USEA CONSENSUS Webinar: The Developing Hydrogen Economy – Potential, Progress, and Challenges

May 20, 2021

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The CONSENSUS Program, founded in 2008, pursuits to educate the Public, Policy Makers, Industry, and Other Stakeholders and Build a Consensus on the wide array of Benefits of **C**arbon **C**apture **U**tilization **S**equestration and Clean Coal technologies.

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Moderators and Panelists

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Mike Moore serves as a Program Director for USEA. He is also a managing partner of East-West Strategic Advisors, located in Washington, D.C. and focuses on energy assets, sovereign energy security, CO2-EOR, and domestic and international policy. In 2018 he co-founded the Energy Advance Center, which focuses on CCUS Policy, with Fred Eames of Hunton, Andrews, Kurth. He was also appointed by U.S. Energy Secretary Perry to the National Coal Council for 2018-2020 term and is the Executive Director to the National Tribal Energy Association.

Mike was the Executive Director of The North American Carbon Capture Storage Association (NACCSA) in Washington, DC from September 2008 until April 2017, and a founding member and officer in the Texas Carbon Capture Association (TXCCSA).

Peter Connors

Tax Partner - Orrick

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Peter Connors is a tax partner in the New York office of Orrick. His practice focuses on cross-border transactions. He also has extensive experience in related areas of tax law, including financial transactions, corporate reorganizations, renewable energy investments and controversy matters. He leads Orrick's Section 45Q practice relating to the tax credit for carbon capture and sequestration. He is the president of the USA Branch of the International Fiscal Association and the immediate past president of the American College of Tax Counsel.

Mark Ruth

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Mark Ruth is the group manager for the Industrial Systems and Fuels group in NREL's Strategic Energy Analysis Center. He leads analysis projects focused on the interface between energy sectors including electricity and industry. His current interests include the H2@Scale concept, which focuses on the potential for hydrogen as an interface with inherent storage between electricity and industry and transportation; the potential for industrial combined heat and power systems to provide grid support; and financial opportunities of tightly coupled nuclear-renewable hybrid energy systems. He has extensive experience in hydrogen, biofuels, and integrated energy system analysis.

Moderators and Panelists

Sonal Patel

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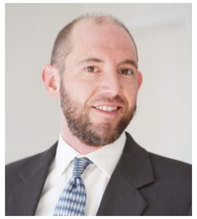
Ms. Patel is senior associate editor for *POWER* magazine. . A multimedia journalist and winner of two national awards, Sonal is based in Houston, where she has covered the energy industry for 15 years, and that includes a more than a decade focused on power generation and grid issues at *POWER* magazine. The nearly 140-year-old publication provides in-depth coverage and analysis of technology, business, and policy issues affecting the power industry worldwide.



Robert Slowinski

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Rob Slowinski is a Managing Consultant in the Boulder, Colorado office of Guidehouse. Rob has worked in the energy industry for 16 years, with an emphasis on hydrogen, energy efficiency, sustainability, and utility programs. Rob's recent hydrogen work involves the orchestration of multi-stakeholder hydrogen projects, as well as helping utilities develop a vision for integrating hydrogen into future business operations.

Robert Wimmer

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Mr. Wimmer directs Toyota Motor North America's (TMNA) Energy and Environmental Research group. He leads a team of engineers and scientists assessing how changes in energy and environmental technology, policy and regulation will affect the automotive industry. Mr. Wimmer is also responsible hybrid, plug-in electric and fuel cell vehicle external affairs and technical activities within Sustainability Regulatory Affairs. Additionally, he manages energy collaborations with other corporations, the company's interaction with the US Department of Energy and a portion of TMNA's university and think-tank research activities.

Ryan Harty

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Ryan Harty is an engineer and Senior Manager of Honda's C.A.S.E. & Energy Business Development division, which leads Honda's North American advanced technology application planning and new business development functions. He loves driving EVs, is passionate about charging them with renewable energy, and is optimistic about the connected and electric customer experience that will inspire technology adoption across the industry. In his spare time he enjoys coaching and curling at the Orange County Curling Club.

The Developing Hydrogen Economy – Potential, Progress, and Challenges

Agenda

- Introduction
- Hydrogen ‘101’
- Hydrogen’s Economic Potential
- The Cost of Hydrogen Power
- Zero Emission Hydrogen Fuel Cell Vehicles
- Tax Incentives for Hydrogen
- Q&A

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Hydrogen '101':

H_2 basics, market, infrastructure, and policy factors

Rob Slowinski
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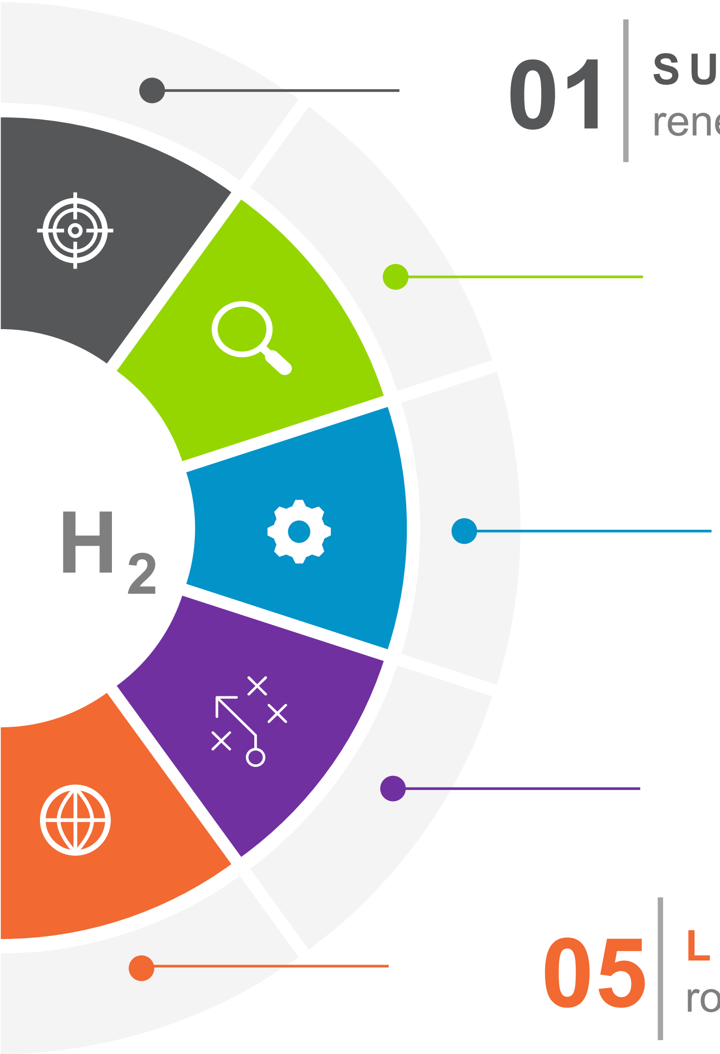
Hydrogen – Dispatchable Clean Energy - 5 key elements



01 **SUPPLY** Clean molecules will be required to fully integrate renewables and meet climate targets.

02 **DEMAND** Hydrogen can unlock decarbonization in multiple sectors of the economy.

03 **INFRASTRUCTURE** Transporting and storing hydrogen will require massive infrastructure investment.

04 **POLICY & INVESTMENT** Policy will be the key driver of most of the short- and mid-term business cases.

05 **LOW CARBON PATHWAYS** Hydrogen can play an important role within a complex decarbonization ecosystem.

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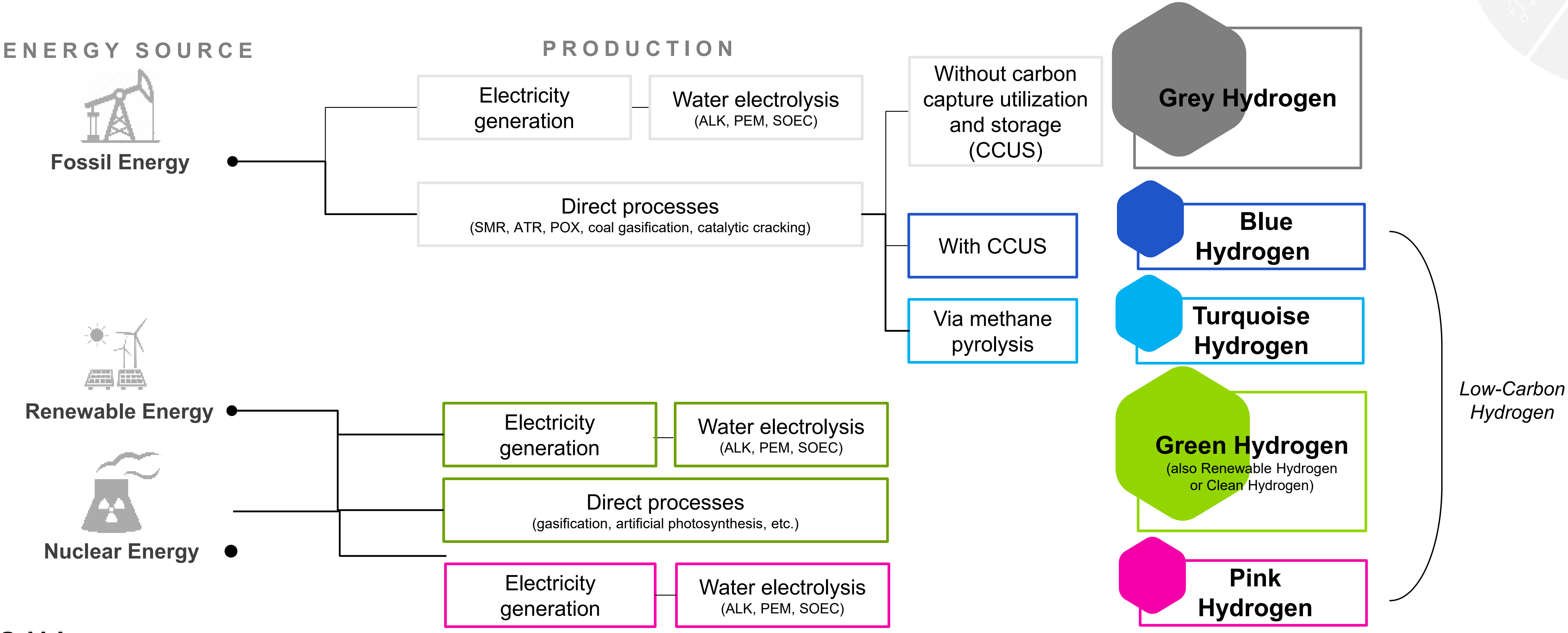
H_2 can be generated in various ways

Cost, complexity, and GHG emission intensities vary significantly, depending on the H_2 production method.



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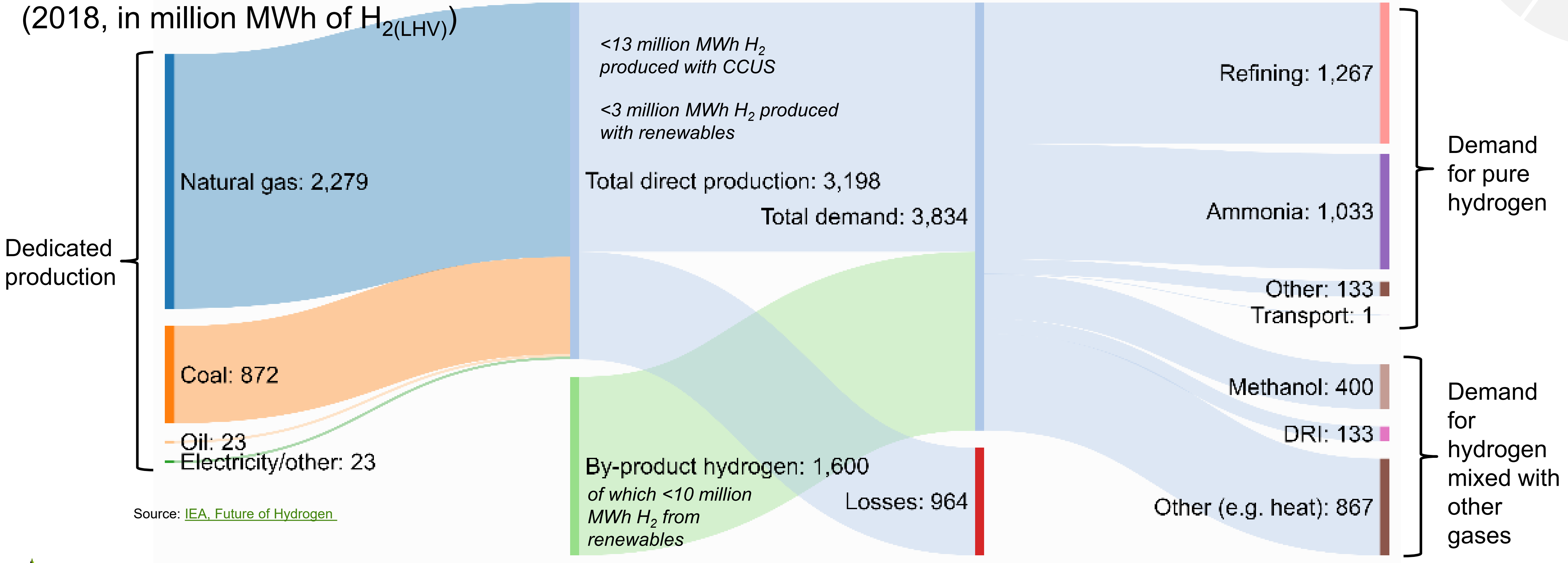
Where are we today?

Current global hydrogen usage and production – mostly for petrochemicals and refining

Today's global hydrogen value chains
(2018, in million MWh of $H_{2(LHV)}$)



Source: IEA, Future of Hydrogen

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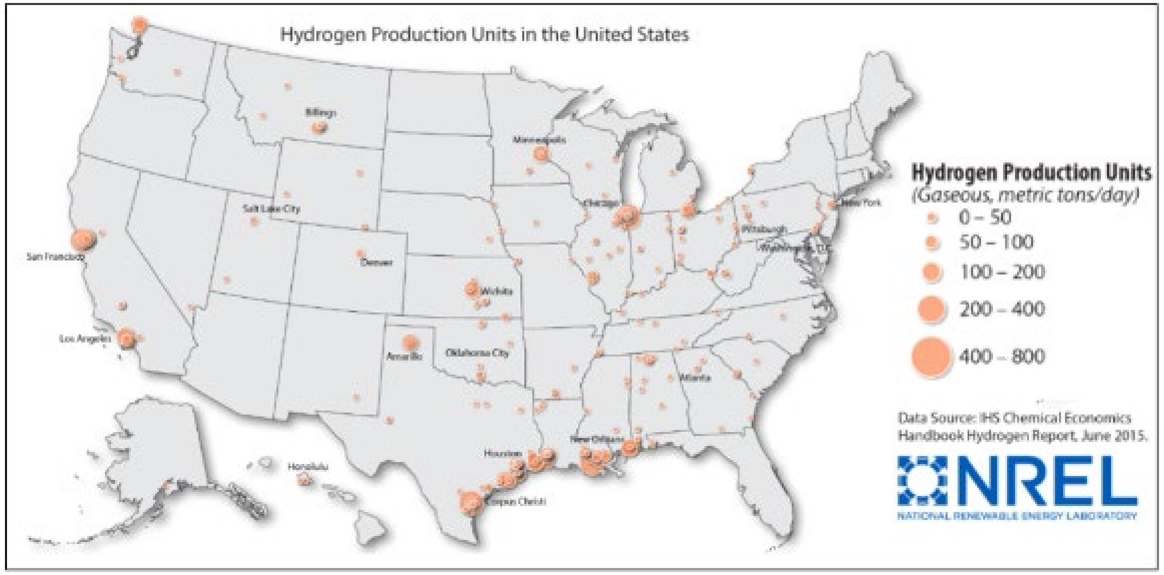
With cheap natural gas, steam methane reforming dominates current hydrogen supply in the United States.

