

# About the GHC

## [www.ghcoalition.org](http://www.ghcoalition.org)

### **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

\*The GHC is a 501c3 Tax Exempt Non Profit Corporation



# What is green hydrogen? The industry is aligned.

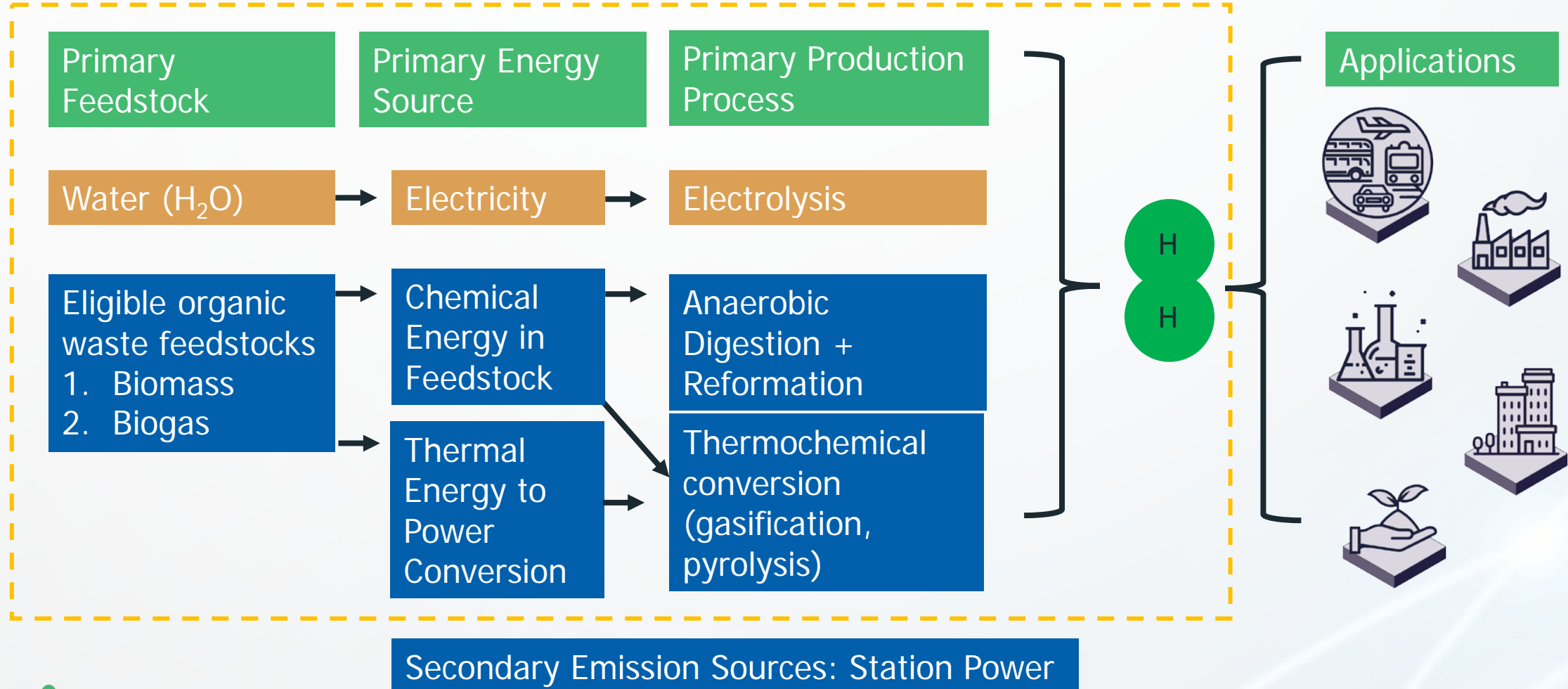


Green Hydrogen: hydrogen that is not produced from fossil fuel feedstocks

Fossil Fuel Feedstocks	Brown	Coal or lignite	Gasification & reformation	Fuel to Hydrogen	- 18 to 20
	Gray	Natural gas	Gasification (SMR)		- 10 to 12
	Blue	Brown or Gray plus CCS	Carbon Capture Sequestration during gasification		- 0.6 to 3.5
Renewable Feedstocks	Green	Biogas or Biomass	Gasification & reformation	Clean Electricity to Hydrogen	- 0
		Water	Electrolysis		Carbon impact (kg CO <sub>2</sub> /kg H <sub>2</sub> )

