Beyond Power: Reimagining the Energy Ecosystem With Green Hydrogen

GREEN HYDROGEN COALITION

Prepared for
Shell & EBI Hydrogen Economy Conference
May 13, 2020

STRATEGEN

Presentation objectives

1. Introduce the Green Hydrogen Coalition
2. Explain why green hydrogen is a gamechanger
3. Open pathways for collaboration

Additional leave behind information

1. Recorded GHC webinars: www.ghcoalition.org
2. Overview of Intermountain Power Project
3. Global progress for green hydrogen

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“Climate change is the defining issue of our time – and we are at a defining moment.”

Antonio Guterres
United Nations Secretary General

About the GHC

Mission:

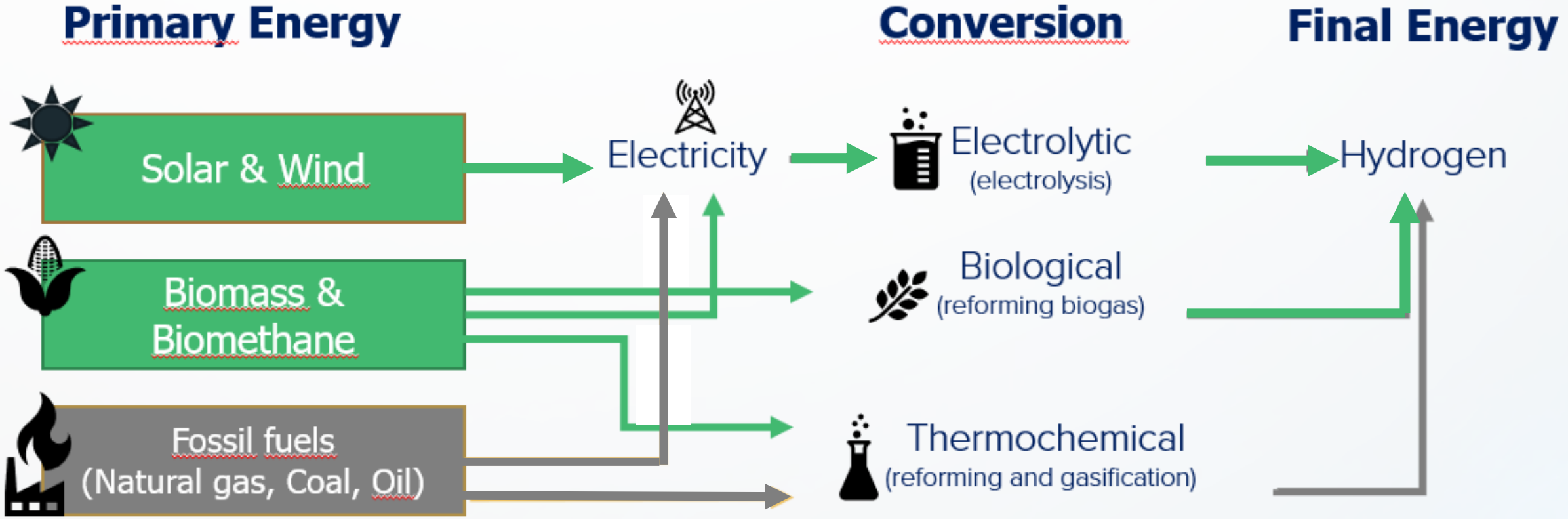
Facilitate policies and practices to advance the production and use of Green Hydrogen in all sectors where it will accelerate a carbon free energy future

Approach:

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

www.ghcoalition.org

There are many ways to make Green Hydrogen…



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What is so special about Green Hydrogen?