10 million metric tons of US-based hydrogen production – nearly all from fossil fuels; 70% used for petroleum refining and 20% for fertilizer production

The vast majority of U.S. hydrogen production occurs by **steam reforming of natural gas** near major oil & gas operations.

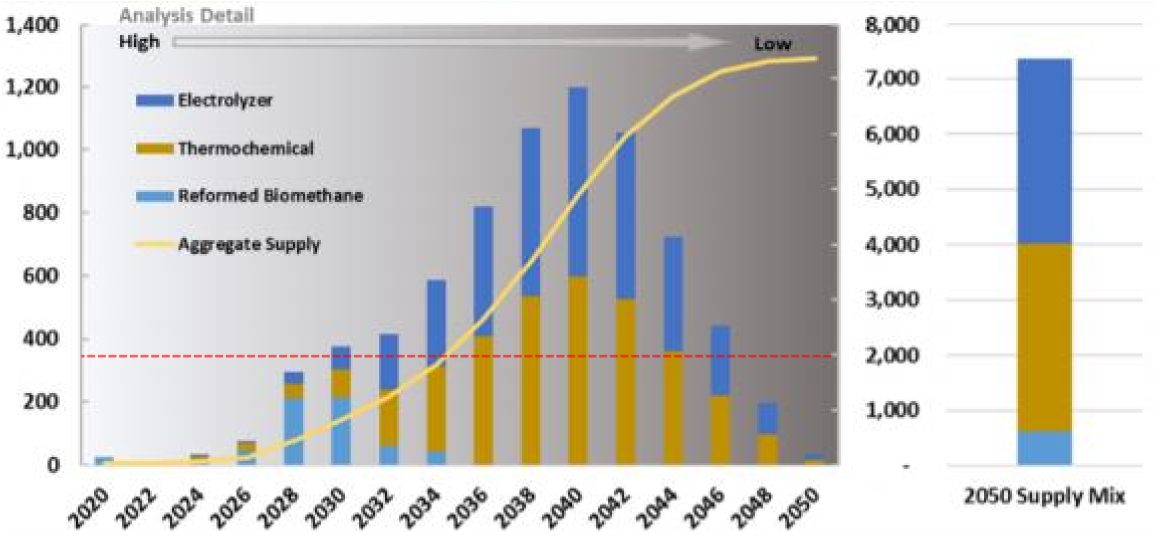


Source: U.S. DOE Office of Efficiency & Renewable Energy

Renewable hydrogen production capacity in California alone could exceed 2,000 tonnes/day by 2030.

Annual Supply Additions MT H_2 per day

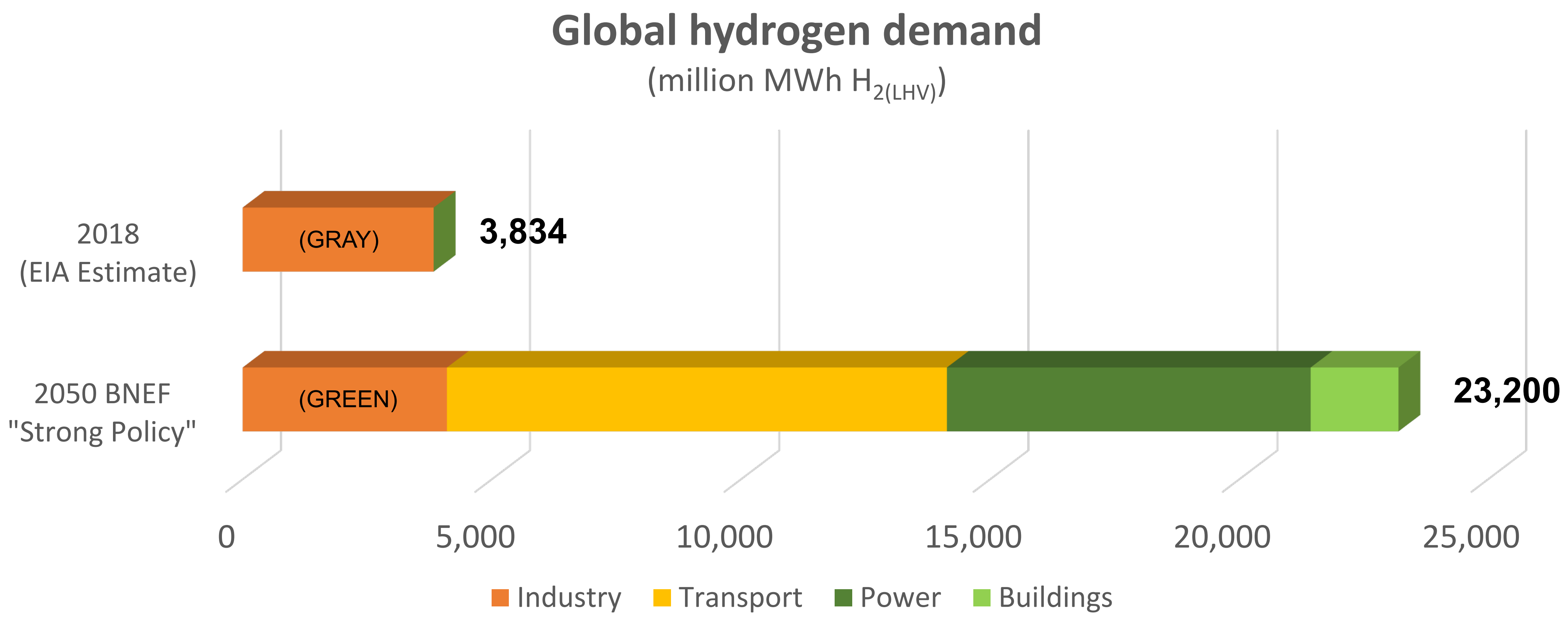
Cumulative Supply MT H_2 per Day



Source: California Energy Commission

What is the future market for H2?

Three sectors drive the growth of long term H2 demand:



Source: IEA, Future of Hydrogen
BNEF, Hydrogen Economy Outlook

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Emerging opportunities across the H2 value chain

Industrial applications and heavy transport will likely be the first tests of the H2 market.

RENEWABLE FEEDSTOCK
Replaces **existing demand** for industrial hydrogen feedstock from hydrocarbons.

TRANSPORT
Potential applications in all forms of transport – from heavy, medium, and light duty vehicles to shipping and aviation.

POWER GRID SERVICES
Provides a buffer to bridge mismatch between demand and supply on various timescales, and, delivering frequency control services.

BUILDING HEAT & POWER
Cost-efficient complementary solution to electrification in buildings.

INDUSTRIAL HEAT
Coverts existing fossil fuel demand for Industrial high-temperature heat into hydrogen-derived heat.

ENERGY DISTRIBUTION
Serves as a carrier for long-range transport of energy, particularly in regions lacking local renewable energy sources.

EARLY MARKET APPLICATIONS → **LATE MARKET APPLICATIONS**

Source: Guidehouse

The availability of infrastructure connecting supply and demand is a key condition for widespread use of hydrogen.

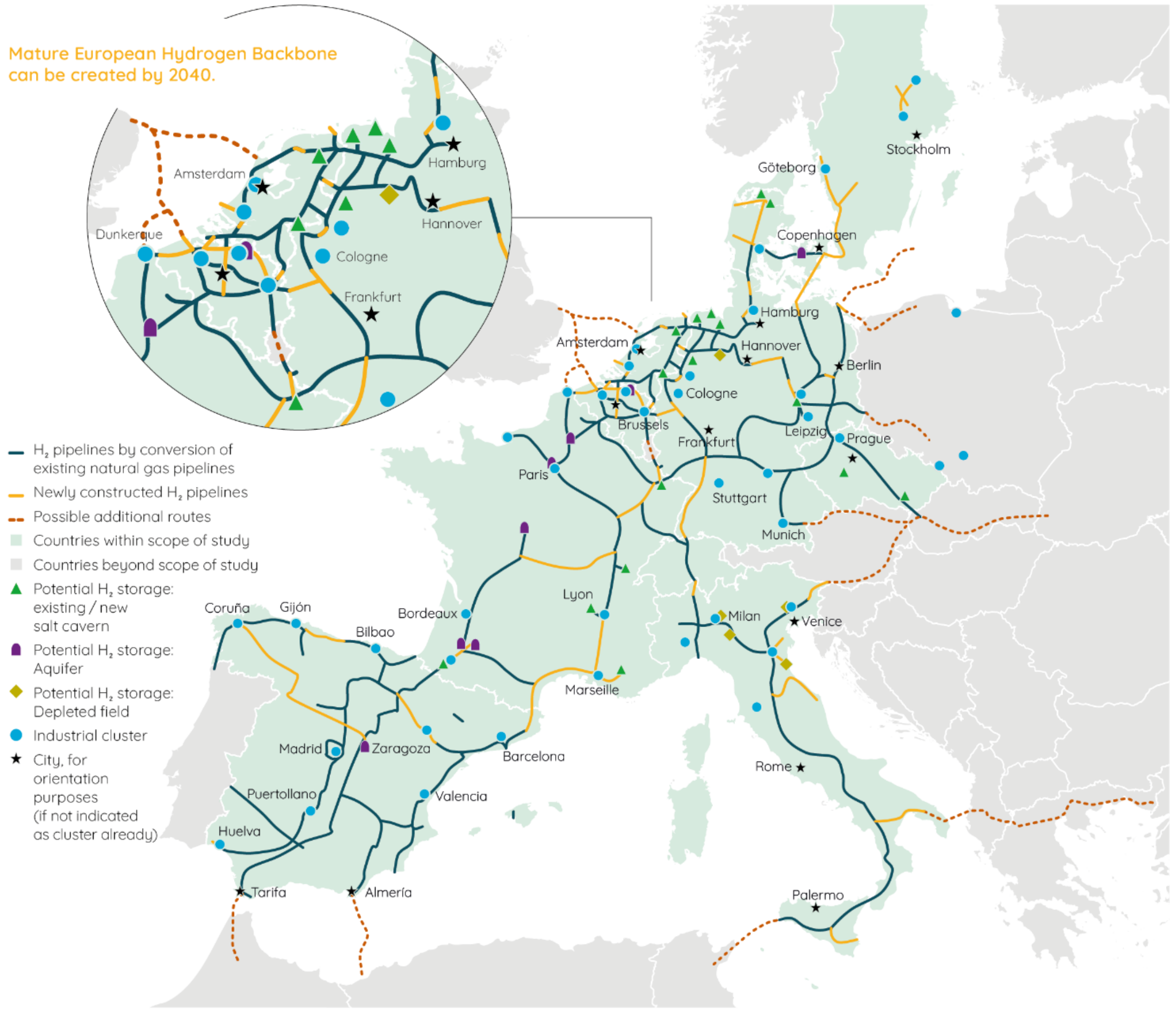
Pipeline infrastructure will be crucial to future development of the hydrogen market.

- Driving hydrogen development past the **tipping point** requires a large-scale infrastructure network.
- An EU-wide or national US infrastructure will enable transport of hydrogen over **long distances** from areas with large renewable potential to demand centres located regions, as well as **international trade** with neighbouring countries.
- Infrastructure plays a facilitating role within a **full value chain approach**, whereby scale-up of production, infrastructure, and market demand go in parallel to activate a **virtuous circle** of increased supply and demand for hydrogen with reduced supply costs.
- With increasing demand, an **efficient and resilient** transport network is needed to create an **open and competitive domestic market** that provides clean and safe hydrogen at the lowest cost to end users who value it most.
- The existing gas pipeline infrastructure can be partially repurposed, providing an opportunity for a **cost-effective transition** in combination with limited newly built dedicated hydrogen infrastructure.

Hydrogen Backbone – opportunity for infrastructure

A hydrogen commodity market can only occur with interconnected supply, storage, and demand.

- Guidehouse performed the analysis of The European Hydrogen Backbone for Gas for Climate.
- The proposal entails a 6,800 km dedicated hydrogen transport infrastructure by 2030.
    - Extension to 23,000 km by 2040
    - Further expansion up to 2050



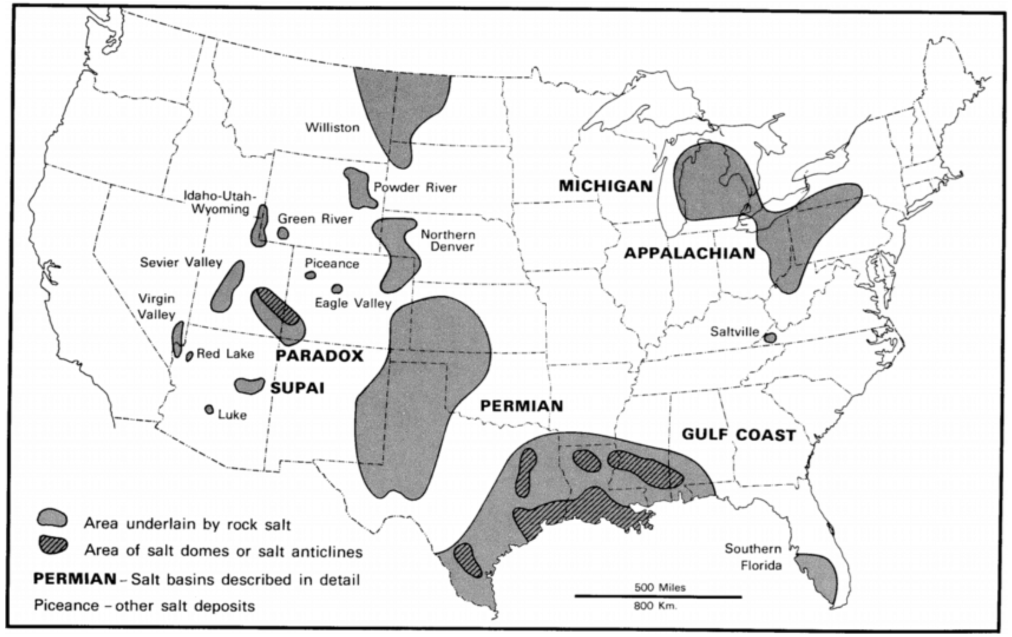
Source: [Guidehouse, European Hydrogen Backbone]

Storage is also key to H2 implementation

Syncing H2 supply and demand requires storage infrastructure.

Why storage?

- As a dispatchable form of clean energy, the use of hydrogen necessitates storage between the supply and demand centers.
- This is particularly true of green hydrogen, which depends on the timing and availability of renewable energy.
- Blue hydrogen adds an additional consideration for storing captured carbon.



How will it be achieved?

- Geography and geology will play a key role in cost-effective storage.
- 'Depleted' reservoirs may be repurposed to store hydrogen or captured carbon.
- Underground salt caverns are common throughout North America and Europe and may be suitable for large-scale storage.

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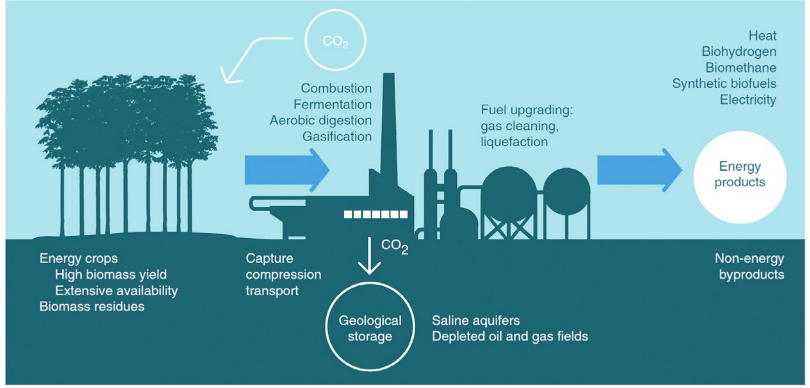
Carbon capture & storage – Blue H2 element

CCS - the process of capturing and storing CO_2 it so that it is not emitted into the atmosphere – is promising, but faces challenges.