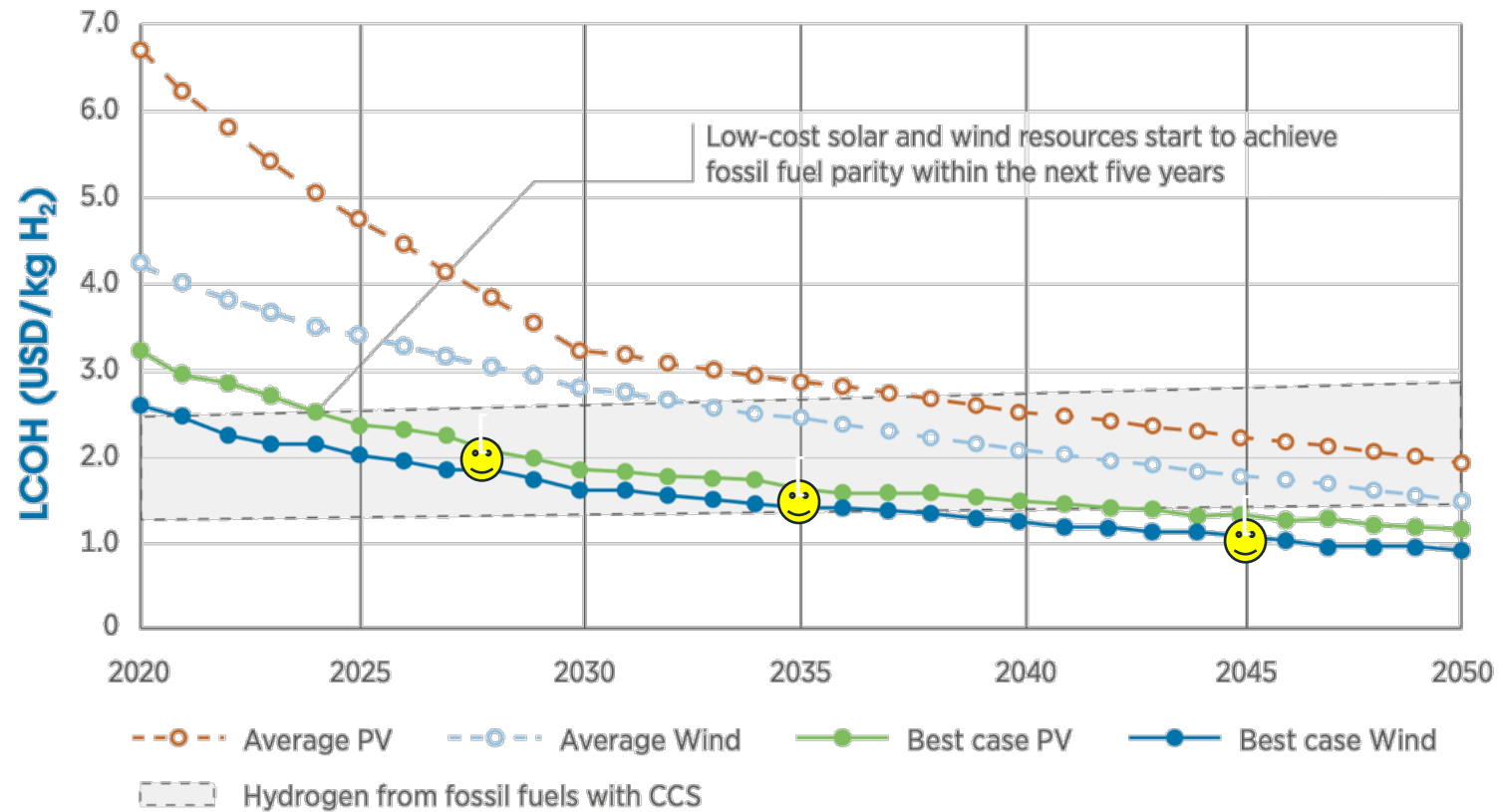
# Green Hydrogen Definition Framework Focuses on the Production Pathway

Each production pathway (outlined below) and application pathway has different carbon and emissions implications that should be evaluated at the program level



# Green hydrogen is commercially viable now and on trajectory for lowest cost

## Hydrogen production costs from solar and wind vs. fossil fuels



Source: IRENA, 2019. *Hydrogen: A Renewable Energy Perspective*. International Renewable Energy Agency (IRENA). [Report](#).



# GHC Focus: Accelerating the green hydrogen economy

## Initiative 1: Intermountain Power Project



Demonstrate an at-scale hydrogen project that enables an affordable and responsible transition  
[www.ghcoalition.org/green-hydrogen-at-scale](http://www.ghcoalition.org/green-hydrogen-at-scale)

## Initiative 2: Western Green Hydrogen Initiative



Achieve a comprehensive regulatory, policy and commercialization roadmap to advance projects at scale  
[www.ghcoalition.org/wghi](http://www.ghcoalition.org/wghi)

## Initiative 3: Regional Demand Aggregation



Enable green hydrogen demand aggregation and ecosystem development for industrial energy & chemical buyers in strategically targeted locations

# Green Hydrogen can repurpose existing infrastructure & jobs

*Source: DNV GL*

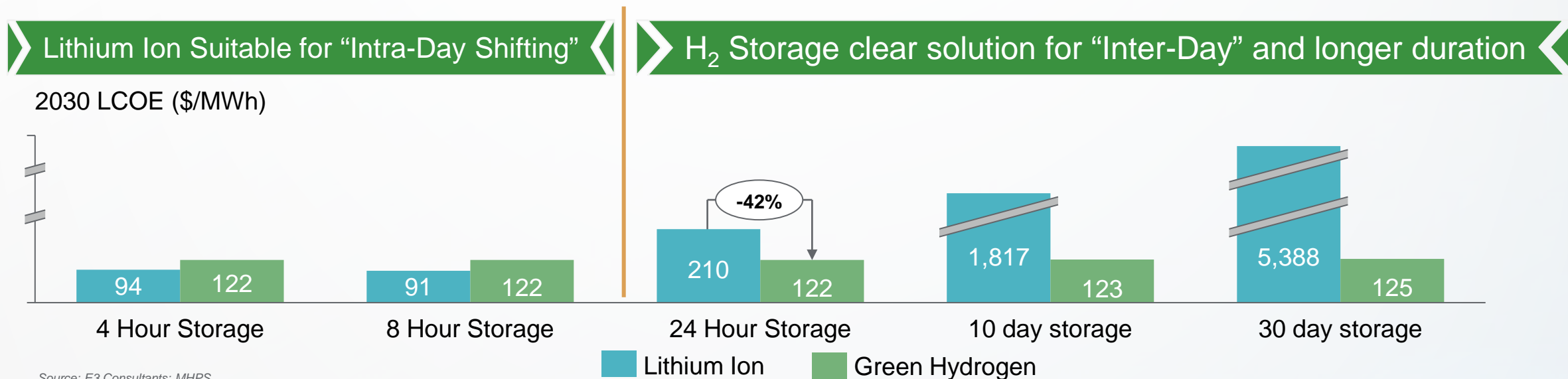


*Source: LADWP*

## Enabling an affordable & responsible transition

# Renewable Energy Storage Alternatives

## Intra-Day Shifting vs. Inter-Day and Seasonal Shifting



### Assumptions

Battery roundtrip efficiency impacted as duration need extends beyond 1-day

MHPS 2019 electrolyzer and H<sub>2</sub> storage cost with learning curve + CCGT

Gas turbine capacity factor: 40%

LCOE includes solar cost



With green H2, we can achieve 100% renewable energy affordably and reliably – at competitive costs with today's wholesale pricing

