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Achieving the goals of SB 100 With Green Hydrogen

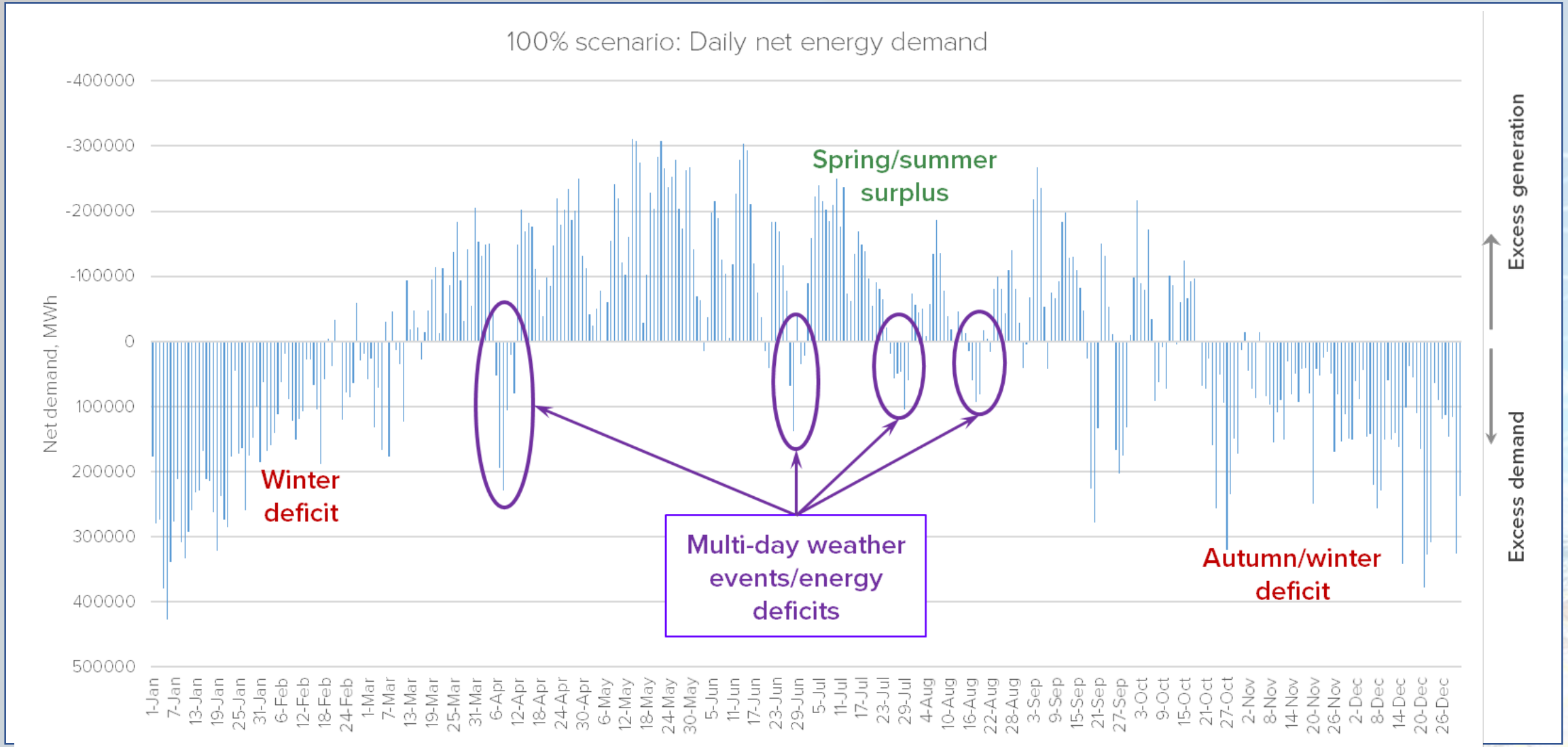
Produced for SB 100 Implementation Workshop

November 18, 2019

GREEN HYDROGEN COUNCIL

STRATEGEN

Why I Became Interested in Green Hydrogen



Source: CAISO and Strategen Analysis

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Hydrogen – A common *element* of our energy future ?

- Momentum currently behind hydrogen is unprecedented, with more and more policies, projects and plans by governments & companies in all parts of the world

- Hydrogen can help overcome many difficult energy challenges

  - ***Integrate more renewables***, including by enhancing storage options & tapping their full potential

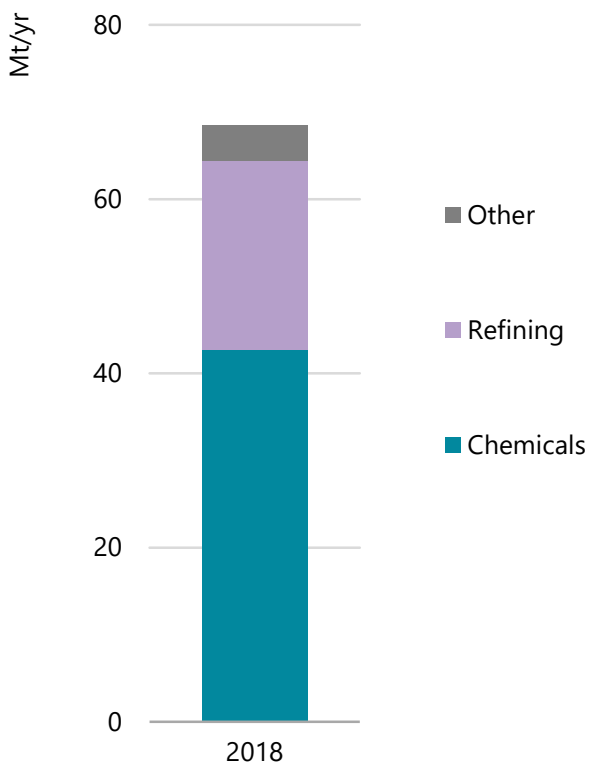
  - ***Decarbonise hard-to-abate sectors*** – steel, chemicals, trucks, ships & planes

  - ***Enhance energy security*** by diversifying the fuel mix & providing flexibility to balance grids

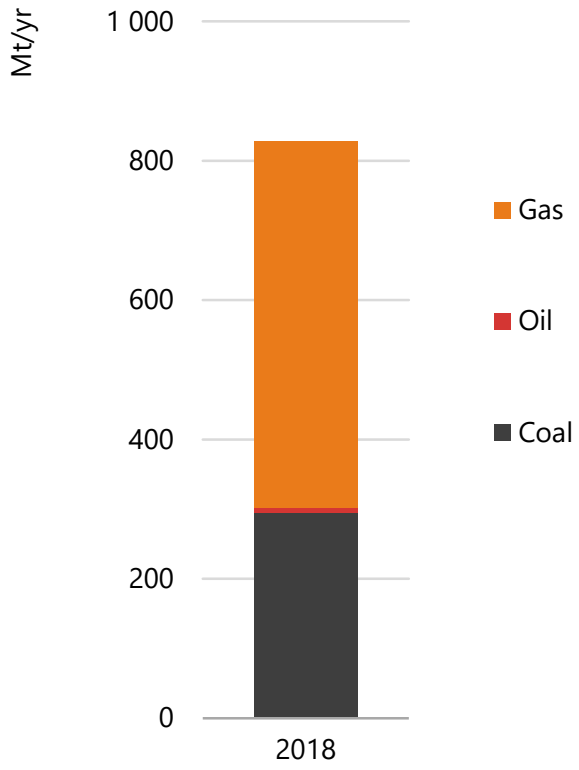
- But there are challenges: ***costs*** need to fall; ***infrastructure*** needs to be developed; ***cleaner hydrogen*** is needed; and ***regulatory barriers*** persist