CCS Facts:

- Some CCS facilities currently capture 90-100% of a plant's emissions.
- Captured CO_2 can be used post steam methane reforming in the production of blue H2
- Storage sites used for CO_2 include former oil and gas reservoirs, deep saline formations, and coal beds.



Source: https://pubs.rsc.org/en/content/articlehtml/2018/ee/c7ee02342a

Source: https://www.rff.org/publications/explainers/carbon-capture-and-storage-101/

Important Considerations

- CCS may reduce a power plant's efficiency and increase water use (read: cost).
- Transporting CO_2 can be costly.
- Pipelines and storage reservoirs must be carefully designed, but the availability of underground storage is <u>not considered</u> a barrier to global CCS implementation.

The hydrogen value chain – H_2-Enriched Natural Gas

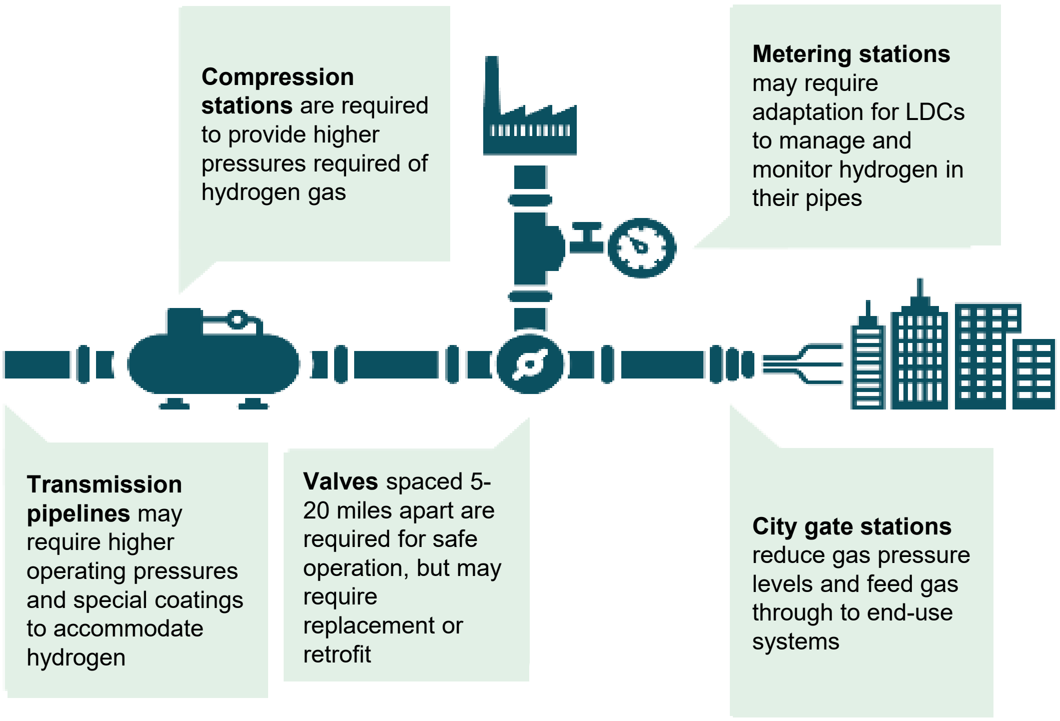
Due diligence is required, but there are reasons for optimism.

Value Proposition
H_2 injection into high pressure/high volume pipelines at a low H_2 percentage – with LDC off-takers earning GHG credits.

Proof of Concept
Several pilot studies are underway, but further analysis is required for the specifics of each deployment.

Theory
Existing studies show that **generally** at relatively low hydrogen concentrations (10-20% by volume), blending may not require major investment or modification to infrastructure and can be done in a safe manner. (IEA, 2015; DNVGL, 2017; NREL, 2013; National Research Council Canada, 2017)

Important Considerations:



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Fundamental drivers

Ever-increasing pressure to decarbonize from five directions

Political and Legal: State and city climate neutrality targets and potential for federal action in 2021.

2021 *While there is currently no federal carbon neutrality mandate, many cities and states have adopted such targets.*

Economic: Investor disclosure requirements (e.g.; Task Force on Climate-related Financial Disclosures (TCFD)); cost of capital for low carbon investment; oil pricing.

77% *Of ESG-focused Global and Core International Equity Funds performed in the top two quartiles in 2019.[2]*

Social: Customer preference for sustainably produced products; employer selection/employee satisfaction; Increasing awareness of impacts of climate change.

45% *Of Fortune 100 employees care about their company's actions on environmental and societal issues.[3]*

Technology: Rapid advances in technology driving down costs and opening new markets and rendering products/services obsolete.

90% *The reduction in solar module prices between 2010 and 2020.[4]*

Environmental: Increasing recognition of physical dangers posed by climate change; observed impacts affecting bottom lines.

$20T *The difference in economic cost between 1.5 and 2 degrees of global warming, or 26% of GDP.[5]*

Sources: 1. World Resources Institute; 2. Morningstar; 3. Povaddo; 4. Guidehouse Insights; 5. Nature

New US policies provide key opportunities

The US market is seeing increased commitment to climate action, yielding new collaboration and investment in hydrogen research, development, and deployment.

Nevada: 2019 Executive Order raised renewable portfolio standards (RPS) to 50%. Requires annual reporting of 20-year GHG projections for all sectors, and policy directives for substantial GHG reductions by 2030

Nevada: Responsible Gas Planning Law - aims to phase out emissions from combustible fuels (to nearly zero by 2050). Requires regular forecasting of decarbonization scenarios, infrastructure investments, and societal costs of GHGs.

Washington state: 2019 bill that authorizes utilities to produce and sell renewable hydrogen, with additional draft legislation aiming to establish an 8-year pilot program for hydrogen fuel cell vehicles

Oregon: 2020 Executive Order to reduce emissions and mitigate climate change. Mandate for state procurement of ZEVs (including H2 fuel cell vehicles). Requires annual GHG reporting and targets

New York: Climate Leadership and Community Protection Act – requires electric grid to be 70% renewable energy by 2030 and elimination of statewide electric emissions by 2040. Green hydrogen is eligible, but blue/gray hydrogen is NOT.

Public/private partnerships and consortia are emerging

The US market is seeing increasing collaboration and investment in hydrogen research, development, and deployment.

Hydrogen Lab Consortia (Announced June 2020)

$100 million from DOE over 5 years for investments in two new National Laboratory-led consortia to advance hydrogen and fuel cell technologies R&D focused on large-scale electrolyzers and HDVs (subject to appropriations).

EPRI & GTI Low-Carbon Resources Initiative (Announced August 2020)

International collaborative, spanning electric and gas sectors. A five-year initiative focused on low-carbon electric generation and low-carbon energy carriers, including hydrogen, ammonia, synthetic fuels, and biofuels.

H2@Scale (Announced July 2020)

Approximately $64 million in DOE funding for 18 projects that will support the H2@Scale vision for affordable hydrogen production, storage, distribution, and use.

Increased hydrogen refueling station deployment in California (Announced September 2020)

The California Energy Commission approved $39.1 million to help construct 36 new H_2 fueling stations across the state, nearly doubling current deployments.

Utility companies are also pushing the technology forward

Utilities in the United States are increasingly entering the hydrogen space. This is evidenced by an uptick in pilot projects across the hydrogen value chain by major utilities.

- As the largest developer and operator of wind, solar and battery plants in North America, **NextEra Energy, Inc.** is closing its last coal-fired power unit and investing in its first green hydrogen facility.
- A proposed **$65 million pilot** to produce 100% green hydrogen from solar power using a 20 MW electrolyzer could be online by 2023 pending approval from state regulators.

- **AES Corp.** is dipping its toes into hydrogen technology through pilot projects at old coal plants
- The company sees off-take opportunities in the trucking sector but currently favors batteries over hydrogen for power storage solutions, as too much energy is wasted in the molecule-to-electron process

- **Sempra Energy** is also working on pilot projects with a focus on heavy transport, blending in the power generation segment and co-location with natural gas facilities.
- "We're quite bullish on the role of hydrogen and renewable natural gas, particularly here in California," CEO Jeffrey Walker Martin said Aug. 5.

- **Duke Energy Corp**. has joined a consortium of U.S. gas and electric utilities supporting a research project aimed at advancing the development of low-carbon liquid fuels including hydrogen, ammonia and biofuels.
- Many of the utilities involved conduct business in states like California, New York and Virginia that have passed laws to fully decarbonize their economies by or before 2050.

The H_2 opportunity – part of a larger ecosystem

H_2 is an integral component of economy-wide decarbonization

Generalized Implementation Order

	1	2	3	4	5
Five Steps to Deep Decarbonization	**Implement Energy Efficiency** Implement energy efficiency measures to the maximum extent possible.	**Decarbonize Electric Power** Decarbonize the electricity supply as much as possible.	**Electrify Building and Transportation End Uses** Utilize the decarbonized energy supply to reduce the emissions of other sectors.	**Employ Carbon Capture and Storage for Economical Production of Blue Hydrogen** Use carbon capture and storage to offset any remaining fossil fuel use.	**Deploy Zero Carbon Fuels** Use zero carbon fuels to reduce the emissions of *hard to electrify* sectors.
The Hydrogen Opportunity		Hydrogen resources will supply seasonal long-duration storage and provide on-call generation to support renewable generation and maintain system resilience.		CCS enables production of blue hydrogen which leverages regional natural gas resources to cost effectively product decarbonized hydrogen.	Hydrogen will be utilized to power *hard to electrify* sectors including industry and heavy transportation.

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Hydrogen ‘101’

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Hydrogen's Economic Potential within the United States

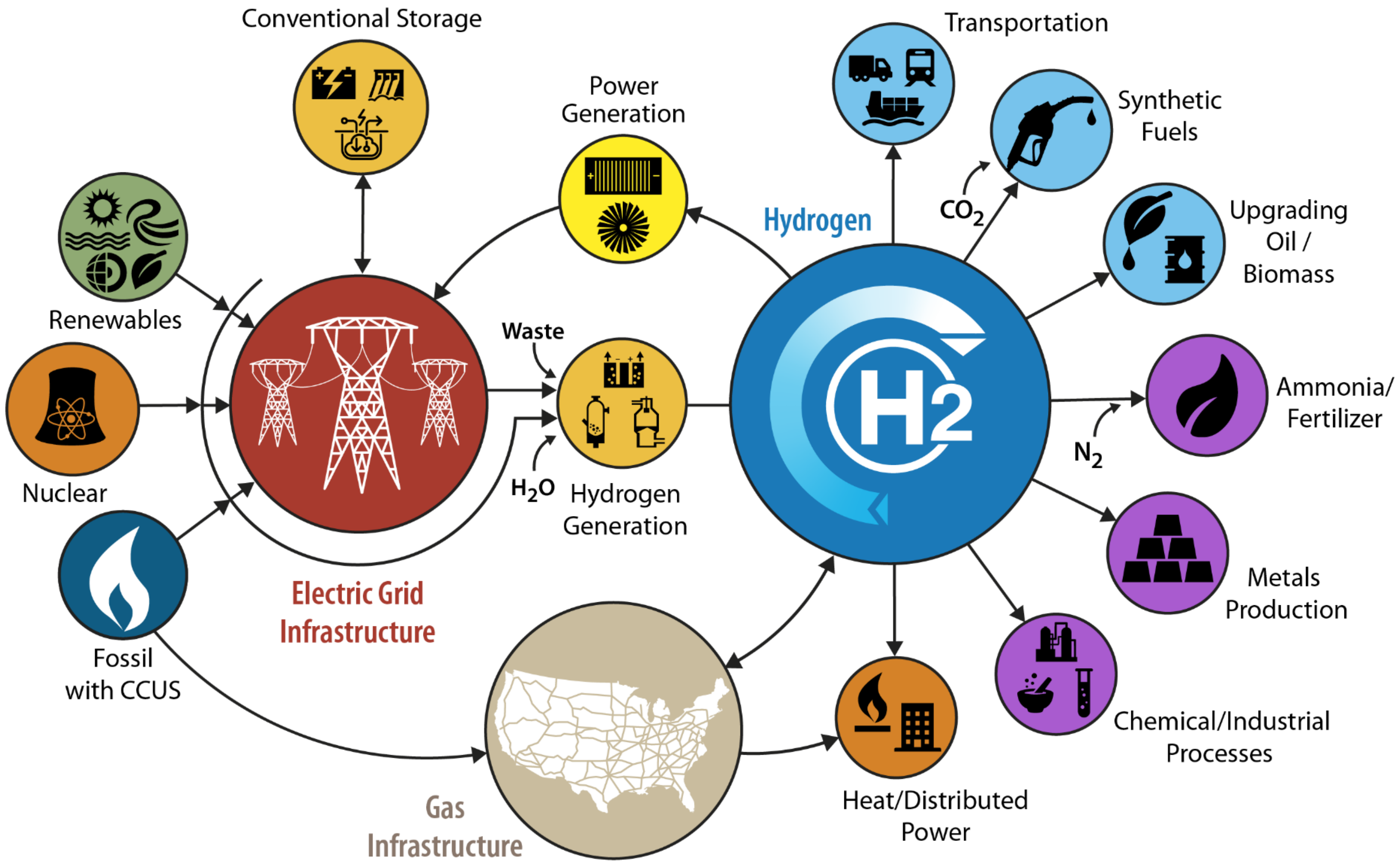
Mark F. Ruth

Webinar on The Developing Hydrogen Economy – Potential, Progress, and Challenges
May 20, 2021

Report available at: https://www.nrel.gov/docs/fy21osti/77610.pdf
Detailed demand report available at: https://greet.es.anl.gov/publication-us_future_h2

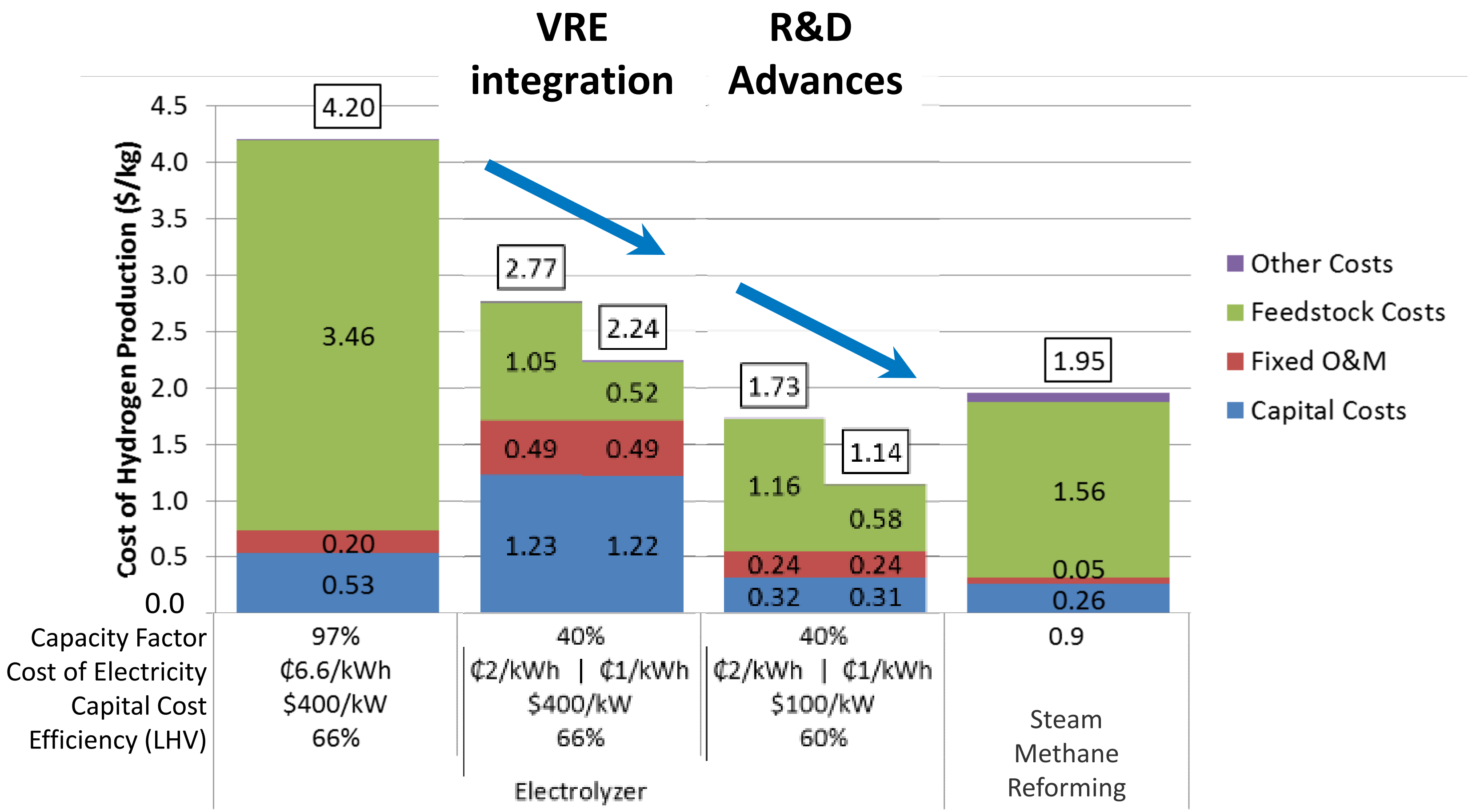
H2@Scale

DOE initiative focusing on hydrogen as an energy intermediate.



https://www.energy.gov/eere/fuelcells/h2scale

Low-Cost, Variable Electricity Could Be Source for Low-Cost Hydrogen



Low-temperature electrolysis (LTE) could produce hydrogen using low-cost, dispatch-constrained electricity.