Group	Variable	Units	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	
Assumptions	Hydrogen %	%	100%	100%	100%	100%	100%	100%	
	Capacity Factor <sup>1</sup>	%	65%	65%	65%	65%	65%	65%	
	Heat Rate <sup>2</sup>	BTU/kWh	6400	6400	6400	6400	6400	6400	
	CC Units <sup>3</sup>	\$/MWh	\$26	\$26	\$26	\$26	\$26	\$26	a
Greenhouse Gas (GHG) Calculation <sup>4</sup>	GHG Cost	\$/metric tons	\$50	\$100	\$50	\$100	\$50	\$100	
	GHG Savings	\$/MWh	(\$17)	(\$34)	(\$17)	(\$34)	(\$17)	(\$34)	b
Hydrogen Calculation	Hydrogen Commodity Cost <sup>5</sup>	\$/kg 🧪	\$1.00	\$1.00	\$1.50	\$1.50	\$2.00	\$2.00	
	Hydrogen Levelized Cost <sup>6</sup>	\$/MWh	\$58	\$58	\$87	\$87	\$116	\$116	c
Renewable Energy <sup>7</sup>	Blended Renewable Energy	\$/MWh	\$7	\$7	\$7	\$7	\$7	\$7	d
BLENDED COST (\$/MWh)		25% x (a+b+c) +75% x (d)	\$22	\$18	\$29	\$25	\$36	\$32	

Dispatchable GH2 costs competitive with peak spot prices

Blended 100% renewable with dispatched GH2 competitive with today's average wholesale prices



# CONTACT:

**Janice Lin**

Founder and President

[jlin@ghcoalition.org](mailto:jlin@ghcoalition.org)

+1 (415) 595-8301



# Appendix





# Is the hydrogen economy finally here?

2000



## New hydrogen buses hit the road

Three buses powered by H<sub>2</sub> are to be introduced on routes in central London as part of a two-year trial



## Fuel Cells Power Up: Three Surprising Places Where Hydrogen Energy Is Working

Hydrogen may not be fueling many cars, but it is delivering clean power for warehouses, data centers, and Telcom towers.



GM and Honda partner to mass produce hydrogen fuel cells in Michigan



## Toyota is pushing ahead with hydrogen-powered cars

Doubling down on its bet that fuel cells will help secure Toyota's future as the industry comes under enormous pressure to slash carbon emissions



## European nations plan to use more hydrogen for energy needs

Energy officials from 25 countries pledged Tuesday to increase research into hydrogen technology and accelerate its everyday use to power factories, drive cars and heat homes.



Initiative Seeks to Fuel Use of Green Hydrogen in West  
The push to develop green hydrogen got a boost with the announcement of a new program to hasten its development for use in the Western Interconnection



Lancaster, CA Becomes the Hydrogen City in the US



## Utility of the Year

NextEra Energy is investing in green hydrogen, solar energy and grid resilience,



## Air Products Plans \$5 Billion Green Fuel Plant in Saudi Arabia

Air Products signed an accord with Saudi-based ACWA Power International and the kingdom's planned futuristic city of Neom to develop a \$5 billion hydrogen-based ammonia plant powered by renewable energy



## Coalition Aims for 25GW of Green Hydrogen by 2026

Seven firms join forces for fiftyfold scale-up of global hydrogen production capacity.

Hydrogen-powered flight

Is the time now ripe for planes to run on hydrogen?