Hydrogen is already part of the energy mix

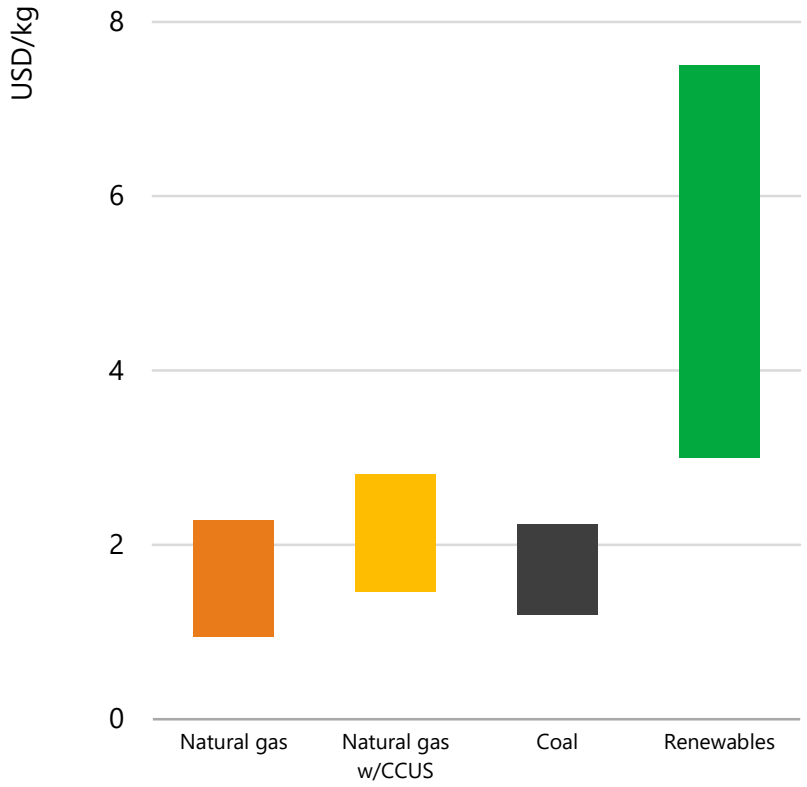
Hydrogen production



CO_2

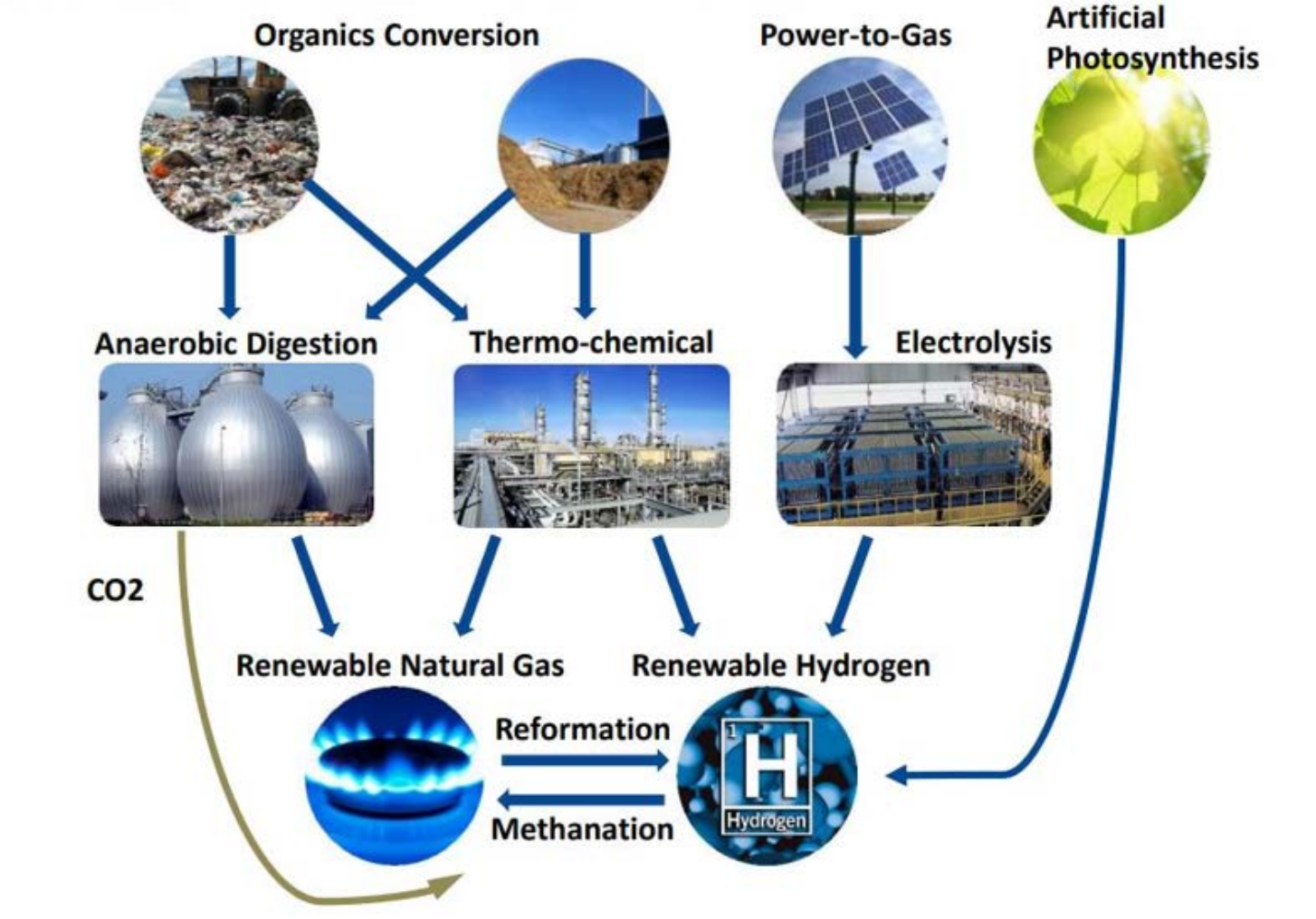


Hydrogen production costs, 2018



Dedicated hydrogen production is concentrated in very few sectors today, and virtually all of it is produced using fossil fuels, as a result of favourable economics

Green Hydrogen =
Eligible renewable sources



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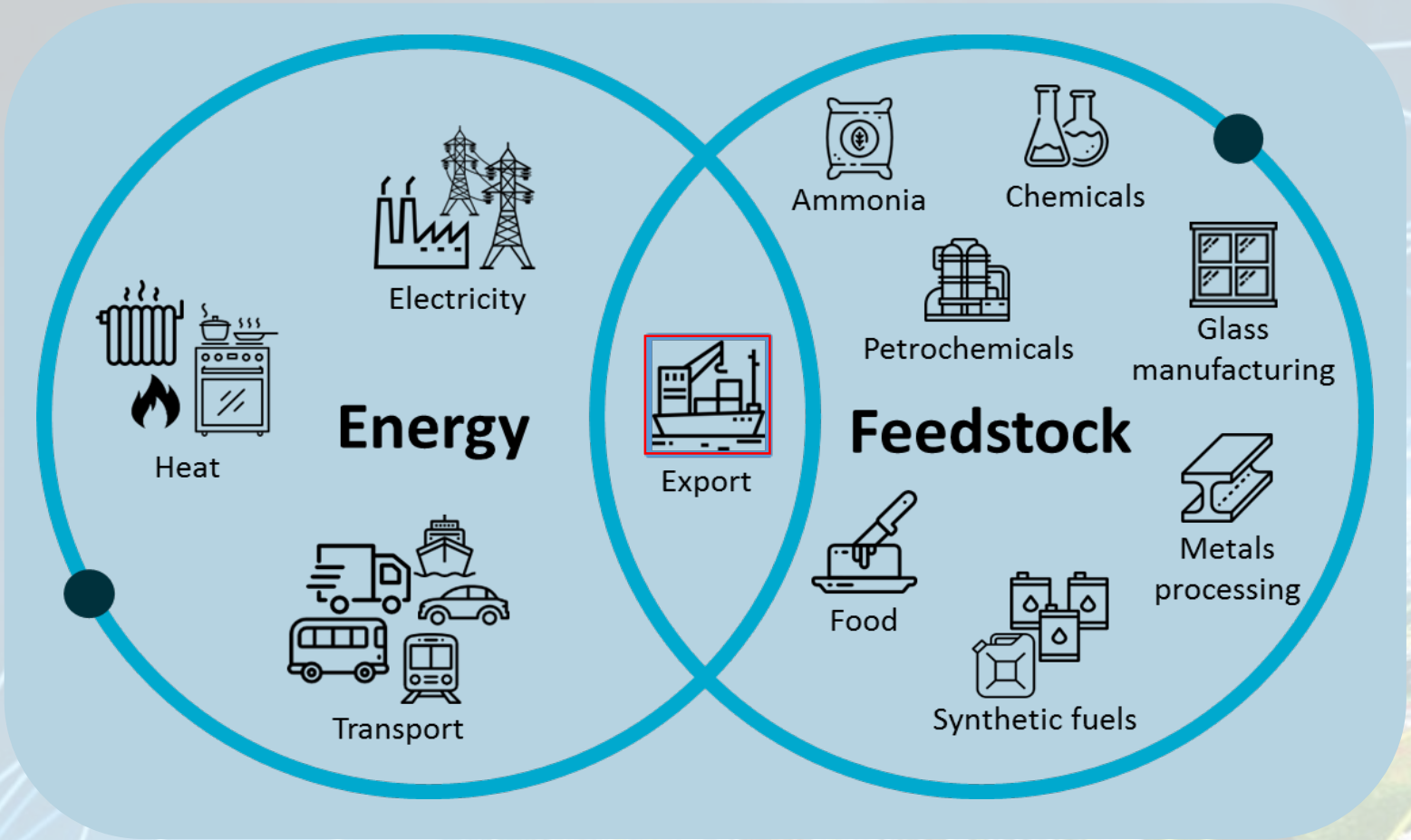
Zero Carbon Sources