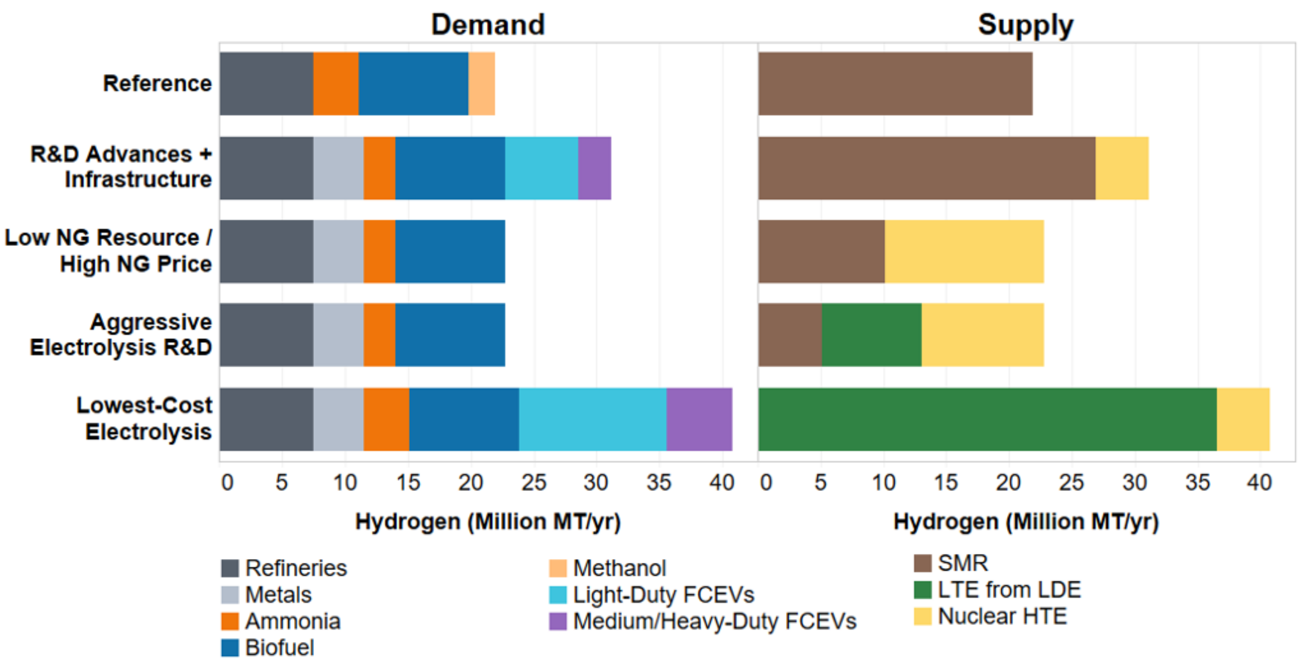
Economic Potential: Limitations and Caveats

- **Market equilibrium methodology** and market size estimates in 2050
  - Transition issues such as stock turnover are not considered
- **New policy drivers, such as emission policies, are not included** either for hydrogen or the grid
- Technology and market performance **involve many assumptions** about adjacent technologies
  - In all but the non-reference scenario, the assumption is that R&D targets are met
- Demand analysis is **limited to sectors that could be forecast** for the foreseeable future
  - Hydrogen use to convert biomass-based market size equal to 50% of aviation demand
  - Hydrogen for industrial heat is not included
  - Single hydrogen threshold price for fuel cell vehicle market estimates
- Estimates of **delivery costs were standardized** and **without location specificity**
- Potential long-term production technologies (e.g., photo-electrochemical) not included
- Economic feedback impacts are not considered
- Competing technologies (both for markets that use hydrogen and for resources to generate hydrogen) are addressed in a simplified manner only

Five Economic Potential Scenarios

The US economic potential of hydrogen demand in 2050 is 2-4X current annual consumption based on our market-equilibrium analysis

Scenario	Insights
Reference	Growing markets for refining, ammonia, and biofuels met with low-cost NG
R&D Advances + Infrastructure	Higher penetrations of FCEV + drivers for metals, SMR dominates production due to low cost NG but have some nuclear HTE
Low NG Resource / High NG Price	High NG price increases cost of hydrogen for same quantity and limits FCEV penetration but more nuclear HTE
Aggressive Electrolysis R&D	Some LTE penetration at $200/kW capital cost with grid value.
Lowest-Cost Electrolysis	Low-cost electrolyzers with high grid value reduce hydrogen cost and can enable additional H_2 applications

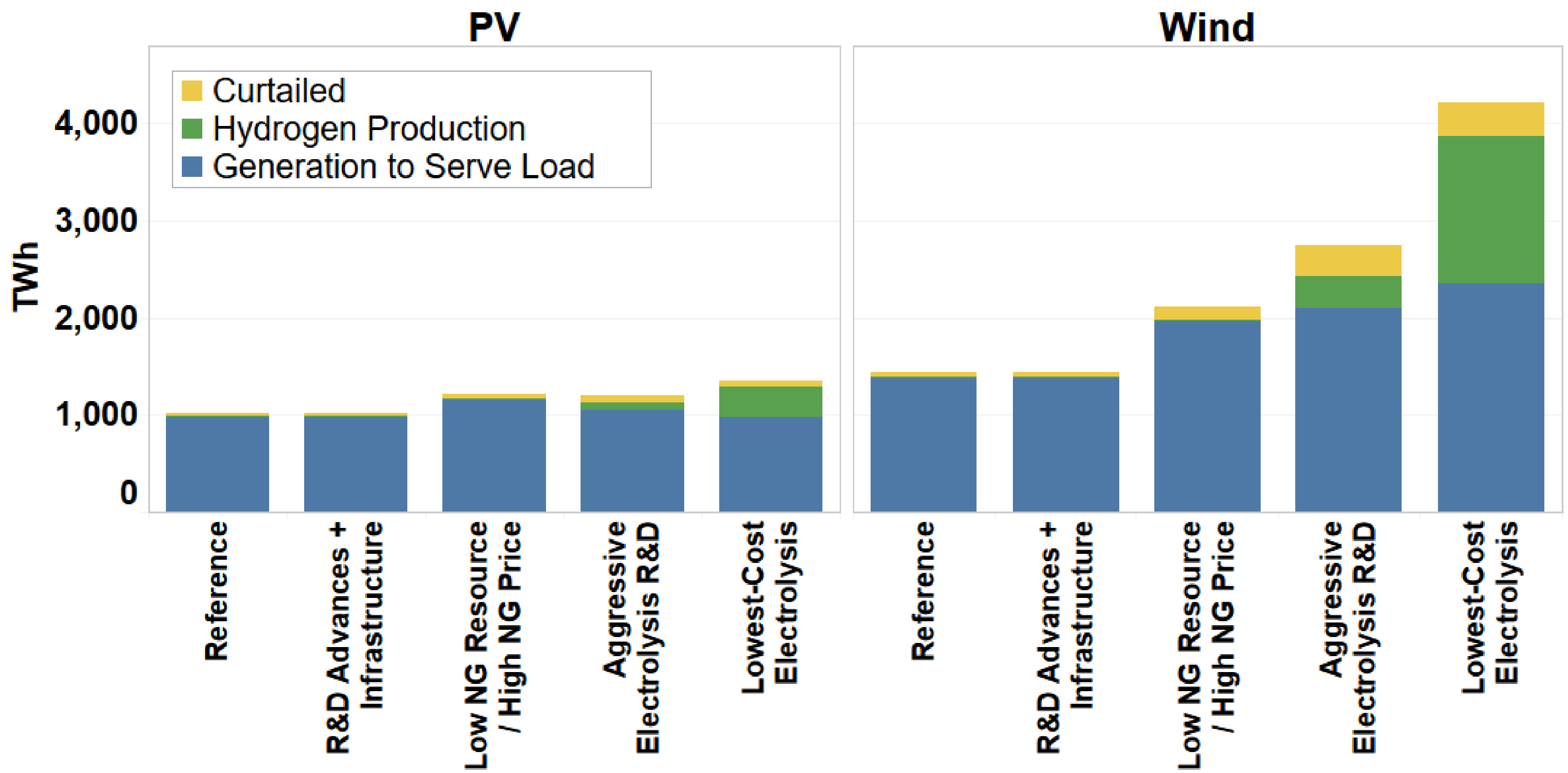


Incentives are needed for hydrogen to compete for long-duration storage / dispatchable electricity generation and for use to generate heat (in place of or supplementing natural gas)

FCEV: Fuel-cell electric vehicles
SMR: Steam methane reforming
NG: Natural gas
LTE: Low-temperature electrolysis
LDE: Low-cost, dispatch-constrained electricity
HTE: High-temperature electrolysis

Increase Market Size of and Available Electricity from Variable Generation

H2@Scale has the potential to increase the total market size of wind and solar photovoltaic (PV) generation



Source: https://www.nrel.gov/docs/fy21osti/77610.pdf

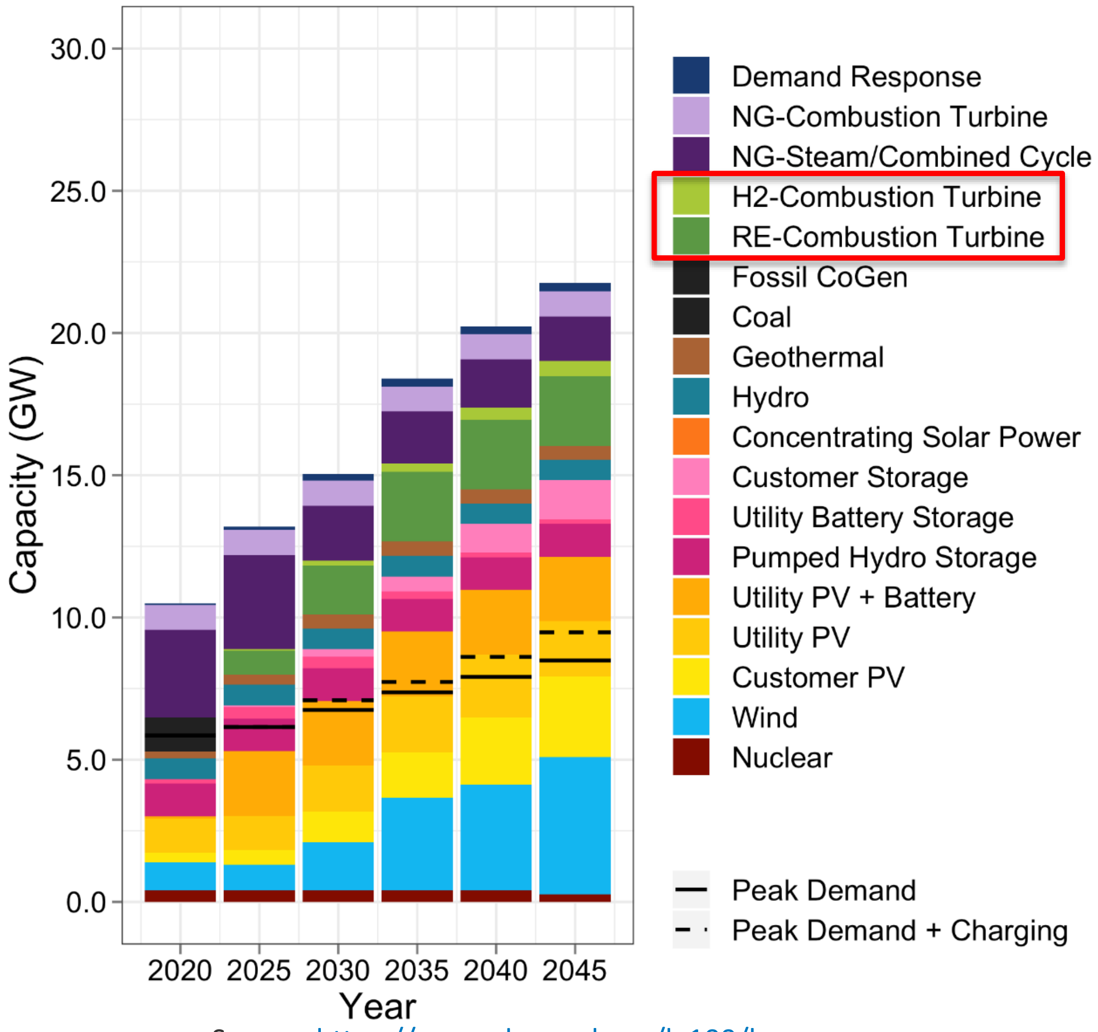
Estimates are based on national scenarios with minimal resolution into regional constraints. Increased resolution will likely impact the most competitive source of energy supply

100% Renewable Electricity Standards for Dispatchable Generation Requires Chemical Energy Storage

The LA100 project analyzed opportunities and challenges for decarbonizing electricity generation.

Optimally, 10% or more of generating capacity will be non-carbon emitting dispatchable generators.

More available at: https://maps-dev.nrel.gov/la100/#



Source: https://maps-dev.nrel.gov/la100/key-findings/scenarios/sb100/moderate#annual-generation-twh-2020-2045

Summary of Report's Key Conclusions

- **The economic potential of hydrogen demand in the U.S. is 2.2-4.1X current annual consumption even without carbon policies**.
- **An increased hydrogen market size can be realized even if low-cost LTE is not available as long as other hydrogen production options are available**
- **Grid-integrated electrolysis can increase renewable energy generation by more than 60%** by monetizing additional low-cost, dispatch-constrained electricity
- **The impacts of an integrated hydrogen system could be larger.** Hydrogen's serviceable consumption potential in the U.S. is >10X current annual consumption. Transportation is the largest new hydrogen market opportunity.