Vestas backs world's first commercial green ammonia plant

Enel teams up on US green hydrogen project

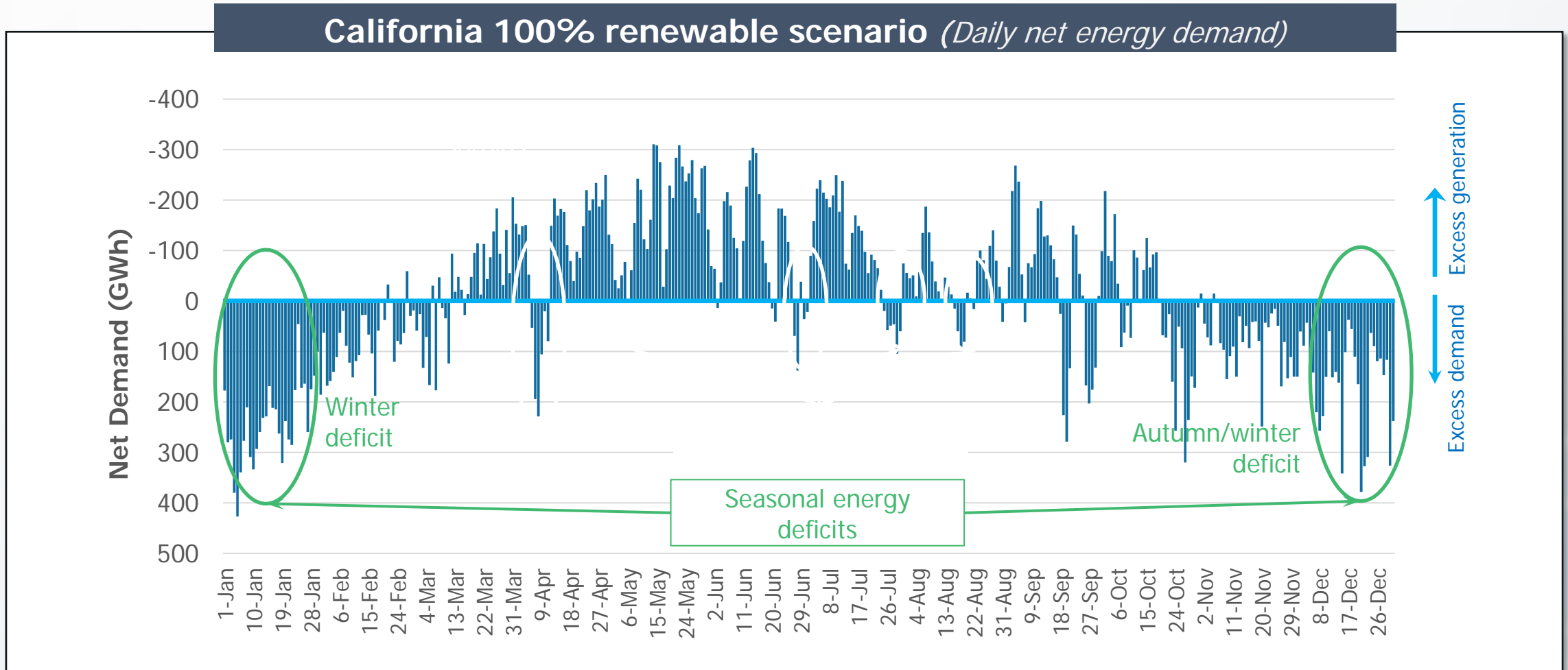


Hydrogen and fuel cells will future-proof shipping

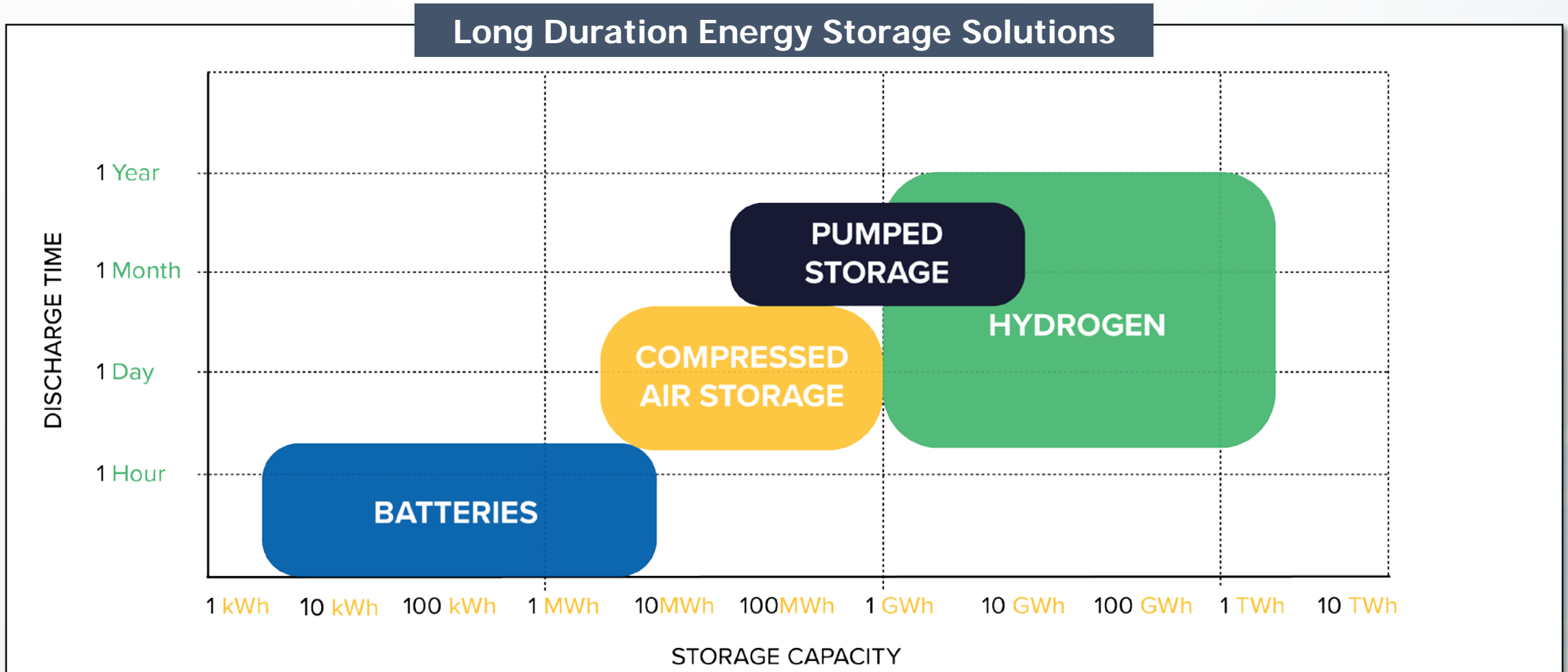
Future Proof Shipping is taking a pioneering step by retrofitting a vessel to run on hydrogen fuel cell propulsion