(e.g. large hydro, curtailed renewable energy)

Image from "Renewable Hydrogen Production Roadmap Project Results Summary prepared by Dr. Jeff Reed and Professor Scott Samuelson from UC Irvine

Green Hydrogen Can Decarbonize Multiple Sectors



Source: CSIRO

Australia's View on Green Hydrogen

Source: ARENA

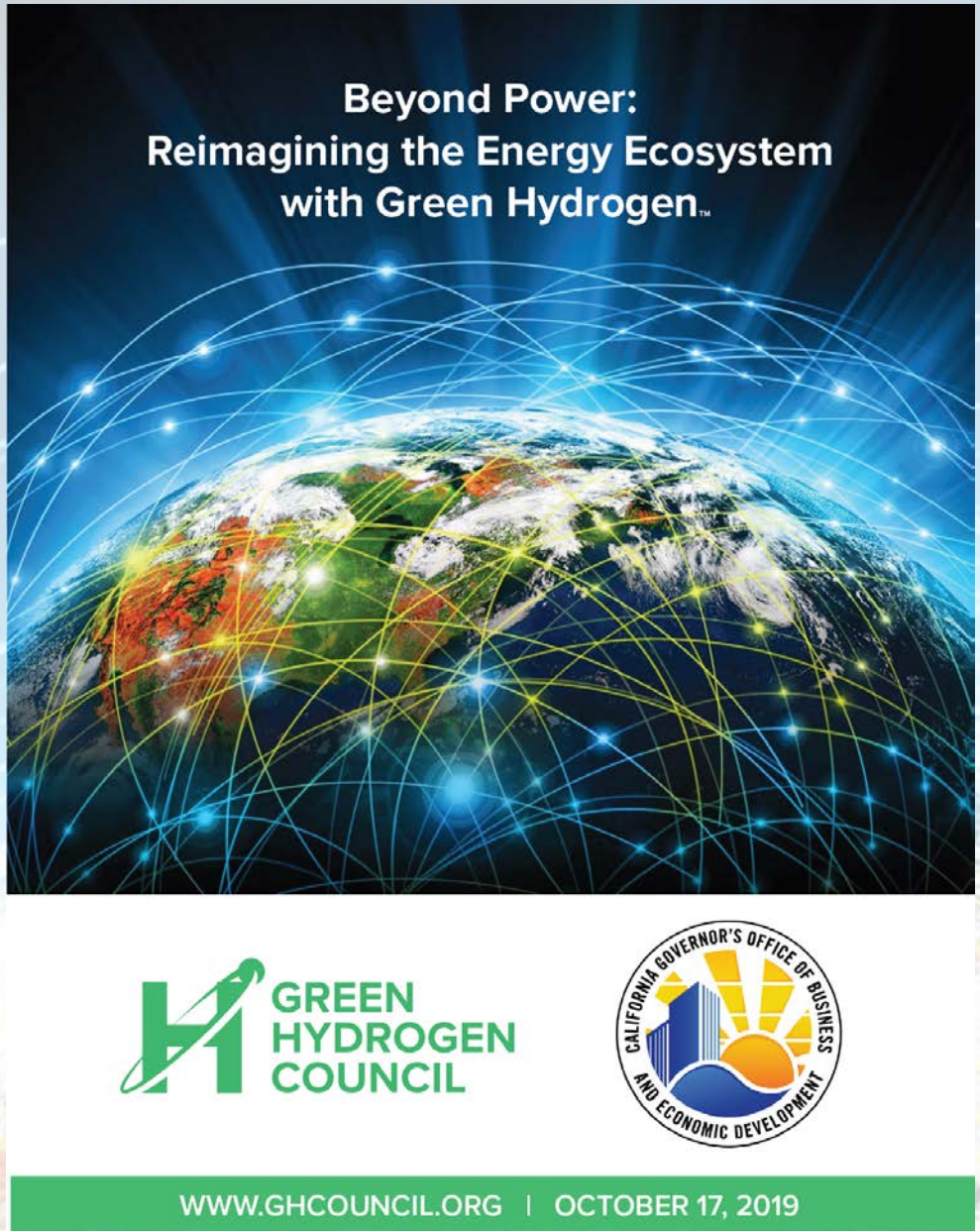
GHC Launched Oct 17, 2019

Mission:

Advance the use of green hydrogen to accelerate the transition to a carbon-free energy supply, greater energy independence, and the decarbonization of the power, gas, industrial, transportation, building, public infrastructure and agricultural sectors.

Approach:

Accelerate green H2 projects at scale; leveraging multi-sector opportunities to scale supply and demand



Intermountain Power Project

IPP Renewed

Project Scope

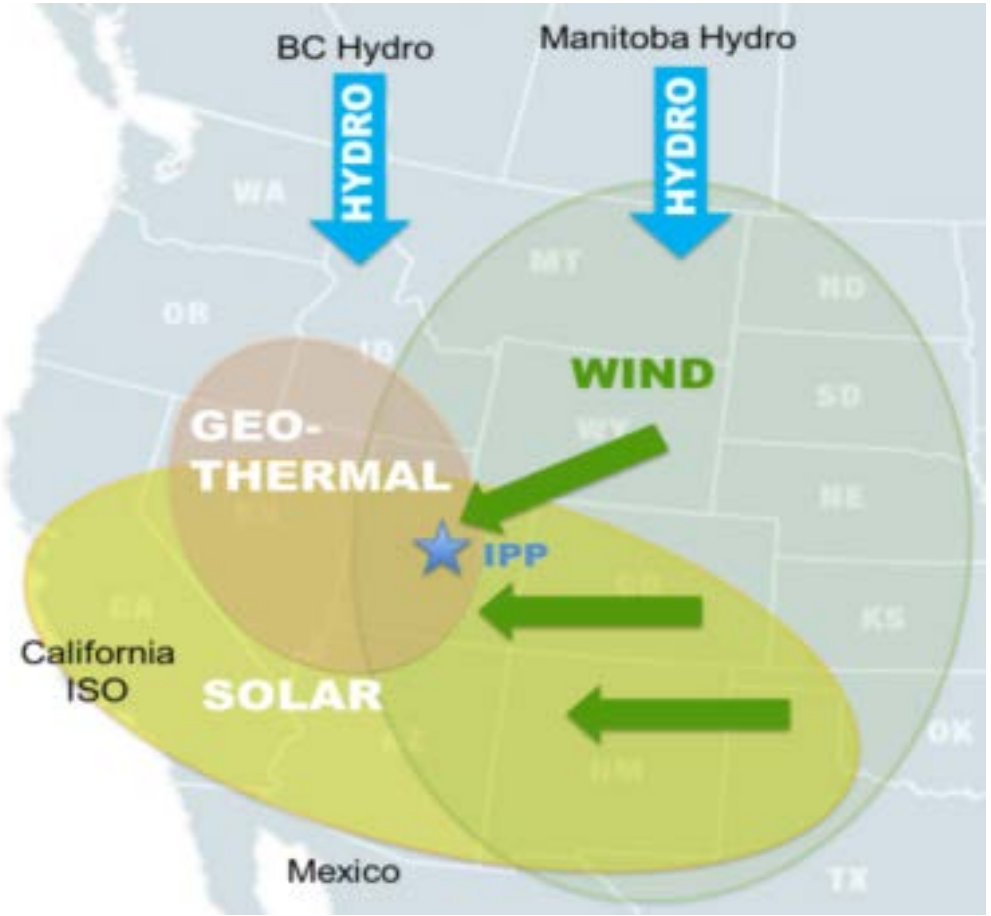
- 840 MW Natural Gas Combined Cycle Facility (reduced from 1,200 MW)
  - Estimated capacity factor = 68%
  - Construction: Start – January 1, 2020 Completion – July 1, 2025
- 2,400 MW HVDC Converter Station Replacements
  - Additional Transmission support allows integration of renewables
  - Construction: Start – May 1, 2021 Completion – April 1, 2026