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The Cost of Hydrogen Power

AN INDUSTRY PERSPECTIVE

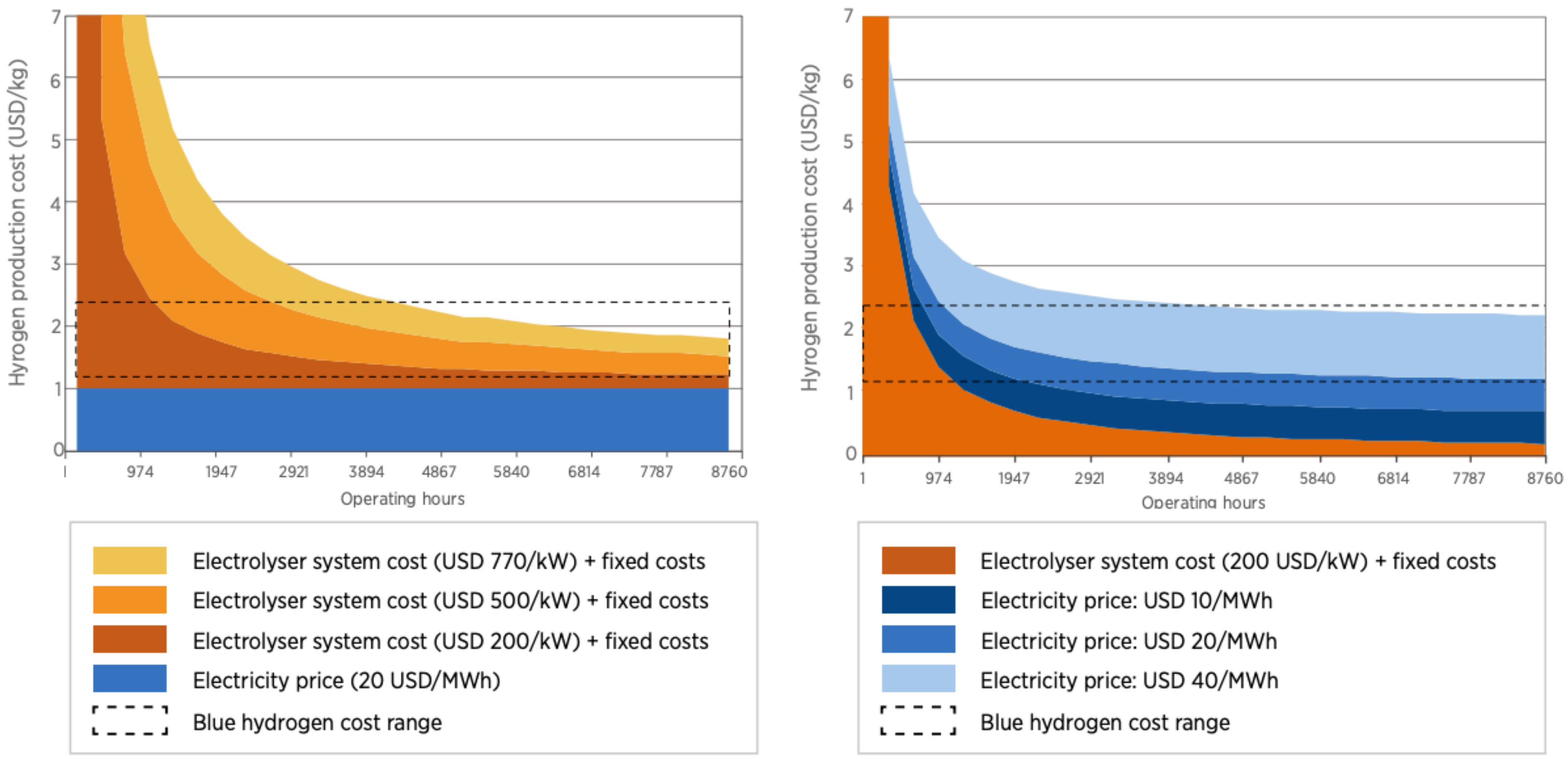
USEA WEBINAR: The Developing Hydrogen Economy—Potential, Progress, and Challenges
(May 20, 2021)

The Cost of Hydrogen Power

Hydrogen's role in decarbonized systems will depend heavily on falling production costs.

- For renewable hydrogen, significant drivers are the decline of renewable costs and electrolyzer costs.
- Value chains for electrolysis and carbon management will also need to be scaled up.
- At-scale deployment of renewable hydrogen will require the development of giga-scale hydrogen production projects.

Hydrogen production cost as a function of investment, electricity price, and operating hours.



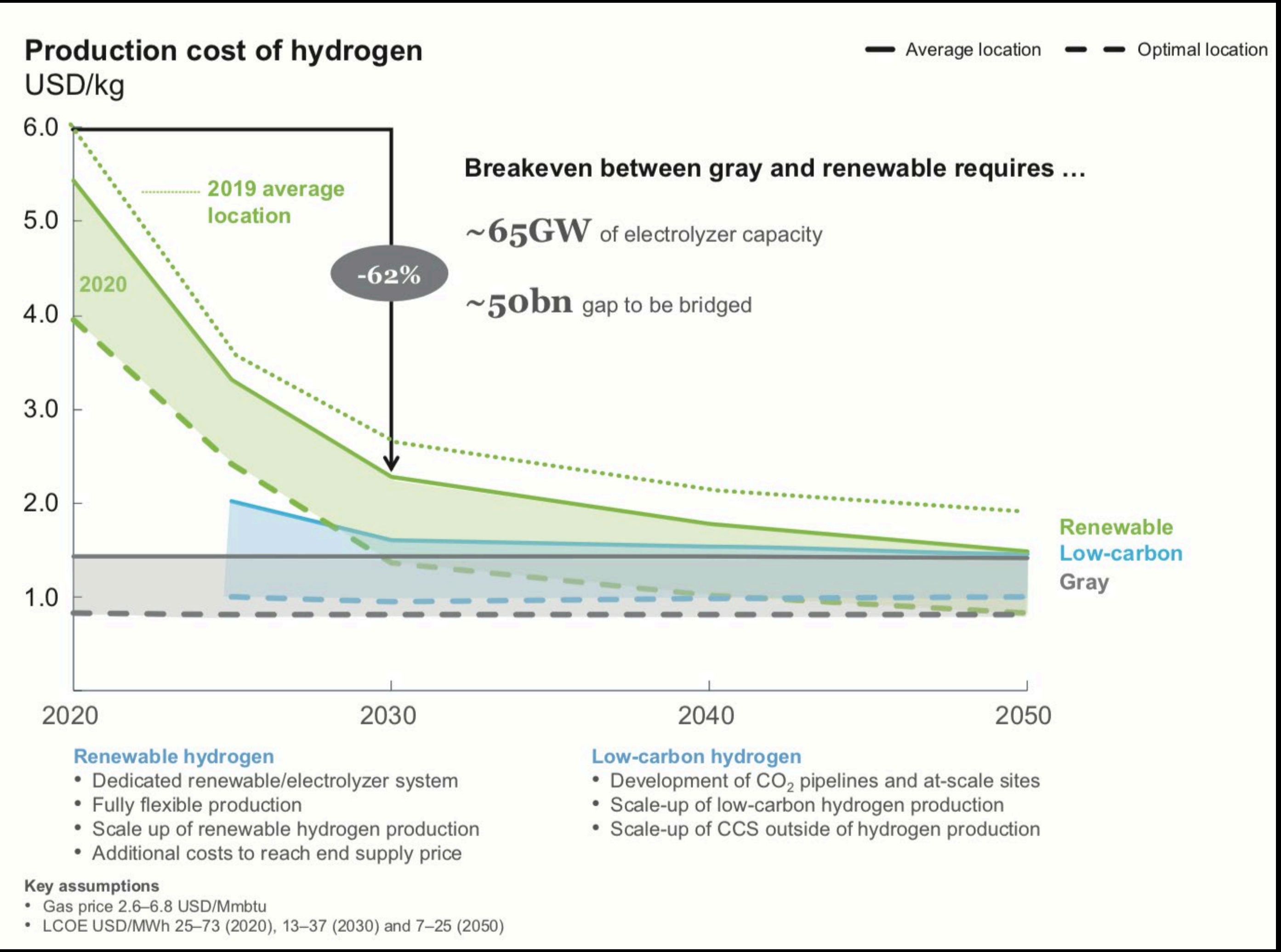
Note: Efficiency at nominal capacity is 65% (with an LHV of 51.2 kWh/kg H_2), the discount rate 8% and the stack lifetime 80 000 hours.

Source: IRENA (2020), Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5ºC Climate Goal, International Renewable Energy Agency, Abu Dhabi.

Cost Parity by 2028?

According to the **Hydrogen Council**, if these cost reductions are achieved, renewable hydrogen production costs could fall to $1.4/kg to $2.3/kg by 2030, varying by region.

The council expects that renewable and gray hydrogen supply could hit **cost parity** in the "best region" by 2028, and in "average" regions, by 2034.

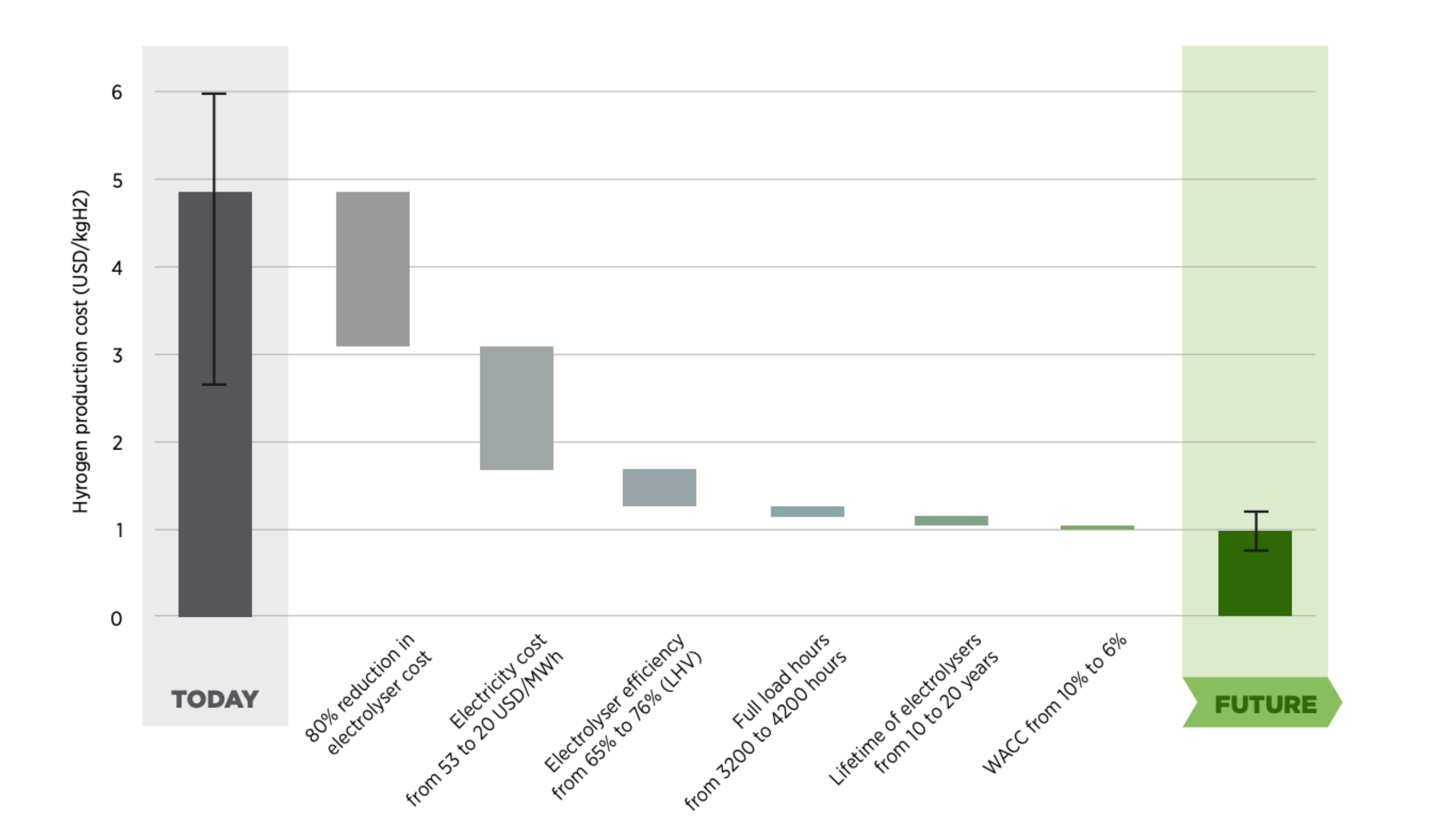


Source: **Hydrogen Insights Report 2021** (Hydrogen Council, McKinsey & Company)

Step Changes to Achieve Green Hydrogen Competitiveness.

"Best and average" conditions today:

- Average investment of $770/kW.
- Efficiency of 65% (LHV).
- An electricity price of USD 53/MWh.
- 3,200 full load hours (onshore wind).
- A weighted average cost of capital (WACC) of 10% (which represents relatively high risk).

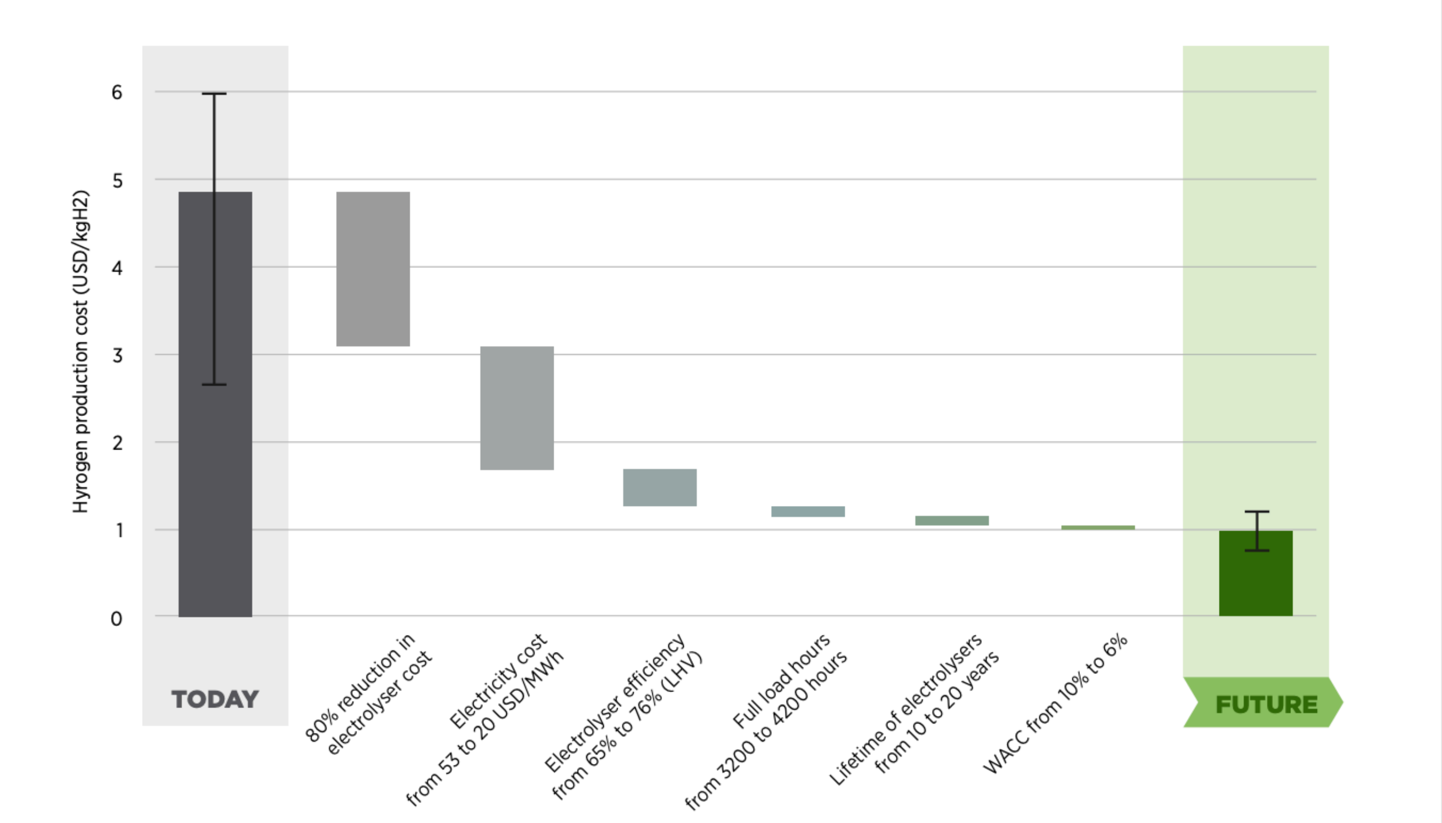


Source: IRENA (2020), Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5⁰C Climate Goal, International Renewable Energy Agency, Abu Dhabi.