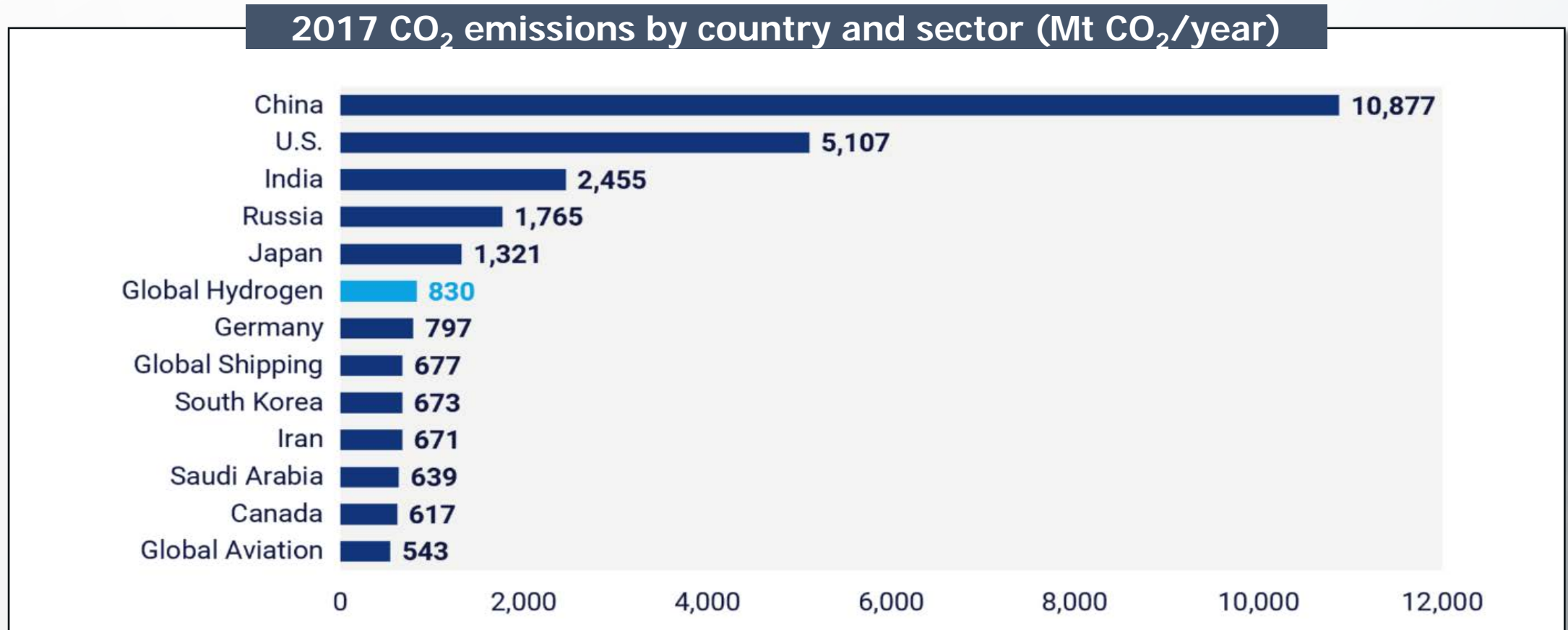
# High intermittent and variable renewable penetration will require multi-day and seasonal energy storage



# Green hydrogen is the only commercially viable seasonal storage solution available today



# Global hydrogen production accounts for 832 Mt CO<sub>2</sub>/year...more than the emissions of Germany



Source: Wood Mackenzie, 2019. "CO<sub>2</sub> and other Greenhouse Gas Emissions

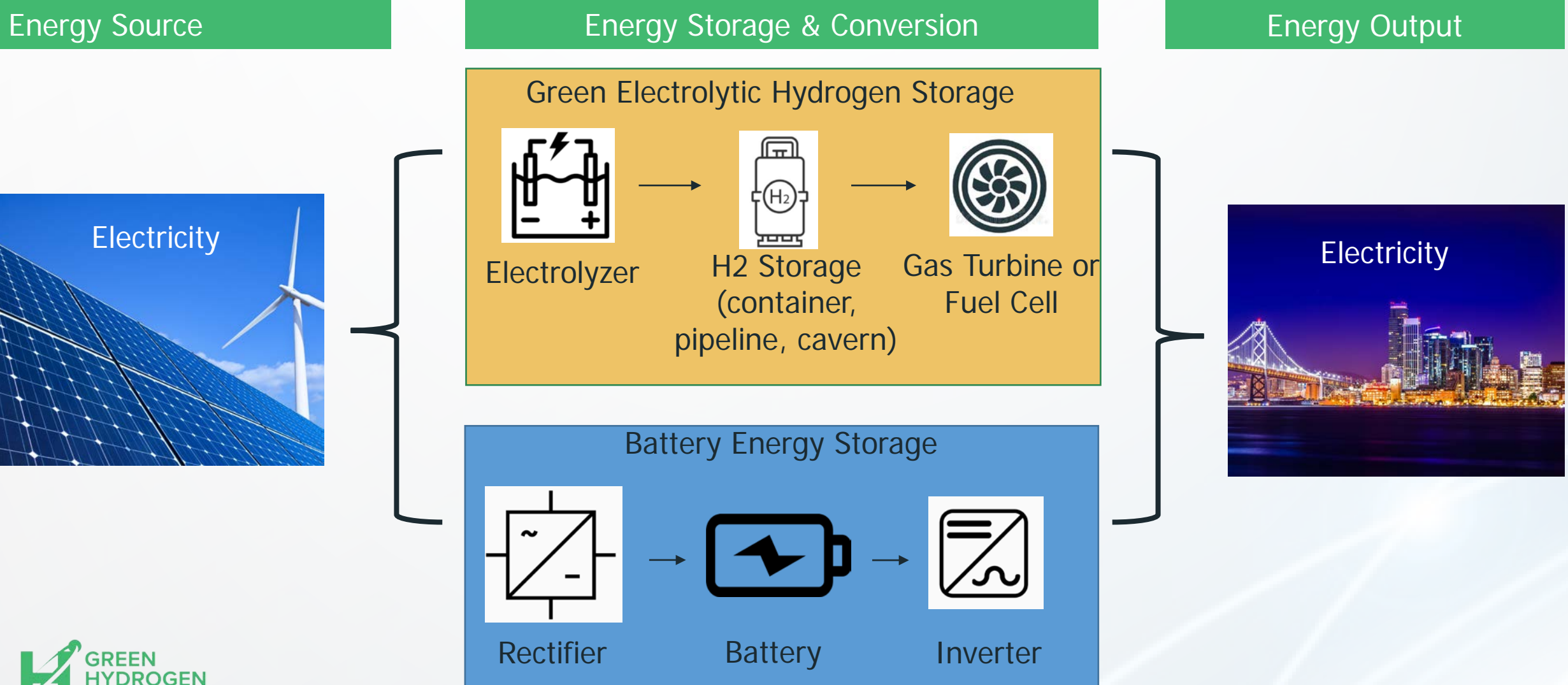


5% Green Hydrogen Blend in CA Natural Gas Pipeline is equivalent to removing 365,000 cars from the road each year!