Project Necessity

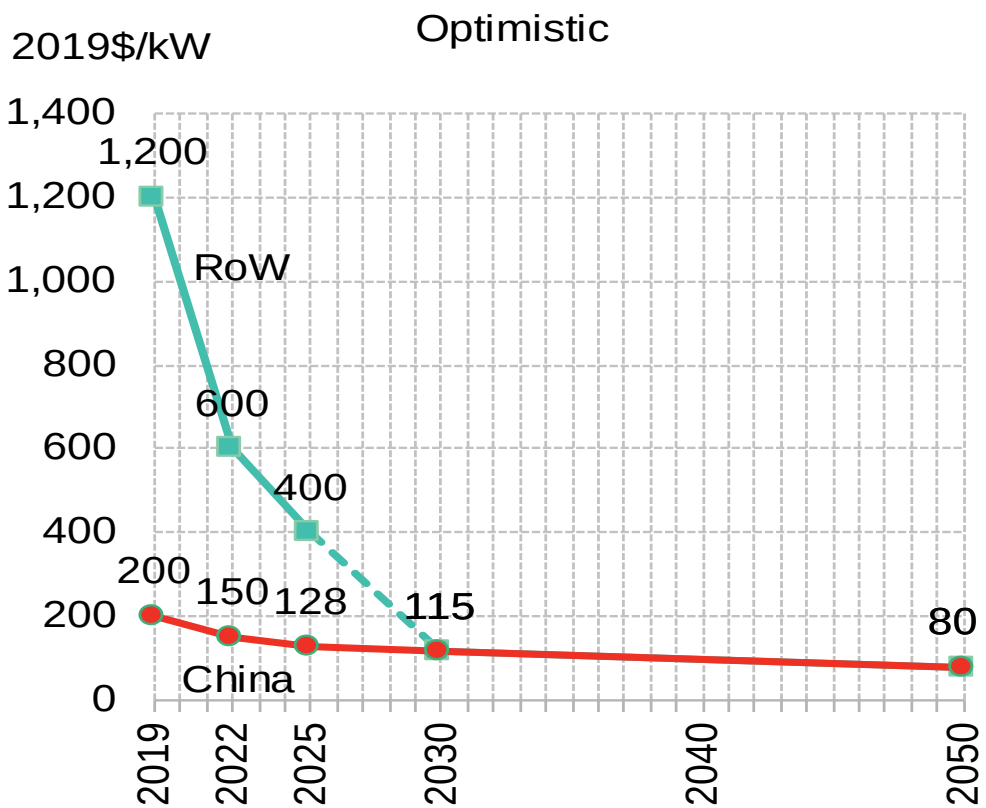
- Required to meet LADWP's 100% Renewable Goals
- Dispatchable energy required to maintain system reliability
- Less reliance on in-basin natural gas units and Aliso Canyon Storage facility

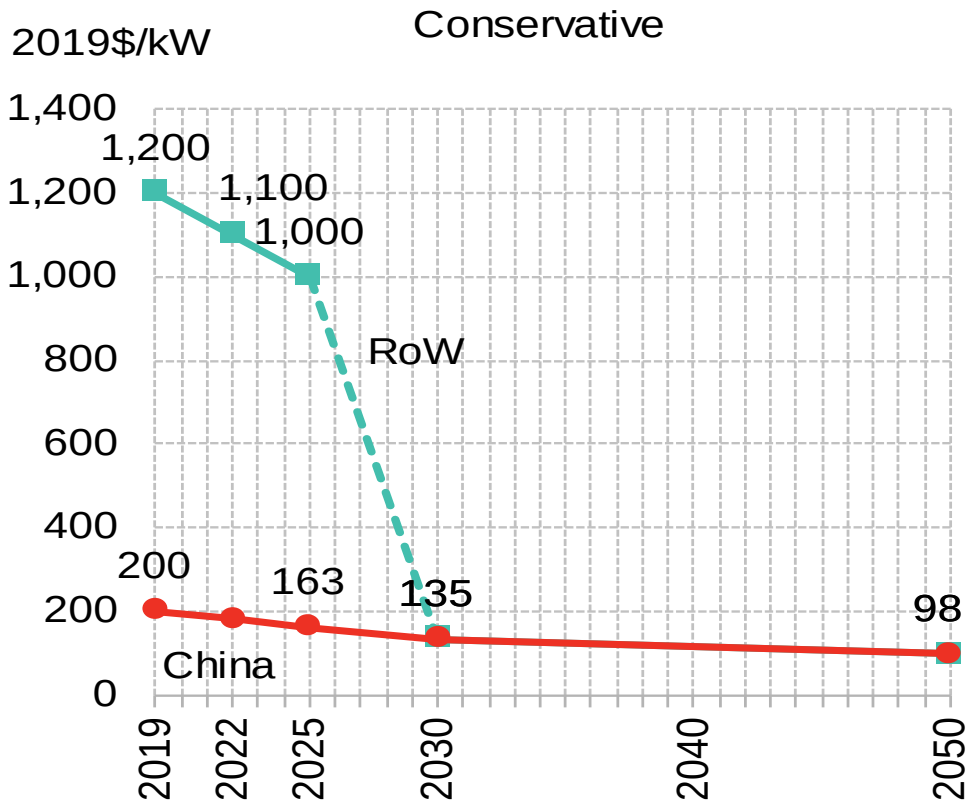
Utah's Renewable Hub

- IPP sits in a confluence of renewable resources
- Currently interconnected to 370 MW of wind generation
- Secondary Path for existing Geothermal Projects and potential for additional geothermal in the area
- 2,300 MW of current solar interconnection requests in queue
- 1500 MW of Wyoming wind interconnects currently being discussed