Step Changes to Achieve Green Hydrogen Competitiveness.

Cost reductions will need better conditions:

- Average investment of are $130/kW.
- Efficiency at 76% LHV.
- Electricity price at $20/MWh.
- 4,200 full load hours (onshore wind).
- WACC of 6%, similar to renewable power today.



Source: IRENA (2020), Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5°C Climate Goal, International Renewable Energy Agency, Abu Dhabi.

Country Hydrogen Targets

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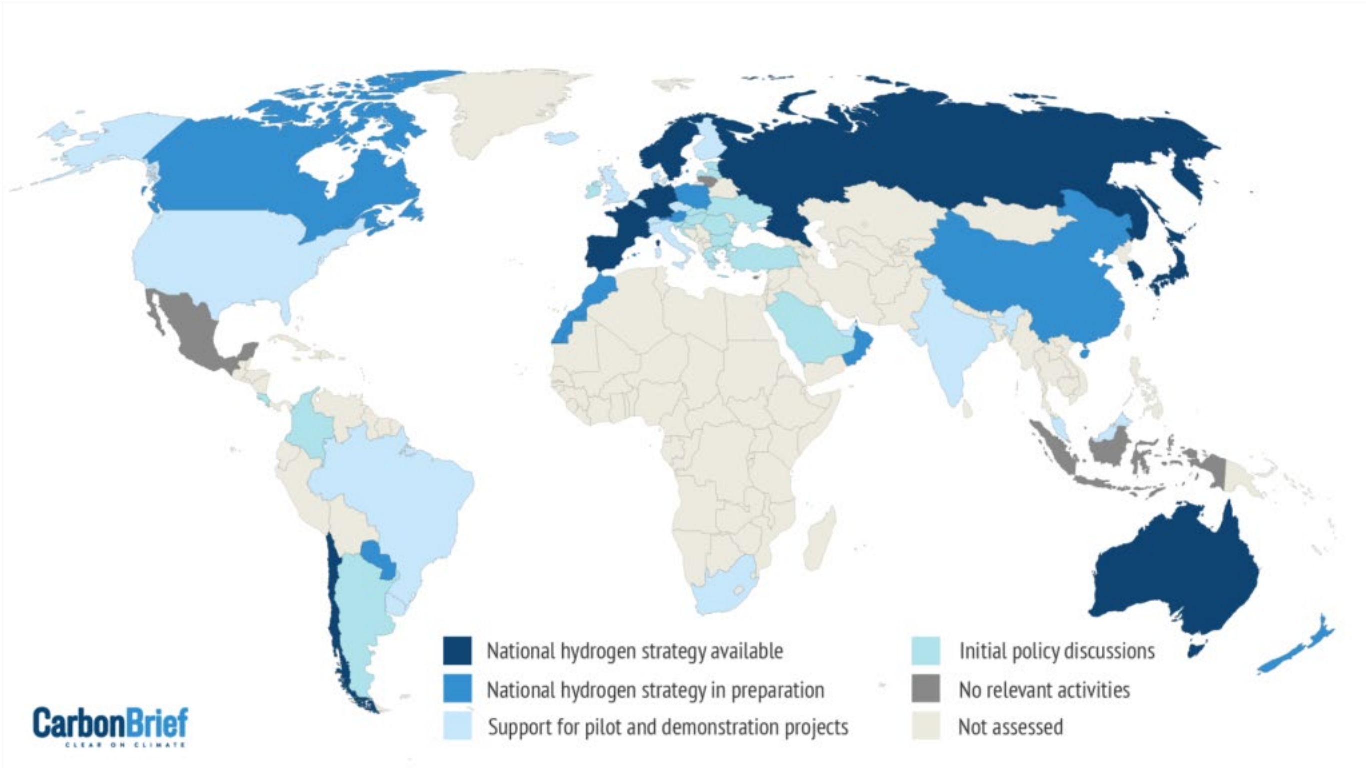
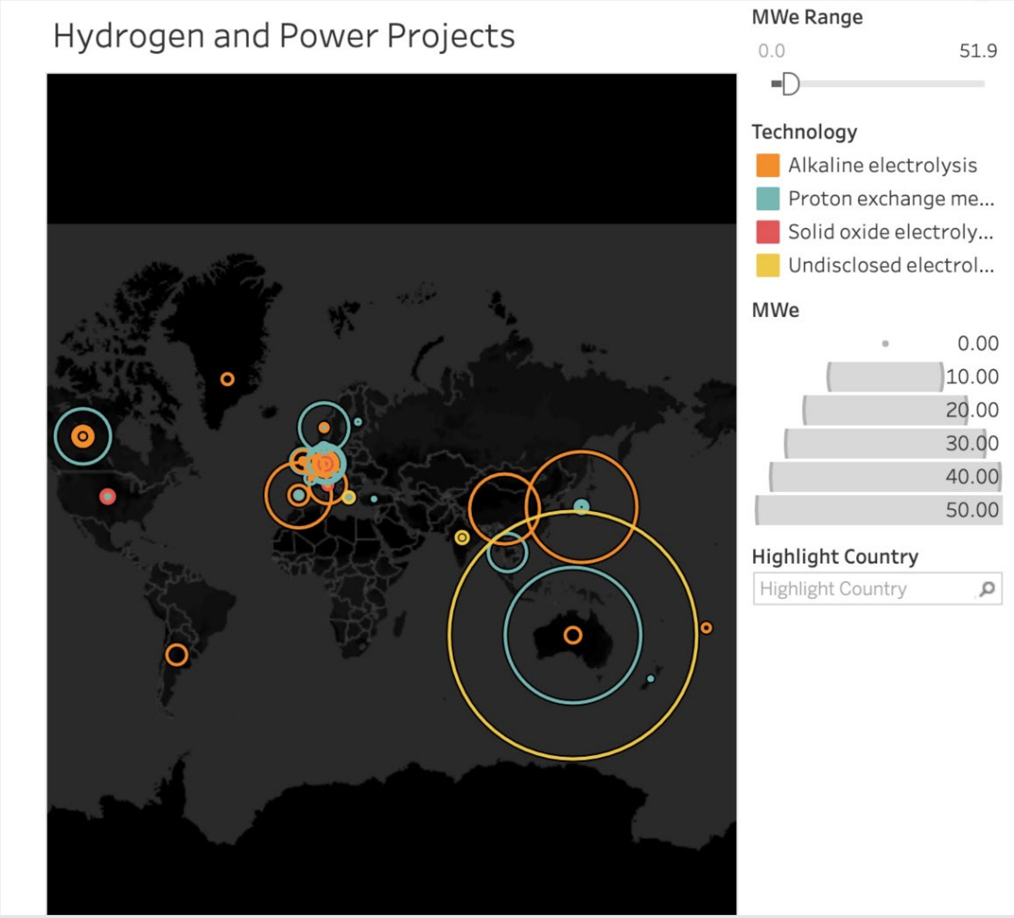


Cost Reduction Targets

- **Japan.** Electrolyzer costs of $475/kW, efficiency of 70% or 4.3 kWh/Nm 3, and a production cost of $3.30/kg by 2030.
- **Australia**. Production cost of below AU$2/kg of hydrogen.
- **Chile**. Strategy sets a target of 25 GW by 2030 with a remarkable hydrogen production cost of less than $1.50/kg.
- **Canada**. Delivered hydrogen costs of CA$1.50–3.50/kg by 2050.

Source: Ludwig-Bölkow-Systemtechik GmbH (LBST) and the World Energy Council's German chapter. (Map by Joe Goodman for Carbon Brief)

Projects Underway



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Industry Perspectives

What some major hydrogen technology developers anticipate:

Mitsubishi Power, which is already offering commercial hydrogen storage packages, says costs will depend on volume and application, but it points out useful cost estimations may be murky until a hydrogen economy is established.

Siemens Energy, an established electrolyzer manufacturer, is targeting renewable hydrogen costs of $1.50/kg by 2025 based on a power cost of $16/MWh and a 100 MW electrolysis system running for 6,000 hours a year.

GE, a notable hydrogen-capable gas turbine manufacturer, says operating a power plant on hydrogen—whose cost ranges from three times to 10 times the current cost of natural gas—will increase the cost of electricity (LCOE) by similar factors.

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Zero Emission
Hydrogen Fuel Cell Vehicles