2*10 <sup>9</sup> MMBtu	Annual natural gas use in CA
106 MMT	CO <sub>2</sub> emissions from annual CA natural gas combustion
1.77 MMT	CO <sub>2</sub> emission reduction from 5% by volume hydrogen blend
4.6 MT	Average annual emissions of one car
384,826 cars	Equivalent annual emissions



# Green electrolytic hydrogen is an excellent storage medium... and unlike batteries can address multi day and seasonal needs





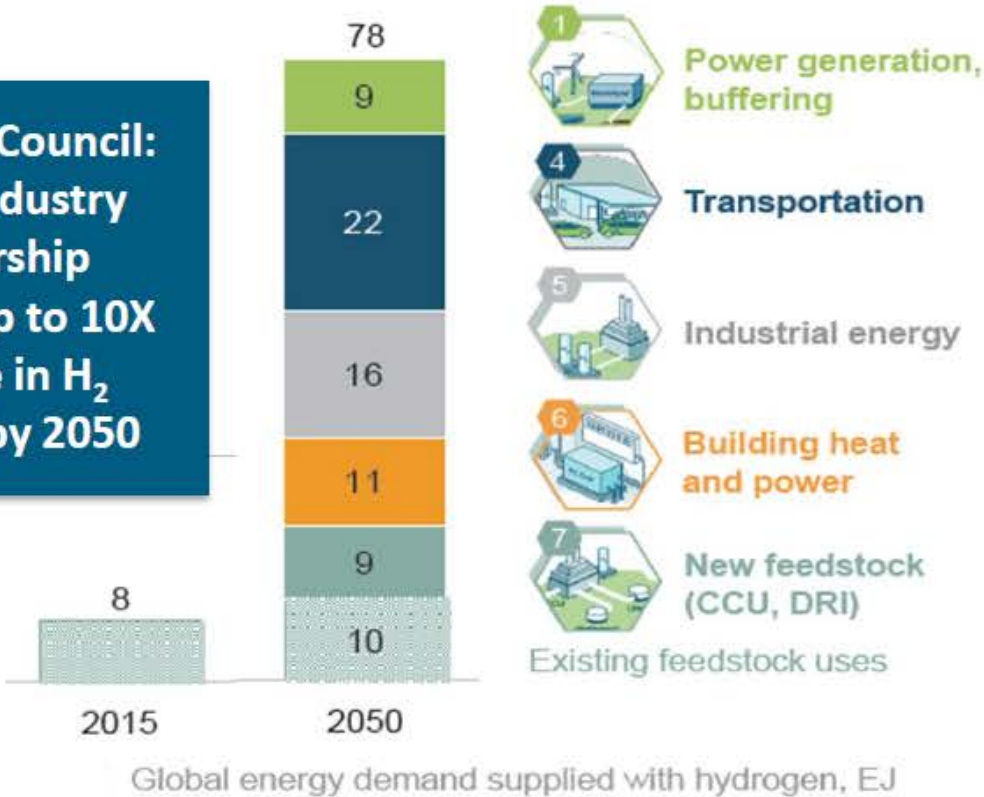
# Roadmaps and plans for green hydrogen are developing worldwide

Source: 2020, Presentation: DOE Hydrogen and Fuel Cell Technologies Office and Global Perspectives, Dr. Sunita Satyapal, Director, Hydrogen and Fuel Cell technologies Office