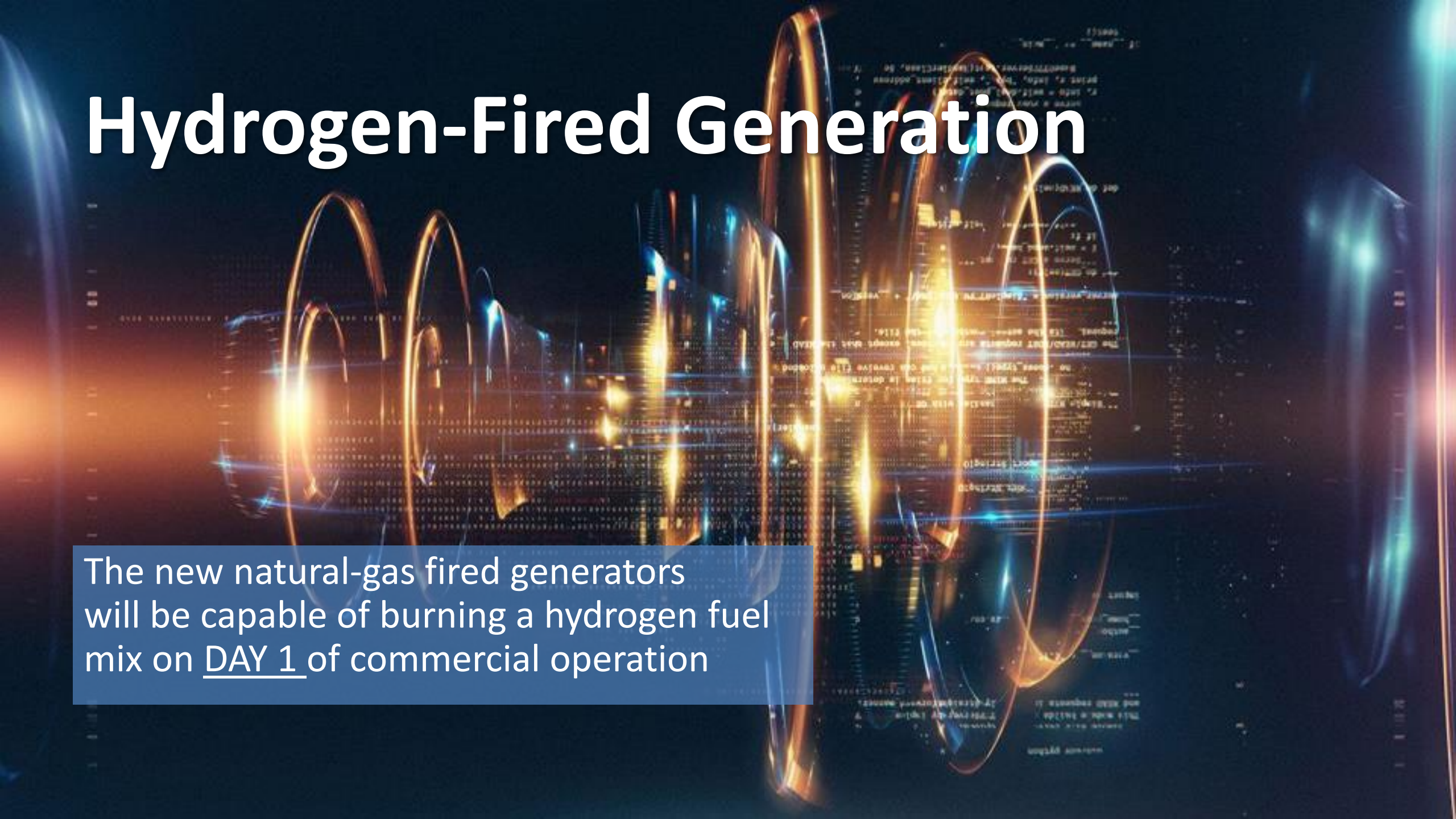
Hydrogen Electrolyzer Capex





Source: BloombergNEF

Hydrogen-Fired Generation

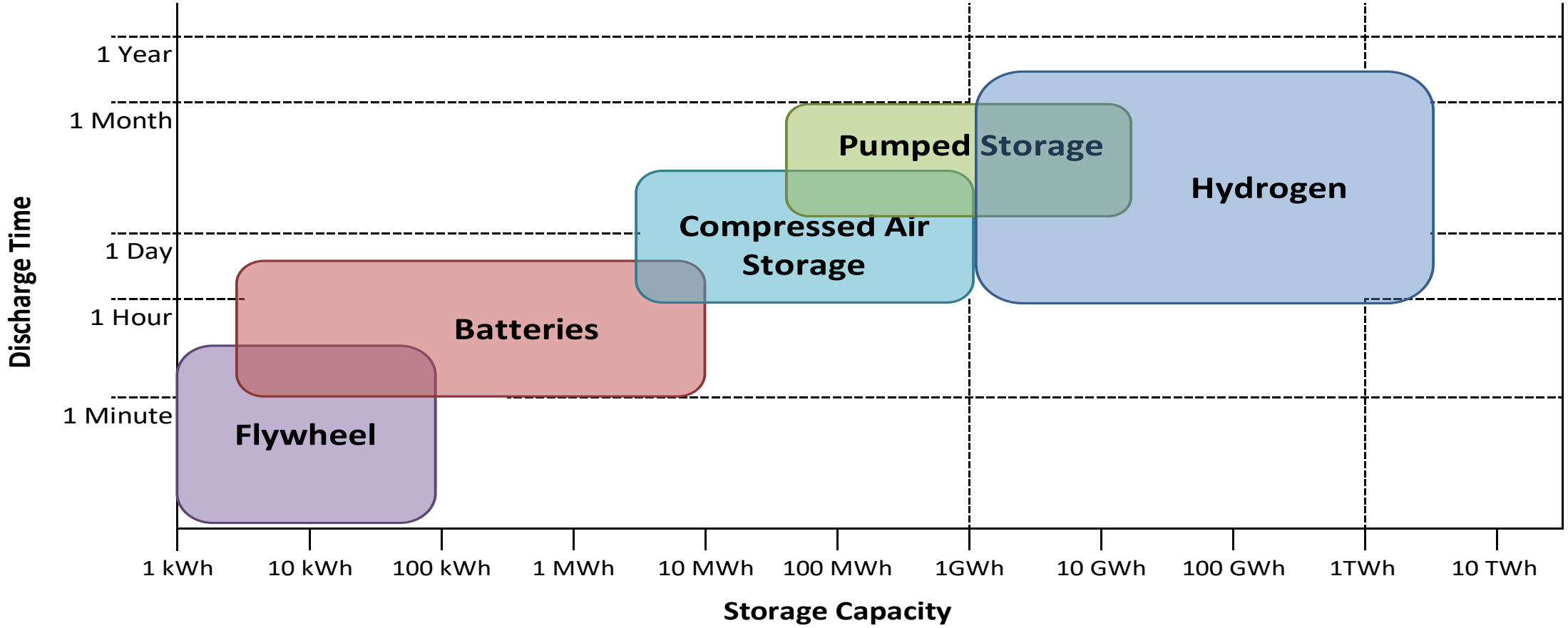


The new natural-gas fired generators will be capable of burning a hydrogen fuel mix on DAY 1 of commercial operation

Hydrogen Storage at IPP

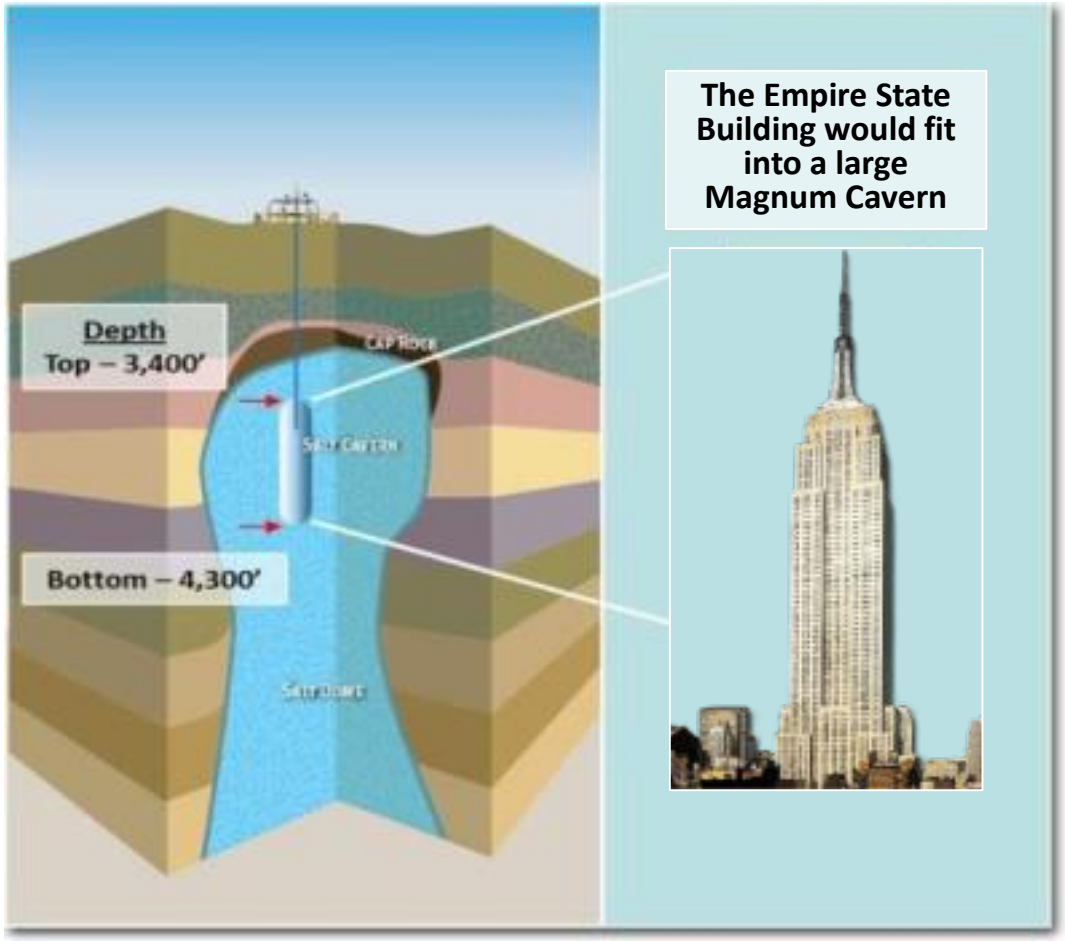
Hydrogen storage is one of IPP's most unique features. Not only does it alleviate the challenges of hydrogen transportation, it also allows for **SEASONAL SHIFTING** of renewable energy; taking the otherwise curtailed energy and storing it as fuel.