USEA Consensus Program Briefing

Robert Wimmer

Director, Energy & Environmental Research

Toyota Motor North America

May 20, 2021

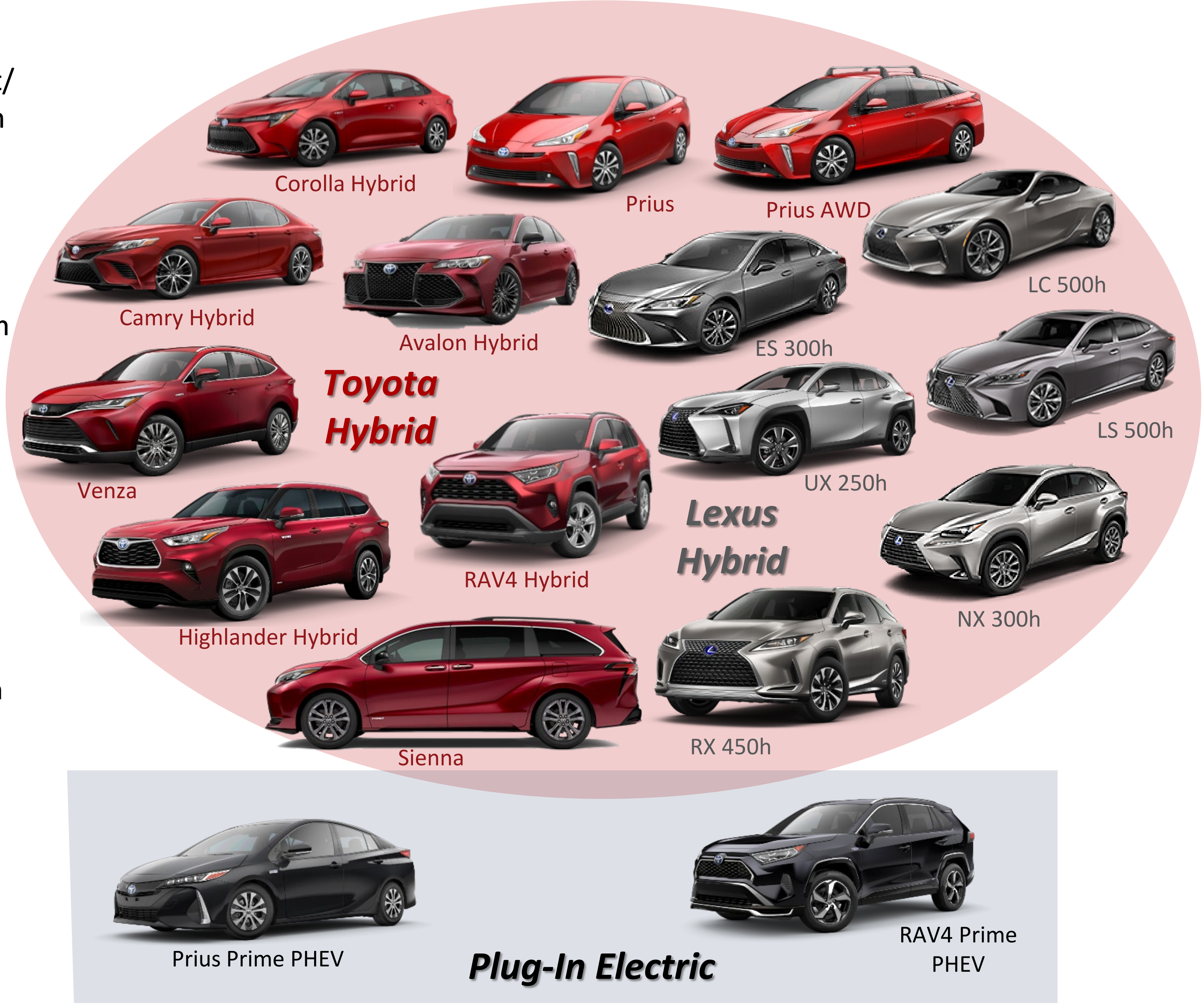
Toyota US Electric-Drive Portfolio

Compact/
Medium

Large/
Premium

SUV

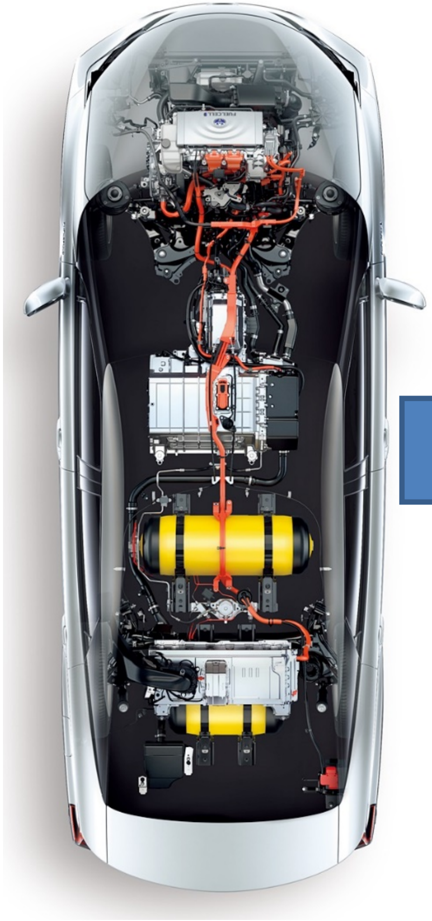
Minivan



Hydrogen Fuel Cell

Mirai FCEV

Scalability of FC Technology



Modular Fuel Cell Power System

2X Systems

Heavy-Duty Applications

__Plus Additional__
- **Batteries**
- **H2 Storage**

Medium-Duty Applications

Marine, Industrial, Rail and Stationary Applications

Toyota Heavy-Duty Fuel Cell Vehicles

Portal – Class 8 Fuel Cell Tractor

Medium Duty Fuel Cell Trucks with Hino Japan

Fuel Cell Power Supply Vehicle Japan

FC Fork Truck

Sora Fuel Cell Bus

Heavy Duty Fuel Cell Trucks with Hino US

UNO FC Utility Tractor

CARB ZANZEFF Project

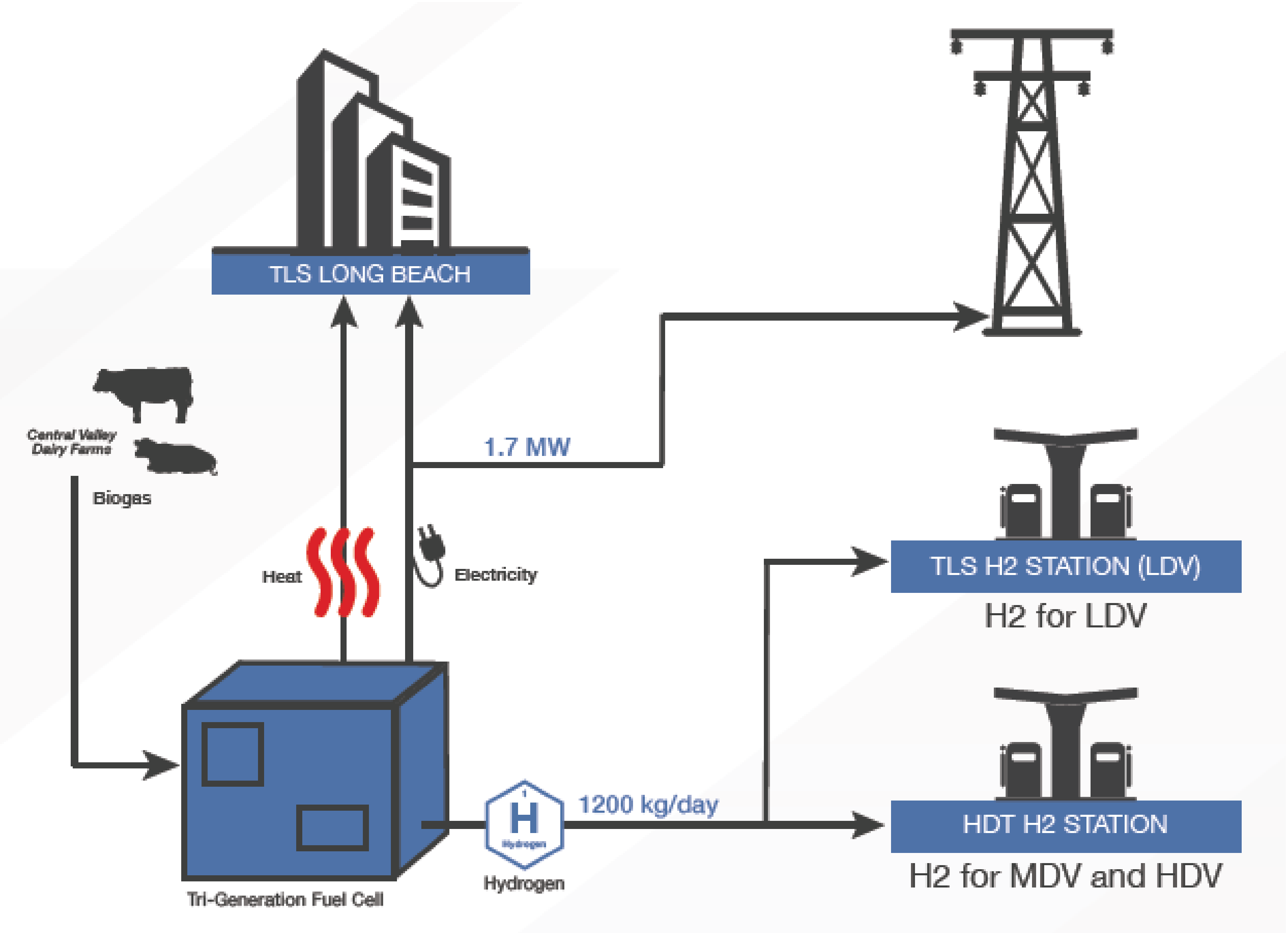
10 CLASS 8 TRUCKS

4 UNIQUE OPERATORS

2 NEW HD H2 FUELING STATIONS

Toyota Green H2 Production Project at Port of Long Beach

Tri-Generation



Power + H2 + Heat

Heavy and Light-Duty H2 Refueling at Port

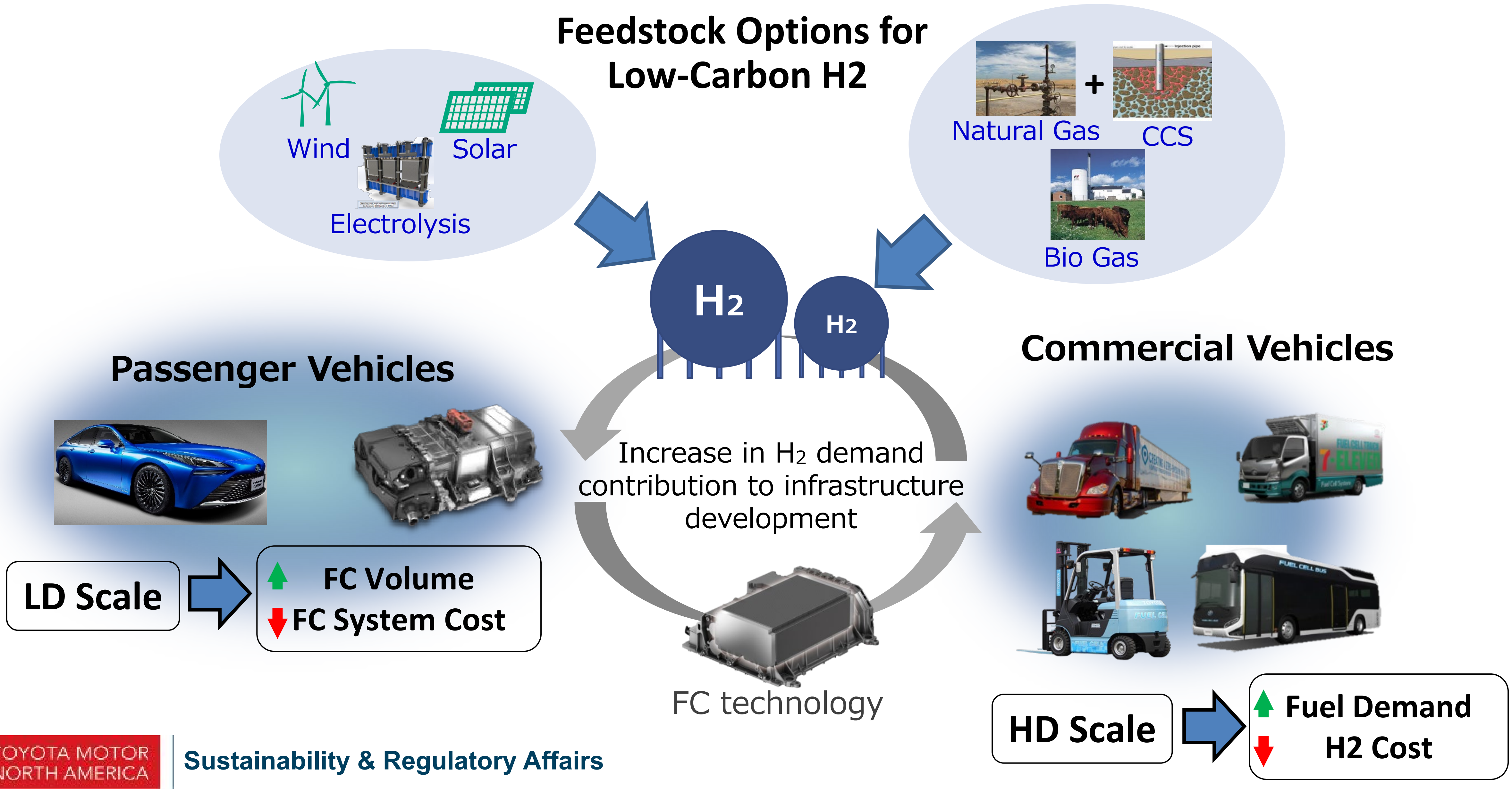
HD Refueling

H2 Dispensers

H2 Storage

Overhead View

Feedstock and Vehicle Diversification Necessary for Success



HONDA
The Power of Dreams

Zero Emission
Hydrogen Fuel Cell Vehicles

USEA Consensus Program Briefing

Ryan Harty
Division Lead, C.A.S.E. & Energy Business Development
American Honda Motor Co., Inc

May 20, 2021

3 Main Points:

Renewable energy is key to achieving Honda’s 2050 carbon neutrality goal

Vehicle-Grid Integration and hydrogen energy storage are key to success with renewable energy adoption

EVs and Hydrogen FCVs enable new value of personal mobility

Honda Environmental Vision

**Realizing the joy and freedom
of mobility and a sustainable society
where people can enjoy life**

BLUE SKIES FOR
OUR CHILDREN

Carbon Neutrality by 2050

Achieve net-zero CO2 emissions by reducing, eliminating, or offsetting CO2 from products and operations.

"Triple Zero" Environmental Goals

Honda introduced **Triple Zero Goals** to achieve zero environmental impact by **2050**.

Carbon Neutral

Achieve net-zero CO2 emissions by reducing, eliminating or offsetting CO2 from products and operations.*

Clean Energy

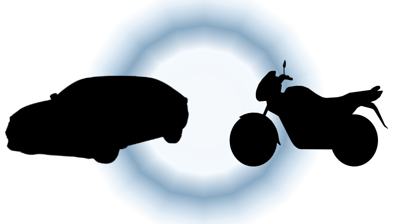
100% utilization of renewable energy, including solar, wind and geothermal

Resource Circulation

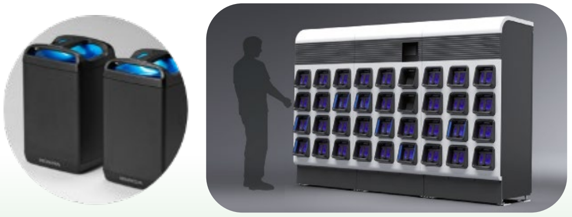
100% use of sustainable materials

*Previous goal was 50% reduction in CO2 by 2050 compared to 2000 baseline.

Pathway to "Triple Zero"



Electrification of automobiles and motorcycles



Mobile Power Pack

Expand electrified products with swappable batteries

Expanding the use of hydrogen fuel cell stacks

Expand use of renewable energy through infrastructure-linked smart power when charging products

Electricity

Hydrogen

Carbon-neutral fuels

Hydrogen & carbon-neutral fuels

Multi-pathway of energy

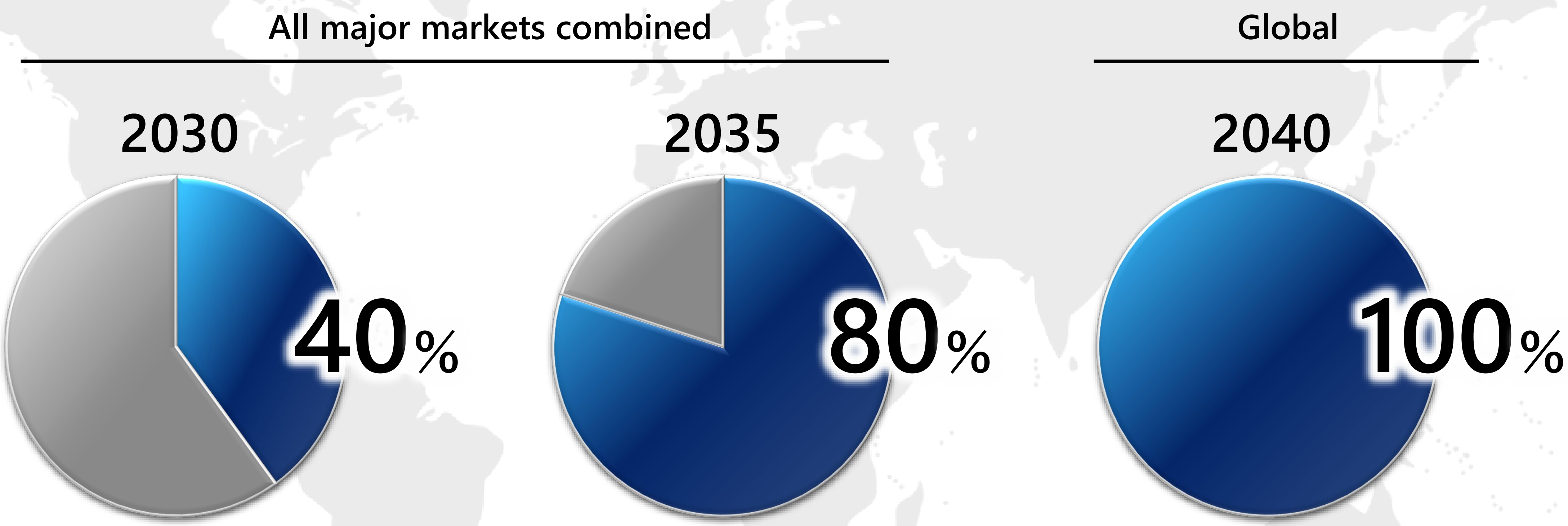
Create products from 100% sustainable materials

Resource circulation

Research on more effective ways to reuse and recycle batteries

Electric Vehicles – Targeting 100% EV Sales by 2040

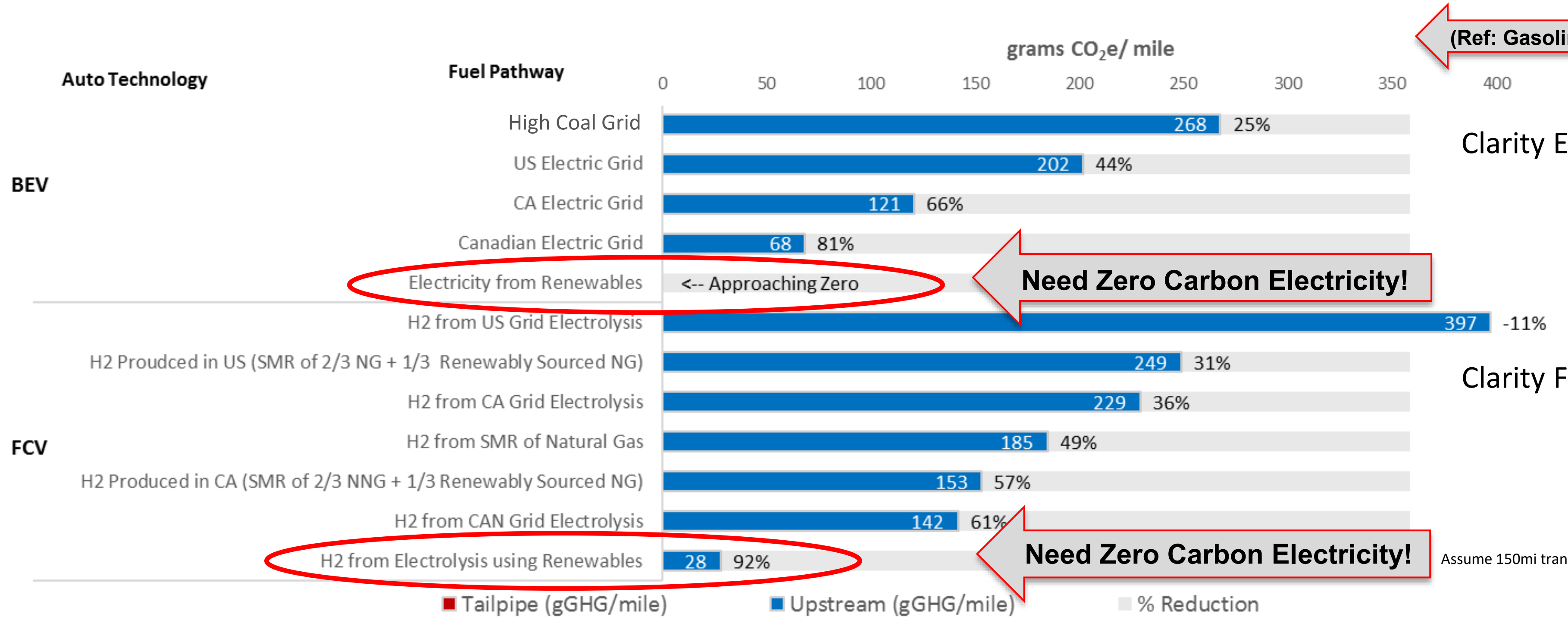
Electrification of automobiles



EV & FCEV

Well-to-Wheel GHG Emissions by Auto and Fuel Pathway

Renewable Energy is Key. Zero emission vehicles need zero emission fuel in order to achieve meaningful CO2 reductions!!



