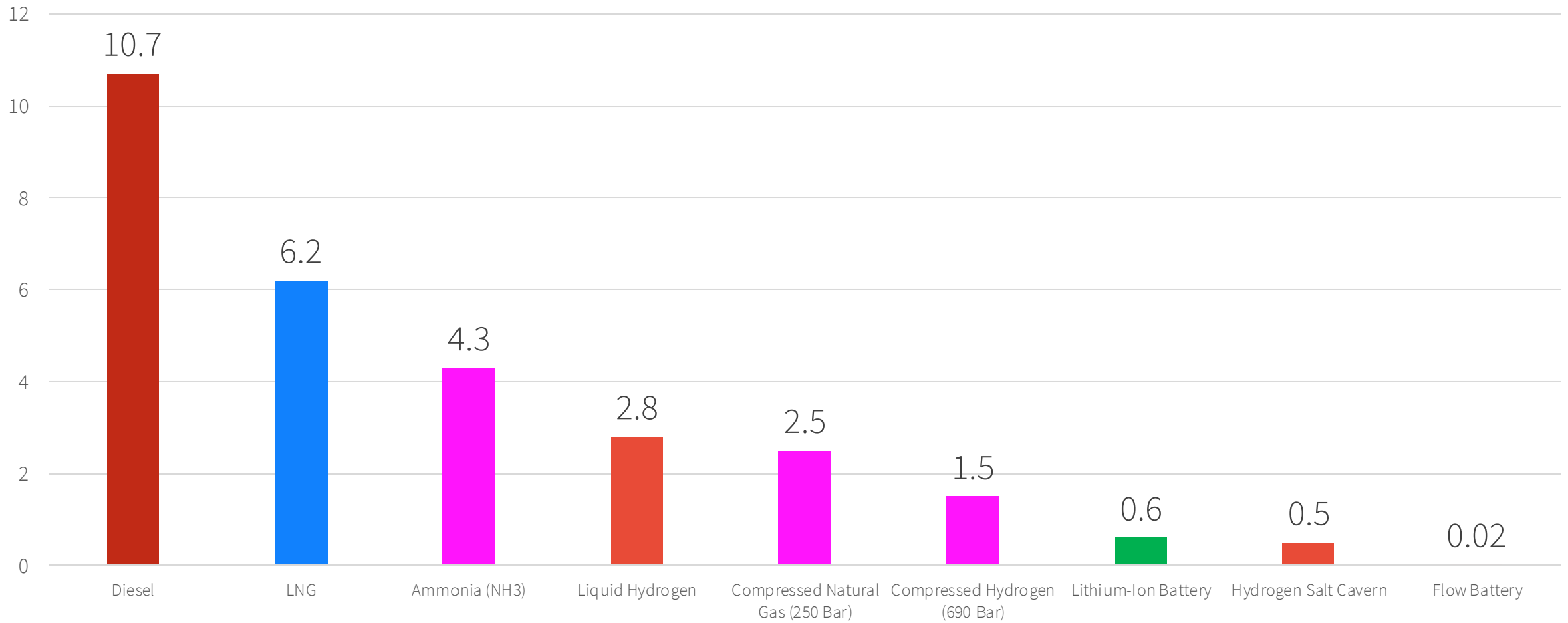
Water + Nitrogen + Electricity \rightarrow Ammonia + O₂