Energy Storage Potential



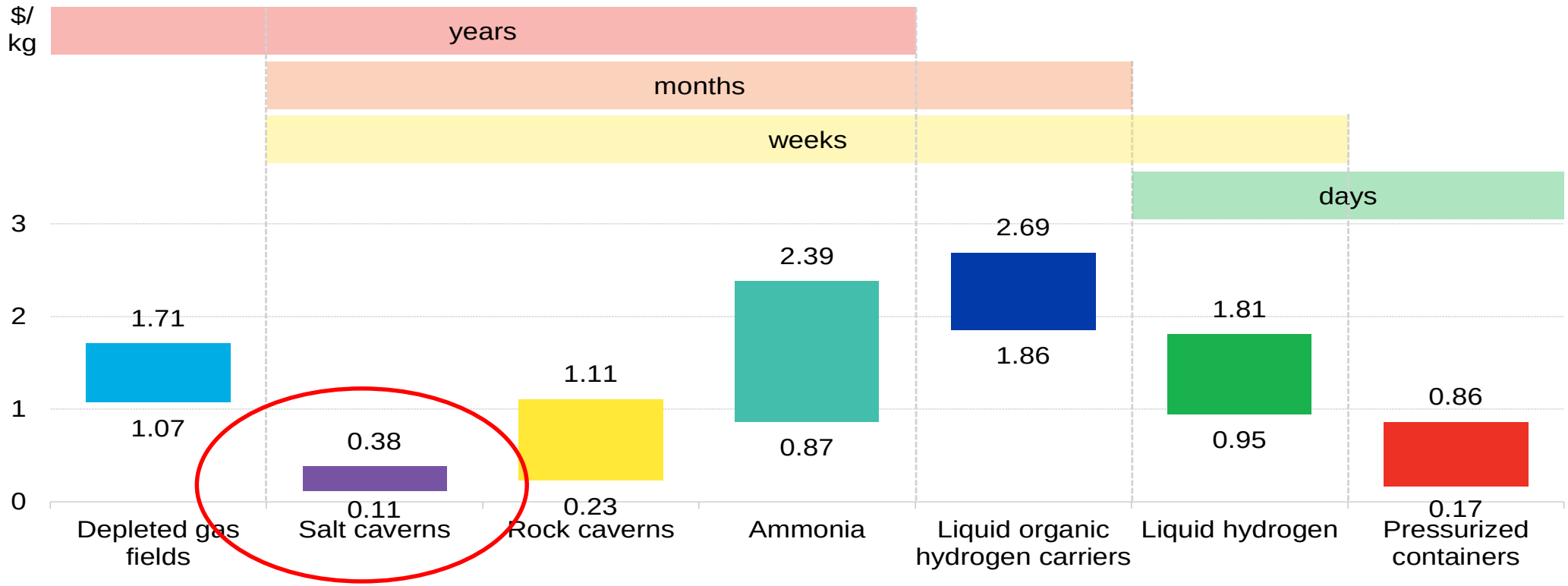
Hydrogen Storage at IPP By The Numbers

- A typical cavern size at IPP = 4,000,000 barrels
- 1 cavern = 5,512 tons of H2 (operational limit)
- This is equivalent to:
  - 200,000 hydrogen buses
  - 1,000,000 fuel cell cars
  - 14,000 tube trailers used for delivery
- Over 100 caverns can be constructed in the salt dome at IPP