Our Thesis:

1. **Green hydrogen is a super gamechanger in our fight against climate change – 'fundamental building block'**
2. **Accelerated adoption is fundamentally a market design challenge: how to achieve production and use at scale**

We Believe:

1. **There are many commercial pathways to safely producing Green hydrogen**
2. **Today, green hydrogen can provide multi-day and seasonal energy storage for the power grid**
3. **Scaling green hydrogen production will enable decarbonization of many sectors including power, shipping and aviation**

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GHC Purpose and Core Values

Purpose:

Accelerate decarbonization to combat climate change

Core Values:

- **Technology and business model neutral**
- **Respectful and constructive collaboration with all stakeholders**
- **Integrity**
- **Safety**
- **Environmental justice**
- **Impact**

Decarbonizes Traded Commodity

Green H_2 can decarbonize today's global hydrogen commodity markets …

Today's Global Hydrogen Value Chains

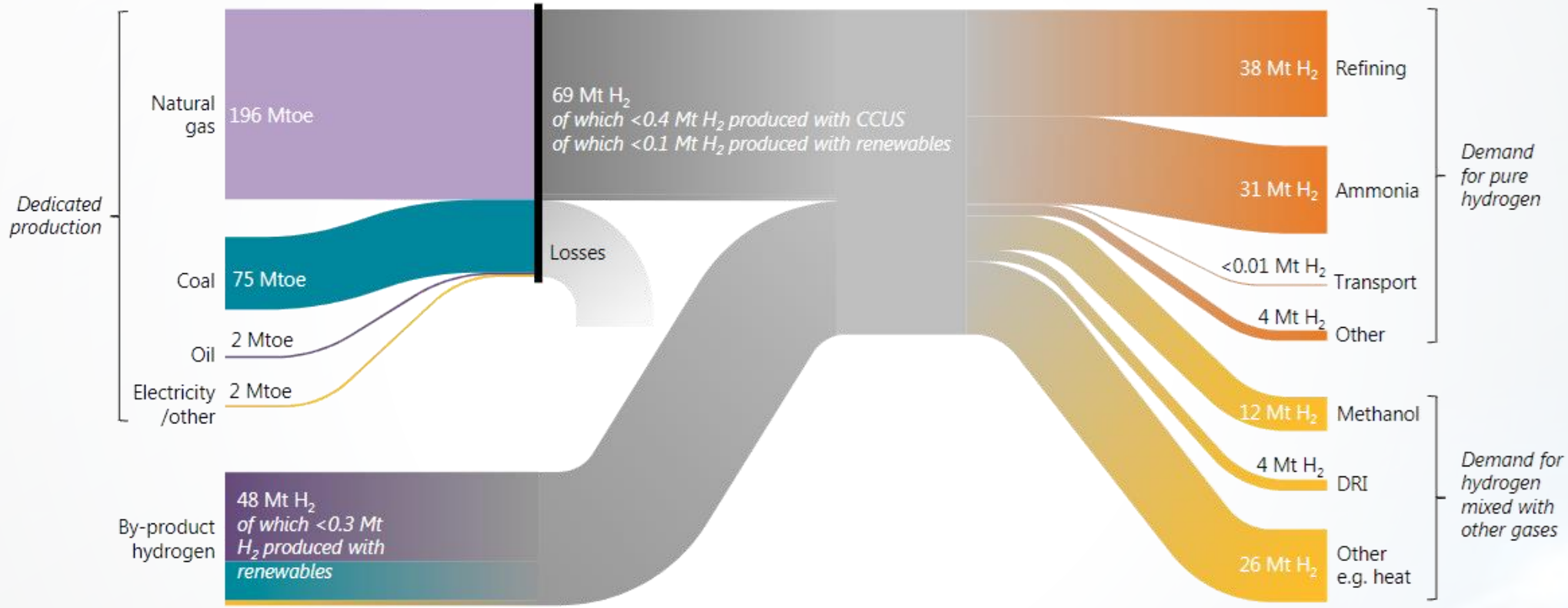

Image from "The Future of Hydrogen: Seizing today's opportunities" report prepared by IEA for the G20, Japan.
Mtoe=million tons of oil equivalent. Mt=million tons