– Ammonia – NH₃ energy density 50% more than liquid hydrogen H₂



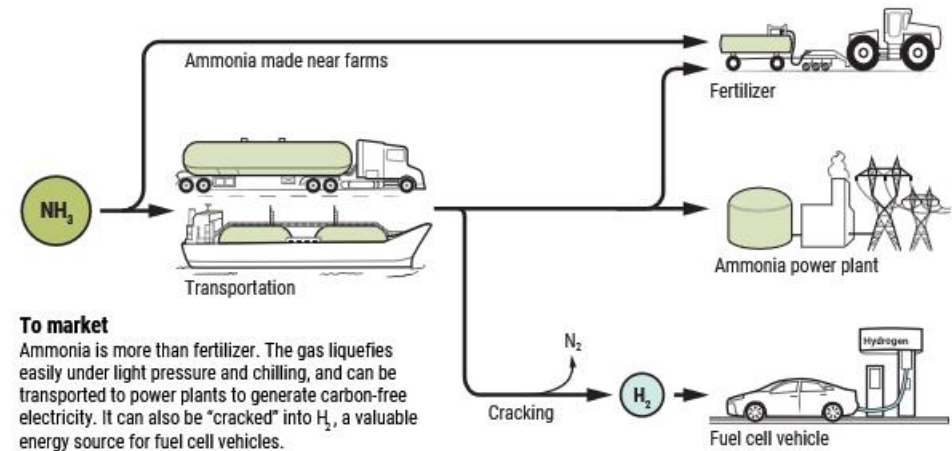
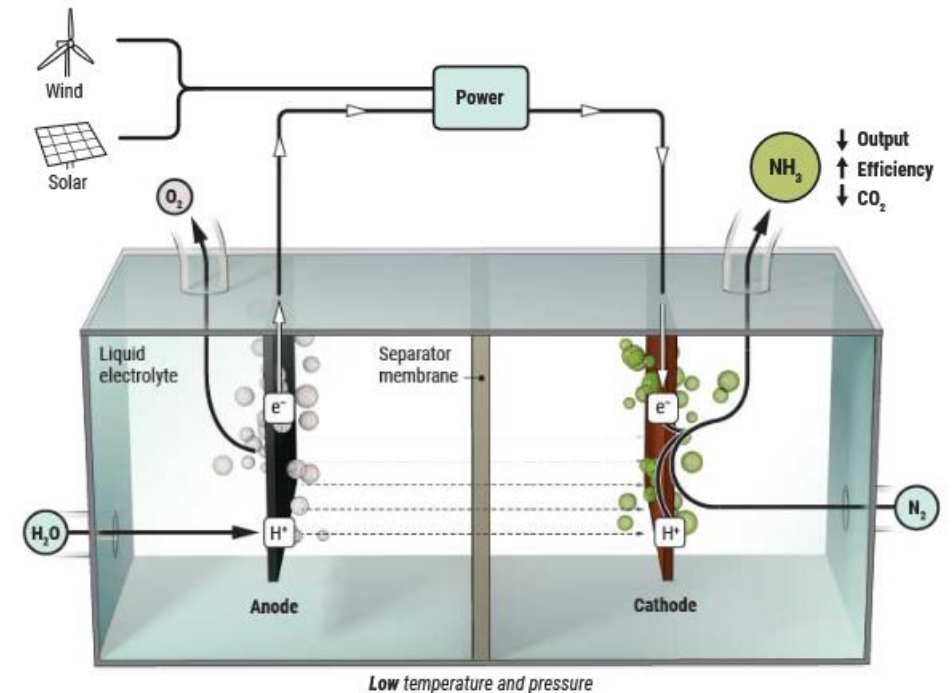
Energy Density

kWh/L



Green Ammonia making.

- Similar to electrolyzer
 - But with N₂ input
 - H₂ + N₂ -> Ammonia + O₂
- Ammonia as fertilizer
- Ammonia as a fuel
- Ammonia for transportation at high energy density; cracking to extract the hydrogen for fuel cell vehicle



Green Hydrogen Adoption

- Decarbonization is a necessity for the mining industry
 - To keep their social licensing to operate
 - To have access to sustainable financing
 - Lower interest rates for greener project
 - No financing at all if not decarbonization is shown for future project
- Green Hydrogen is one important pillar to achieve zero emissions
- Green Hydrogen Production Cost to decrease continuously year to year for the next 30 years... from 4.5 \$US/kg to lower than 1 \$US/kg due to project scale and product improvement and lower cost of renewables

+

Thank You

For more information,
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AIR, LAND, AND EARTH: MULTI-SECTORAL DECARBONIZATION



SEPT. 17



10:00 AM



Pathways for Collaboration

Objective	Pathway for Collaboration
<ul style="list-style-type: none"> • Shape market design for green hydrogen project development, obtain latest news, information and global best practices about green hydrogen market development 	<ul style="list-style-type: none"> • Membership – join GHC!
<ul style="list-style-type: none"> • Non profit and government organizational collaboration – information sharing, messaging, events and networking 	<ul style="list-style-type: none"> • Become a GHC Supporting Partner
<ul style="list-style-type: none"> • Learn about green hydrogen pathways and innovation. Stay informed, at a high, level on green hydrogen news and market developments 	<ul style="list-style-type: none"> • Attend GHC events, sign up for newsletter



Goal: Efficient collaboration to accelerate progress and momentum for green hydrogen

GHC Supporters





*“We spend **1000x** more on global **fossil fuel** subsidies than on **natural-based solutions.**”*

-Greta Thunberg

Why Fund the GHC?

Funding matters in the fight for our climate and a clean energy future.

Visit
ghcoalition.org/fund

Green Hydrogen

**is the gamechanger to fight
climate change and provide a
clean energy economy for
everyone**

Q & A

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Thank you!

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