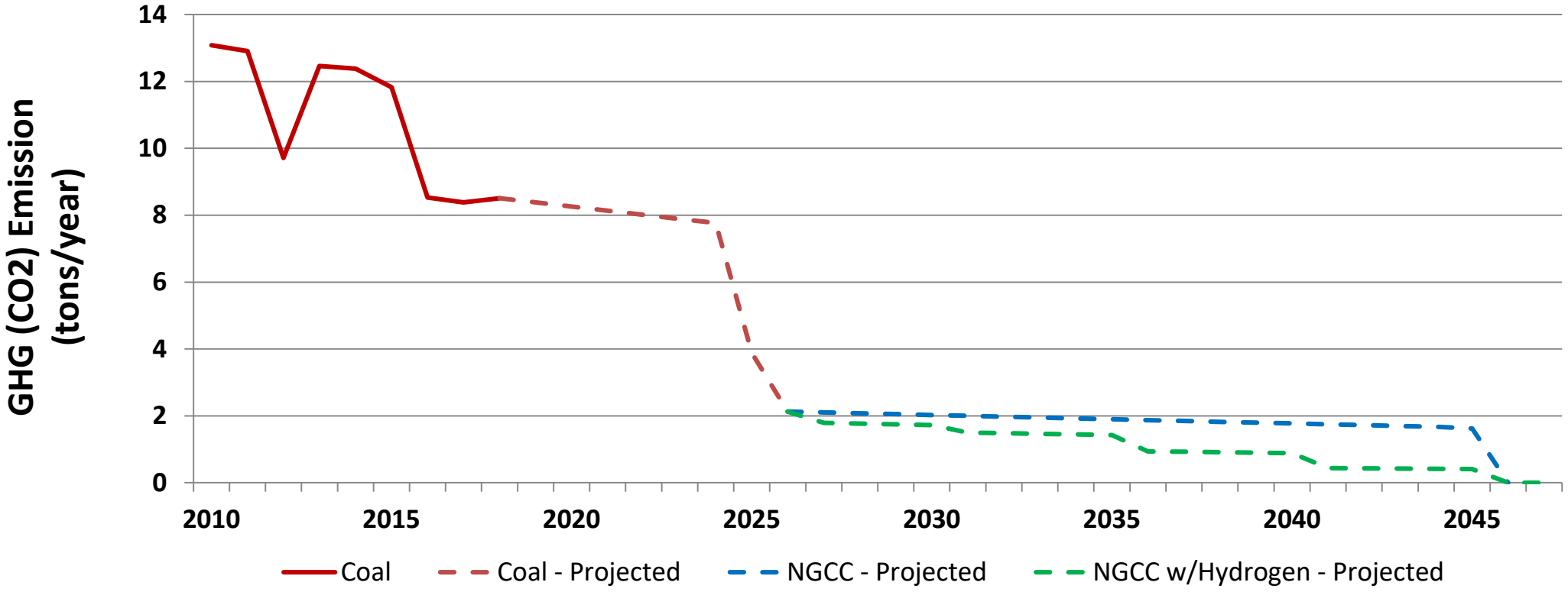
Levelized Cost of Hydrogen Storage

FUTURE BEST CASE

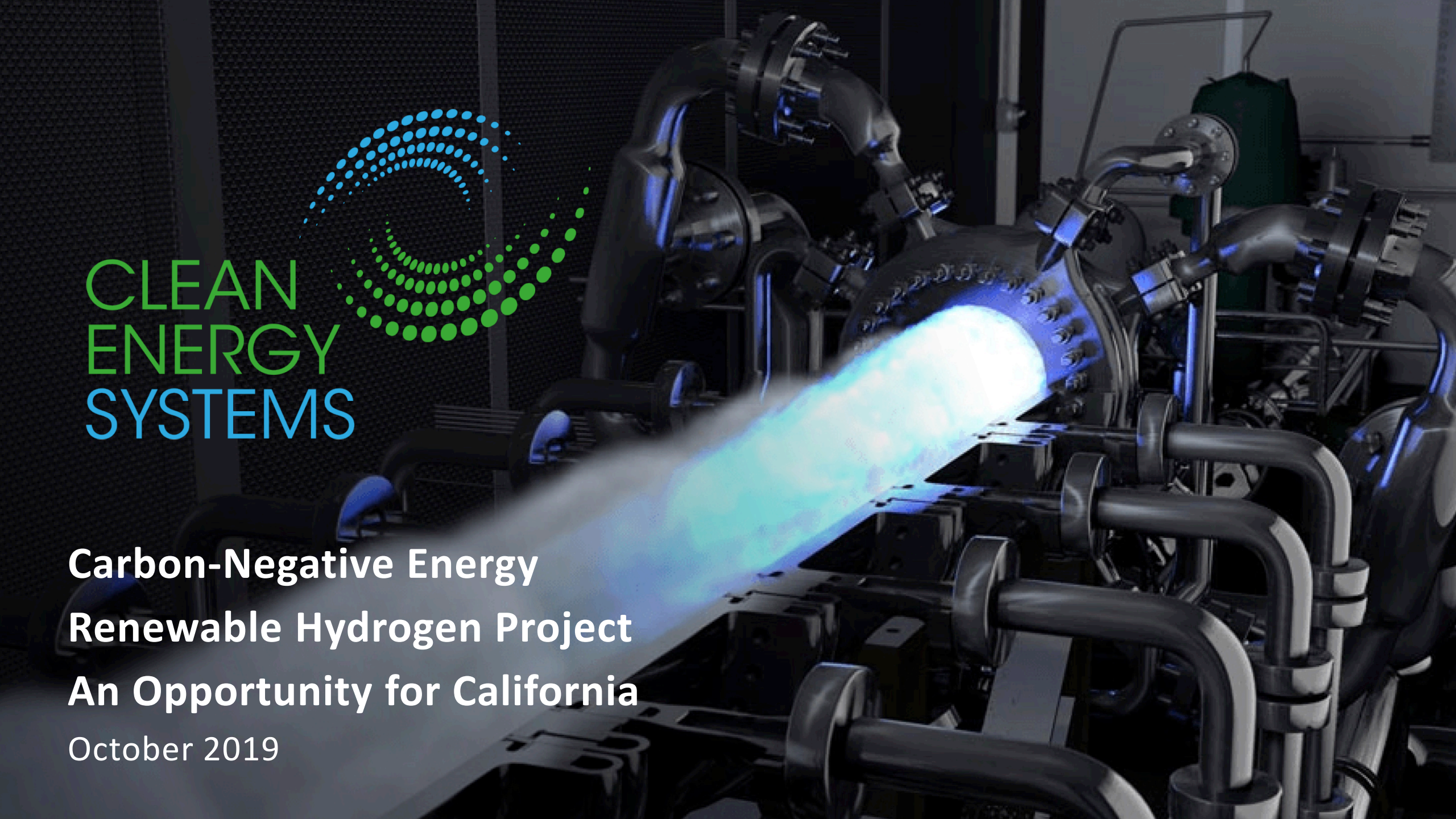


Source: BloombergNEF

IPP Potential Emissions Profile



%Hydrogen by Heat Rate	2026-2030	2031-2035	2036-2040	2041-2045	2046 -
	15%	25%	50%	75%	100%



CLEAN ENERGY SYSTEMS

Carbon-Negative Energy Renewable Hydrogen Project An Opportunity for California

October 2019

Bakersfield
Carbon Negative Energy Project

CLEAN ENERGY SYSTEMS

2019 American Lung Association "State of the Air" Report

Top 10 Most Polluted U.S. Cities:

Ozone	Short-Term Particle Pollution (24-hour $PM_{2.5}$)	Year-Round Particle Pollution (Annual $PM_{2.5}$)
1 **Los Angeles-Long Beach, CA**	1 **Bakersfield, CA**	1 **Fresno-Madera-Hanford, CA**
2 **Visalia, CA**	2 **Fresno-Madera-Hanford, CA**	2 **Bakersfield, CA**
3 **Bakersfield, CA**	3 Fairbanks, AK	3 Fairbanks, AK
4 **Fresno-Madera-Hanford, CA**	4 **San Jose-San Francisco-Oakland, CA**	4 **Visalia, CA**
5 **Sacramento-Roseville, CA**	5 Missoula, MT	5 **Los Angeles-Long Beach, CA**
6 **San Diego-Chula Vista-Carlsbad, CA**	6 Yakima, WA	6 **San Jose-San Francisco-Oakland, CA**
7 Phoenix-Mesa, AZ	7 **Los Angeles-Long Beach, CA**	7 Pittsburgh-New Castle-Weirton, PA-OH-WV
8 **San Jose-San Francisco-Oakland, CA**	8 Salt lake City-Provo-Orem, UT	8 **El Centro, CA**
9 Houston-The Woodlands, TX	9 Seattle-Tacoma, WA	9 Cleveland-Akron-Canton, OH
10 New York-Newark, NY-NJ-CT-PA	10 Pittsburgh-New Castle-Weirton, PA-OH-WV	10 Medford-Grants Pass, OR

CNE: WHY NOW?
CLIMATE CHANGE AND AIR QUALITY

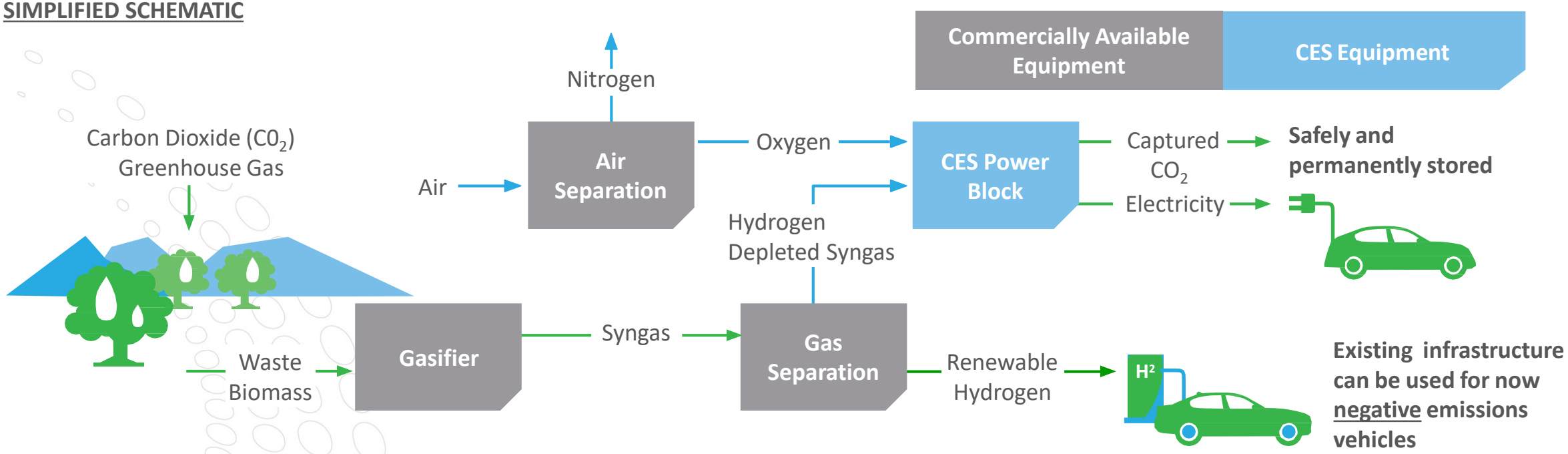
CLEAN ENERGY SYSTEMS

CNE | HOW IT WORKS

CLEAN ENERGY SYSTEMS

CES Carbon Negative Energy (CNE) plants use waste biomass fuels that are gasified to produce a synthesis gas. This “syngas” is then used to produce renewable hydrogen (RH_2), and/or electricity with full carbon capture using proprietary oxy-combustion technology