**H2 Ministerial Global Action Agenda Goals:**  
**“10, 10, 10”**  
**10M systems, 10K stations, 10 years**

**Hydrogen Council:**  
**Global industry partnership projects up to 10X increase in H<sub>2</sub> demand by 2050**



**18%**  
of final energy demand

**6 Gt**  
annual CO<sub>2</sub> abatement

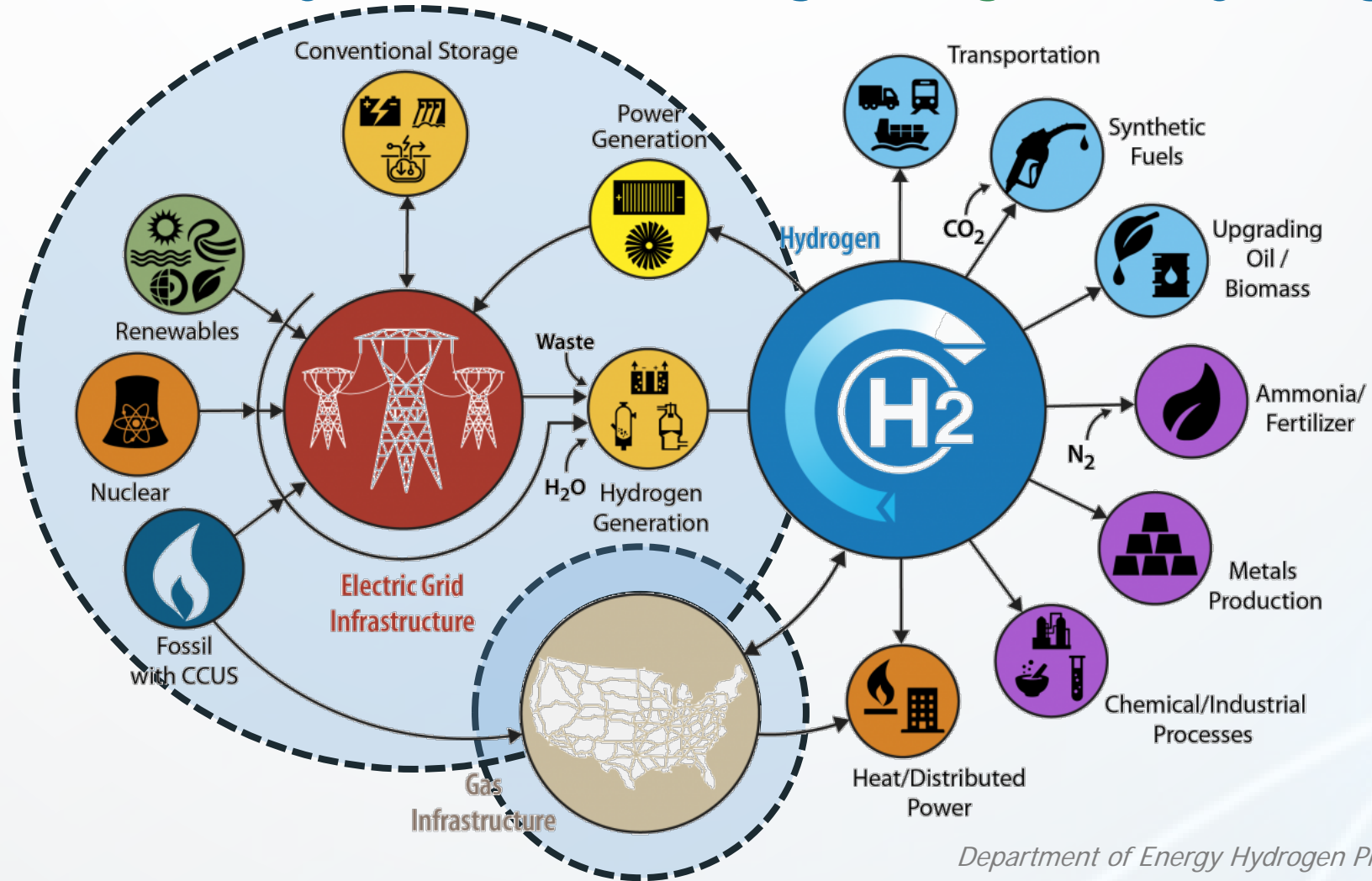
**\$2.5 tr**  
annual sales (hydrogen and equipment)