Clarity Electric

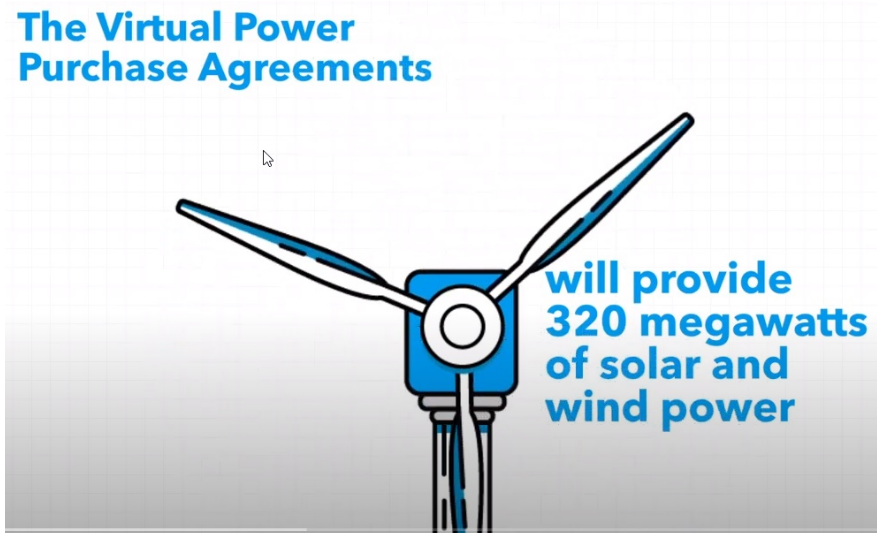
Clarity Fuel Cell

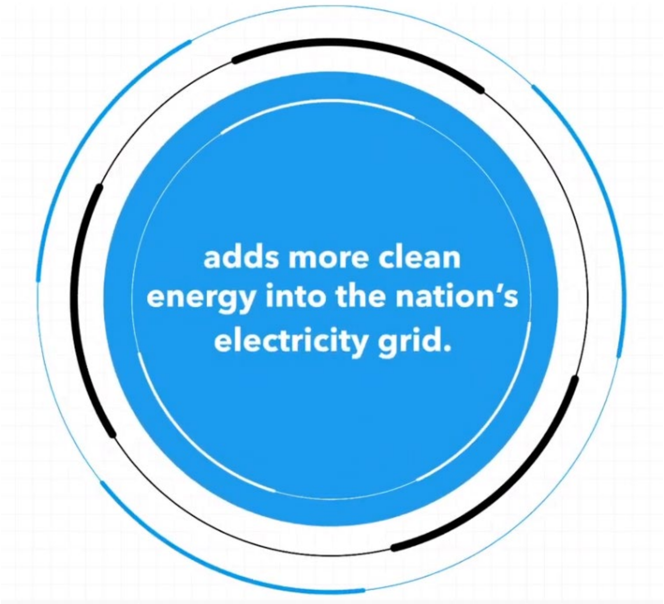
Source: Honda Sponsored 3rd Party Analysis using GREET 2016 and Honda Internal Calculations. 2018.

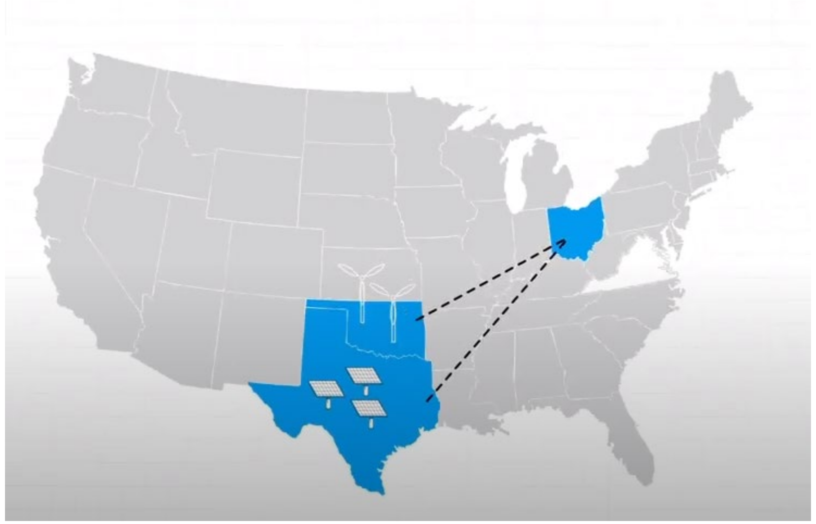
Renewable Energy: Virtual Power Purchase Agreements

HONDA
The Power of Dreams

Towards our goal of 100% zero carbon energy, 60% of electricity we use in North America has been contracted to come from renewable wind and solar by 2024, offsetting fossil fuel-powered electricity used by Honda's auto plants.





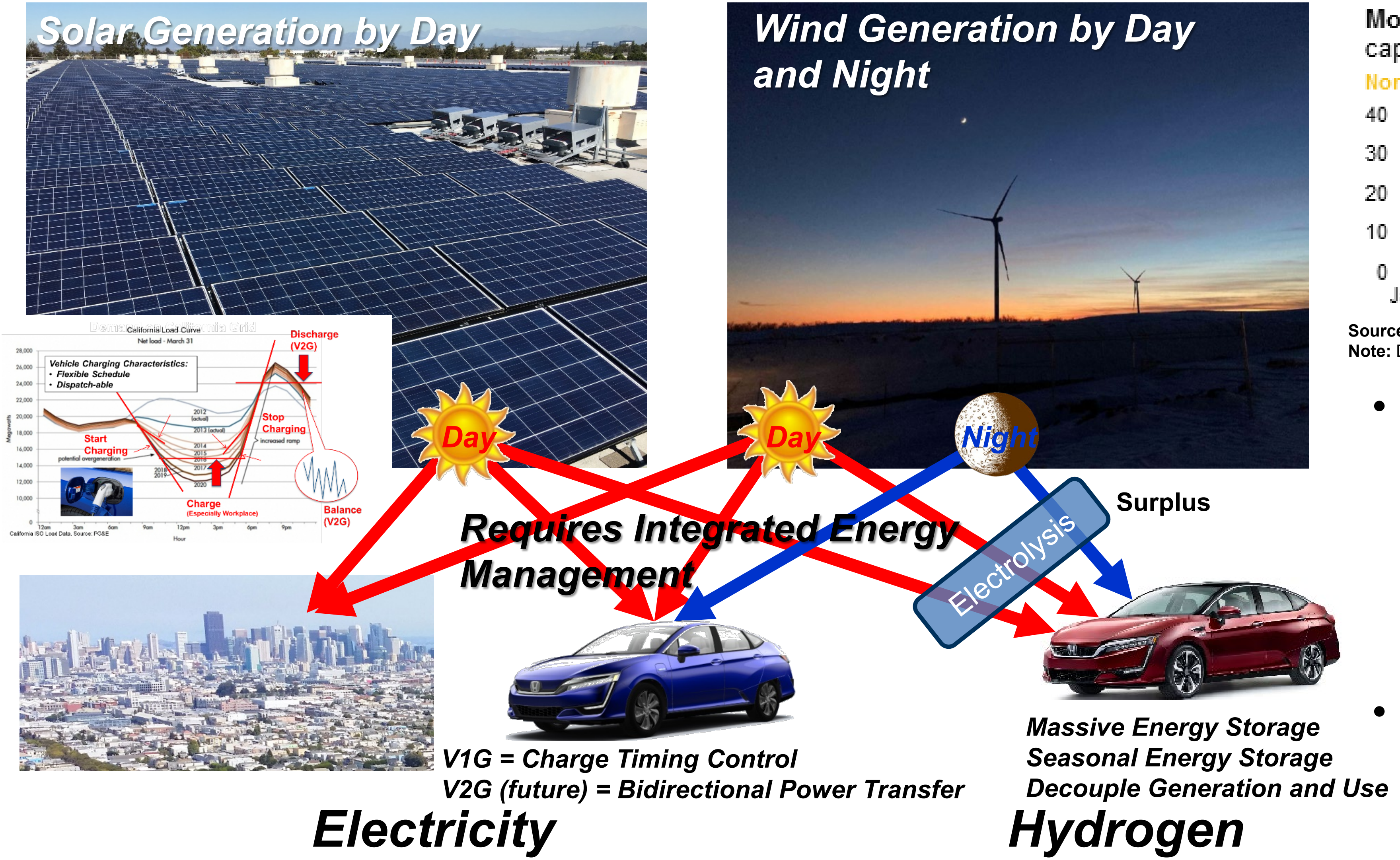


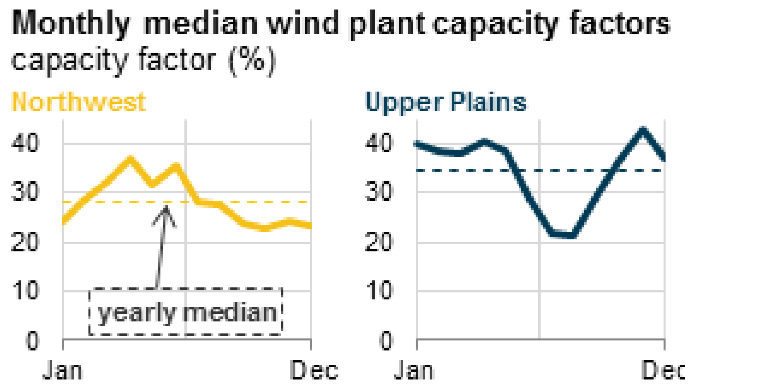
How It Works:

- Honda buys electricity from a renewable energy supplier that is sold into the electricity grid where the clean power is generated.
- This "virtual purchase" reduces the amount of electricity generated by fossil fuels, reducing CO_2 emissions.

The Power of Dreams

Vehicle-Grid Integration is Key to Renewable Energy





Source: U.S. Energy Information Administration, Forms EIA-860 and EIA-923
Note: Data include facilities with a net summer capacity of 1 MW and above only.

- **EV Charging flexibility can help address daily renewable energy supply/demand matching and moment-moment balancing**
- **Seasonal differences need hydrogen storage to utilize surplus renewable energy.**

A renewable energy system needs flexible demand from transportation to balance the intermittency of renewable energy. Honda is already working to achieve this vision.

Vehicle-Grid Integration – Honda SmartCharge™

HONDA
The Power of Dreams

Vehicle-Grid Integration, including hydrogen generation for transportation, is a key enabling technology for a zero-carbon electric grid.

https://www.honda.com/environment/SmartCharge

Vehicle-to-Home – Electricity or Hydrogen

Installed 2014 with V2H. V2B/V2G implemented 2018.

Hondasmarthome.com

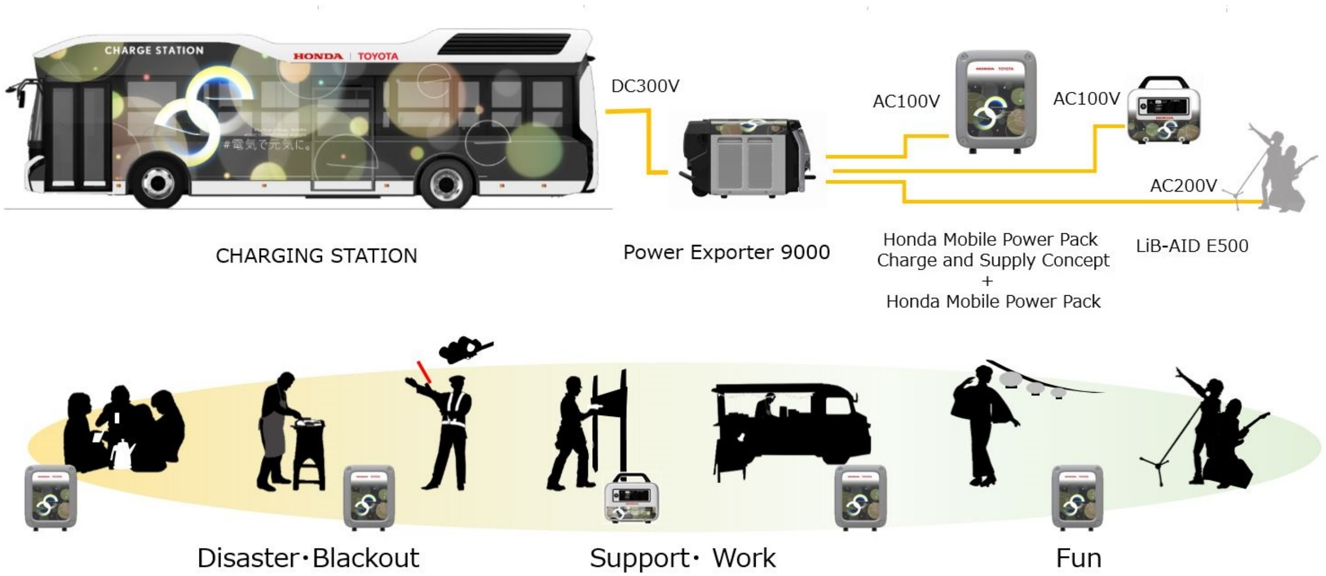
EVs and FCVs can be used to provide home back-up power for resiliency.

Vehicle-to-Load – Electricity or Hydrogen

Power Exporter Concept – for V2L, V2H

Community Resiliency - Concept

https://global.toyota/en/newsroom/corporate/33598951.html



(Japan based demo shown)

EVs and FCVs can be used to provide mobile power where it is needed.

3 Main Points:

Renewable energy is key to achieving Honda’s 2050 carbon neutrality goal

- ***Requires focused inclusion of transportation in storage policy.***

Vehicle-Grid Integration and hydrogen energy storage are key to success with renewable energy adoption

- ***Requires regulatory inclusion of transportation in storage policy.***

EVs and Hydrogen FCVs enable new value of personal mobility

- ***Requires support for public refueling infrastructure for market success of EVs and FCVs.***

HONDA

The Power of Dreams

TAX INCENTIVES FOR HYDROGEN UNDER BIDEN?

Peter Connors

May 20, 2021

orrick

Renewables Tax Incentives

ITC Only

Solar Projects, Fuel Cells.

ITC or PTC

Wind, Geothermal, Biomass, Hydro, Marine and Hydrokinetic

PTC Only

Carbon capture and sequestration (CCUS)

- Applicable to Blue Hydrogen

Tax Incentives for Hydrogen

<u>Current Law</u>

- Hydrogen-Fueled Vehicles, from $8,000 to $40,000. Through 2021
- Alternative Fuel Refueling Property, $30,000. Through 2021.
- Hydrogen Fuel Cells—Investment Tax Credit, 26 percent if completed by the end of 2022 and 22 percent for property that begins construction by the end of 2023.
  - In all cases, construction needs to be completed before 2026.

Proposals

Clean Energy for America Act (Senator Wyden, April 21, 2021)

- Incentives for Clean Electricity
- Technology-neutral tax credit for domestic production of clean electricity.
- Open to all resources – renewable, fossil fuel,– but available only to facilities that are at least 35 percent cleaner than average.
- Available as either a production tax credit of up to 2.5 cents per kilowatt hour or an investment tax credit of up to 30 percent.
- Includes a clean energy fuel credit of $1.00 a gallon (or gallon equivalent).
- An increase in the credit for charging stations from $30,000 to $200,000.

Hydrogen Utilization and Sustainability Act (Senators Young and Whitehouse, December 7, 2020)

- Adds "Qualified Hydrogen" to Production Credit

GREEN Act of 2021 (Rep. Mike Thompson, February 4, 2021)

- Expands ITC to include "energy storage technology" which includes hydrogen storage

The American Jobs Plan Proposals

- **Build next generation industries in distressed communities**.

  President Biden believes that the market-based shift toward clean energy presents enormous opportunities for the development of new markets and new industries. For example, by pairing an investment in 15 decarbonized hydrogen demonstration projects in distressed communities with a new production tax credit, we can spur capital-project retrofits and installations that bolster and decarbonize our industry.

- Production credit for hydrogen?

Questions for any of the presenters?

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Peter Connors

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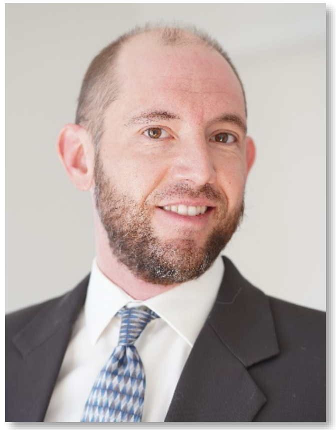

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