SIMPLIFIED SCHEMATIC

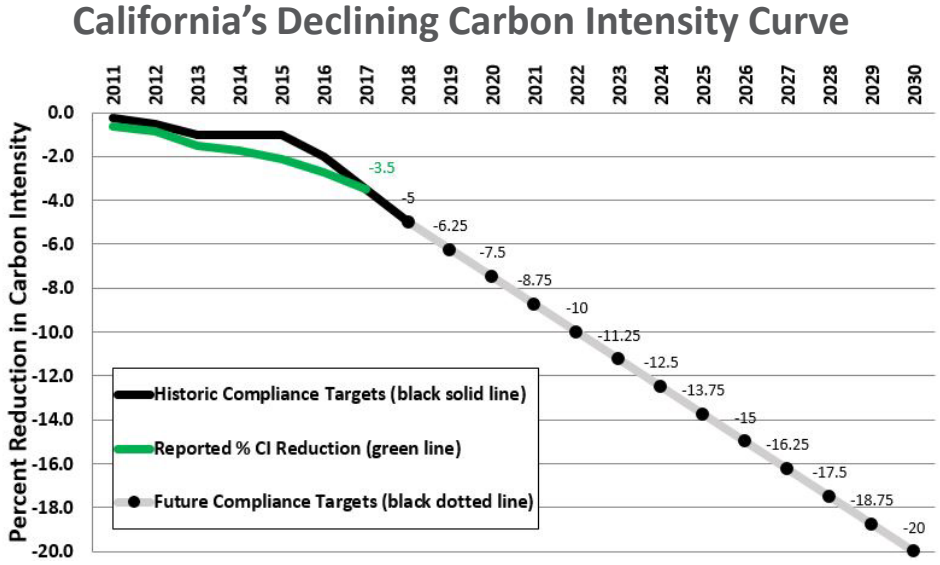


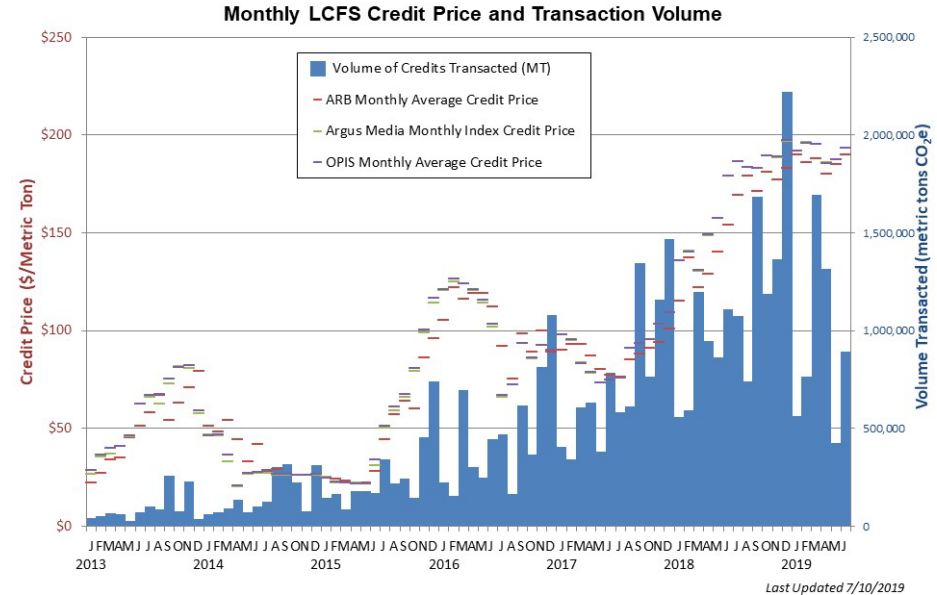
CNE: WHY NOW?
ECONOMICS

CLEAN ENERGY SYSTEMS

Revenues have increased from $20 to $250/tonne for Carbon Capture in select markets

- Value Proposition for CCS projects today:
  - Renewable Hydrogen sales <u>at avoided cost</u>
  - Federal Tax Credit (45Q); increased from $20 to $50/tonne CO_2 in 2018
  - California's Low Carbon Fuel Standard (LCFS); credit prices exceeding $190/tonne
- Concurrently, the Biomass Power industry in California has collapsed due to competition from wind and solar
  - Stranded assets may be used for alternative purposes
  - Feedstock pricing collapse; long-term contracts available
- Required CES capture tech. ready for commercial deployment
  - More than 25 years and $135 million invested





CES DEPLOYMENT I ENVIRONMENTAL IMPACT

- CES plans to deploy a fleet of CNE plants across California by retrofitting existing, idled biomass facilities
- First plants will be deployed in the Central Valley; CES has site control for the first four plants to be deployed by 2025
- Significant fuel production and environmental benefits for the state by replicating and scaling CNE plants

	First Four CNE Plants 2022-2025	Future Potential 2025+
Fuel Production (tonne/day)		
RH_2 Produced	33	425
Emissions Avoided (tonne/yr)		
CO_2 Captured & Avoided	1,300,000	16,200,000
NOx Avoided	2,400	29,900
Particulates Avoided	5,100	64,100

Preliminary list of barriers …

- Understanding green hydrogen use cases: supply and demand
- Establishing evaluation & procurement framework for the costs/benefits of green hydrogen, including use cases that span jurisdictions
    - EX: include green hydrogen in IRP modeling
    - EX: value & compensate renewable reliability for green hydrogen storage
    - EX: consider green hydrogen for local resiliency fuel
- Reducing the cost of physically moving green hydrogen from supply sources to demand centers
    - EX: establish gas pipeline injection and standards
    - EX: encourage smart siting of early projects close to large off takers
- Pricing and REC accounting structures for distributed green hydrogen production
    - EX: establish wholesale & retail electric tariffs for electrolysis

…requires multi jurisdictional focus

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REC accounting challenges for green H2

GRID TIED ELIGIBLE MWH

1

Possibilities
- Onsite
- Contract MWh + REC
- REC purchase w/ Grid MWh

Scenario 1
REC created

NOT GRID TIED ELIGIBLE MWH

2

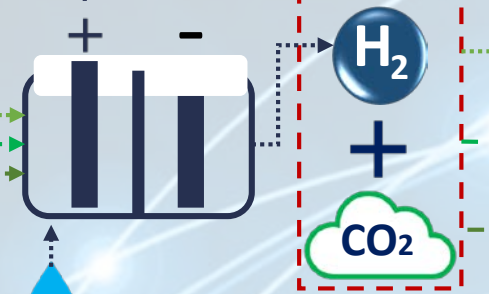
Purpose – built renewable energy

GRID TIED GHG FREE MWH

3

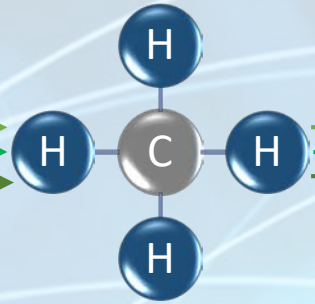
O_2

H_2O



H_2 + CO_2

GRID CONNECTED ELECTROLYZER (LOAD ON GRID)



RENEWABLE & ZERO CARBON METHANE

ZERO CARBON HEATING

GENERATOR

RENEWABLE & ZERO CARBON ELECTRICITY

Scenario 2
REC created

As % of eligible REC input, from input meter to electrolyzer

Scenario 3
No REC

Still counts as Renewable + Zero Carbon

ZERO CARBON TRANSPORTATION FUEL

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Thank you!

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Strategen is a mission-driven professional services firm dedicated to decarbonizing the grid

ASSOCIATIONS

Strategen co-founded and manages the California Energy Storage Alliance (CESA) and the Global Energy Storage Alliance (GESA). Through these organizations, Strategen's 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 public sector leaders, utilities, developers, and global corporations helping them to achieve transformational and sustainable 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. Now in its 7th year, the annual event connects over 2000 participants from 30+ countries.