**30 m**  
jobs created

**H2 Council Global Impact Potential by 2050**

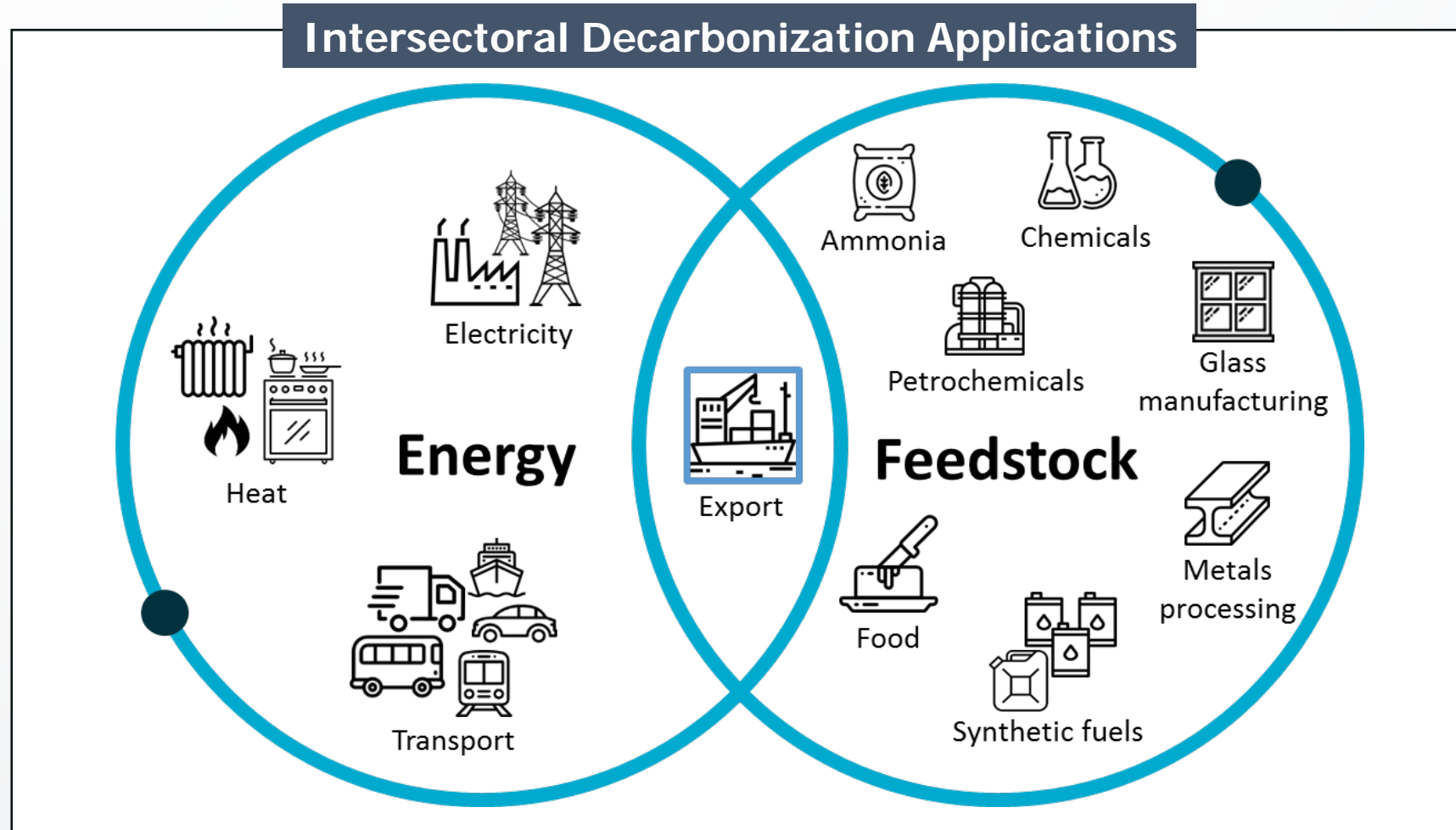


# Regulatory reform of existing gas and electric infrastructure is key to accelerating the green hydrogen economy



Department of Energy Hydrogen Program Plan, 2020

# Green hydrogen can achieve multi-sectoral global decarbonization

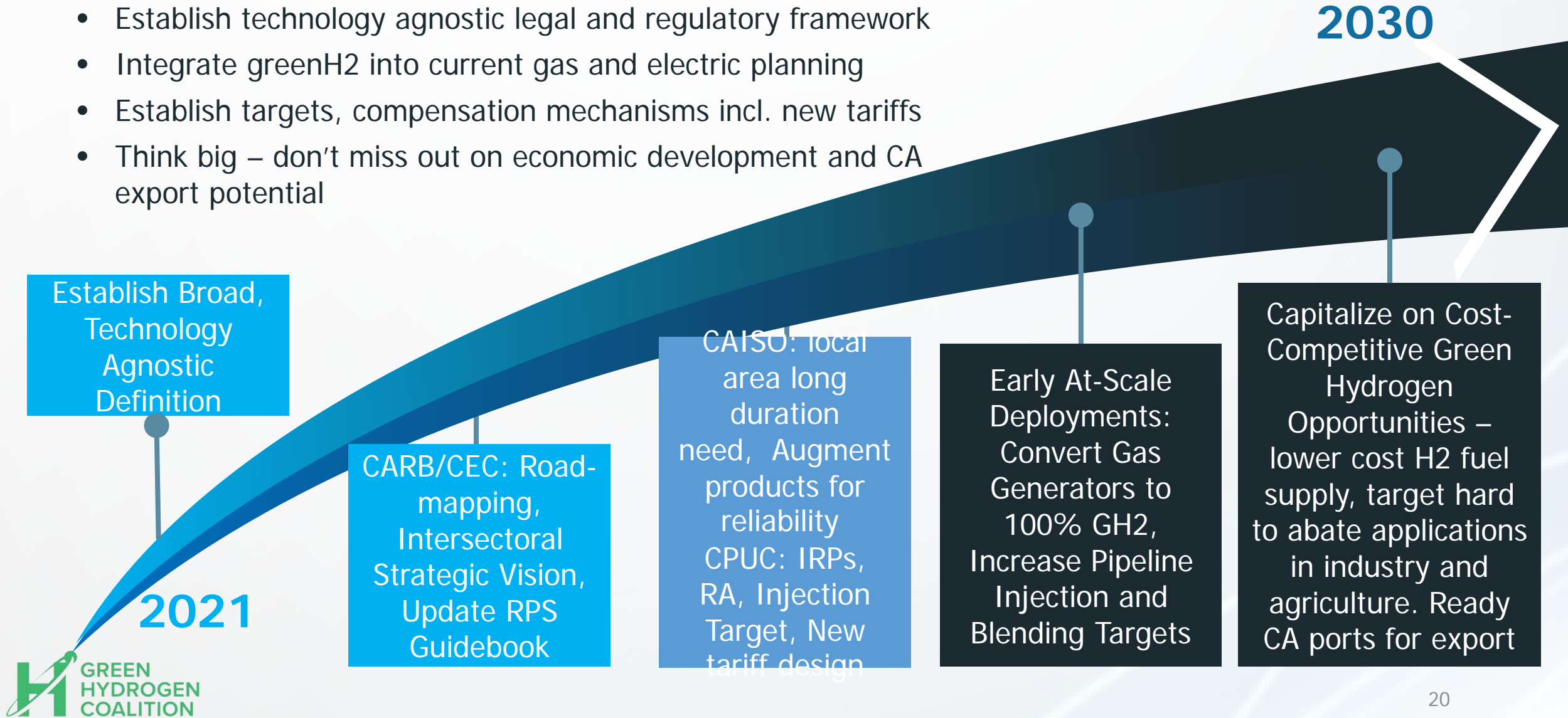


Source: CSIRO, 2018. National Hydrogen Roadmap

# California Greenprint for Action

## California can lead the green hydrogen economy globally

- Establish technology agnostic legal and regulatory framework
- Integrate greenH2 into current gas and electric planning
- Establish targets, compensation mechanisms incl. new tariffs
- Think big – don't miss out on economic development and CA export potential





# Joint Agency Recommendations

## Recommendations for CPUC

- Establish technology agnostic legal and regulatory framework
- Integrate greenH2 into current gas and electric planning
- Establish preference for 'green system RA'
- Establish 5% by volume injection/procurement target for gas pipeline
- Establish necessary new greenH2 injection tariff and electrolytic production tariff
- When upgrading gas pipelines, include modifications to allow higher % of greenH2
- Consider utility ownership of 100% greenH2 pipelines, leveraging existing pipeline right-of-ways


## Recommendations for CAISO

- Inform CA planning decisions regarding long-duration energy needs (H2 combustion or electrolysis) in local areas
- Augment CAISO products to better reflect evolving reliability and renewables integration needs.

## Recommendations for CEC

- Complete proposed "Role of GH2 in a Decarbonized California Study" – consider opportunities for underserved communities
- Integrate greenH2 (procurement and targets) into current long-term gas and electric planning, including future load forecast (electrolytic)
- Update CEC RPS Guidebook to include green hydrogen
- Expand CEC authority to permit Green H2 power plants in CA (in partnership with AQMD)

Plants make fuel from water and sun,  
and so can we



Green hydrogen is the strategic fuel  
for our generation