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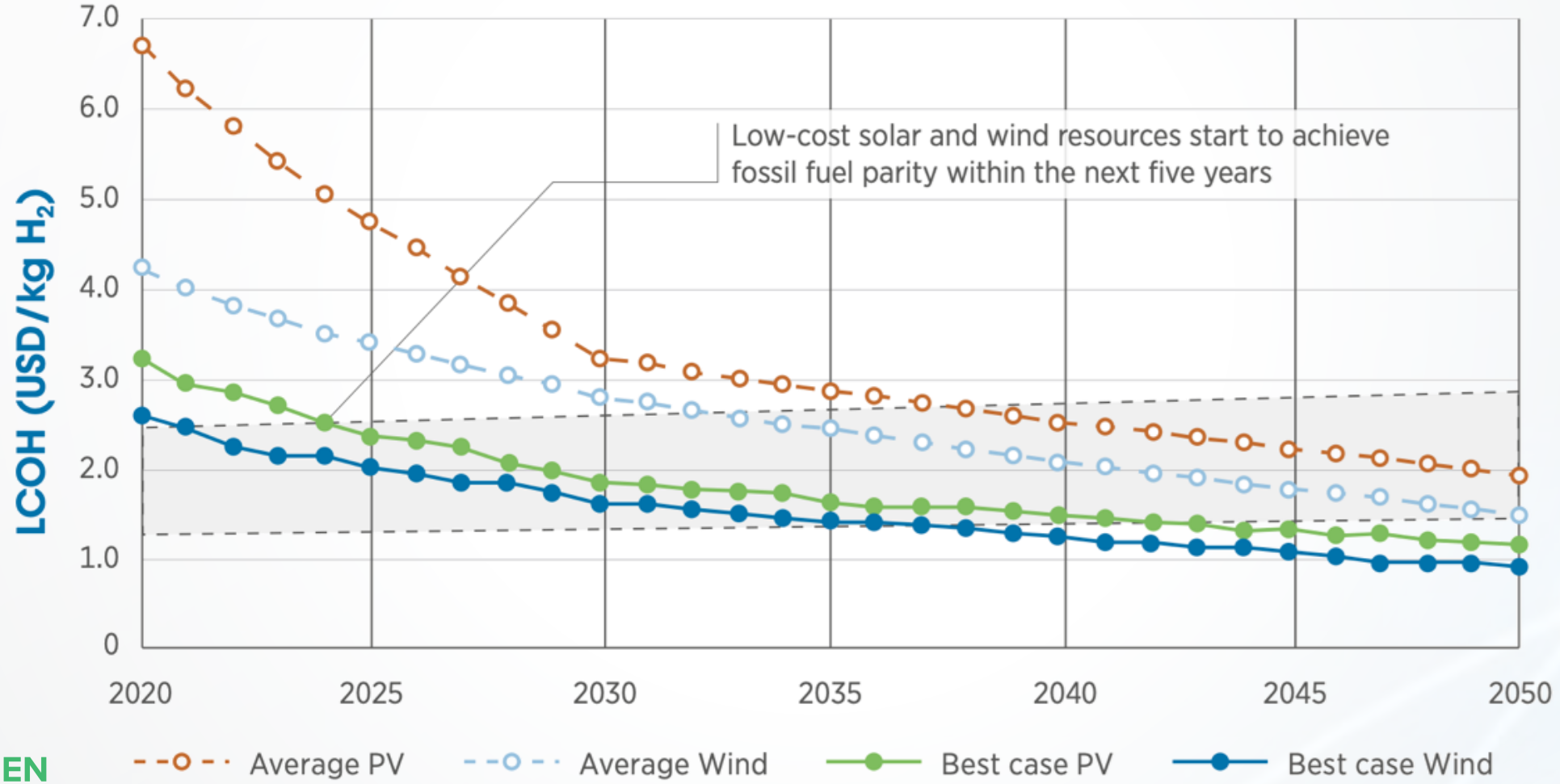
>99% is made from fossil fuels

Commercially Viable

Green H_2 is commercially viable; on trajectory for lowest cost



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•*IRENA, 2019*: Dolf Gielen, Emanuele Taibi and Raul Miranda, 2019. *Hydrogen: A Renewable Energy Perspective.* International Renewable Energy Agency (IRENA). Report.

Repurposes Infrastructure & Jobs

Green Hydrogen (H_2) can repurpose existing infrastructure …

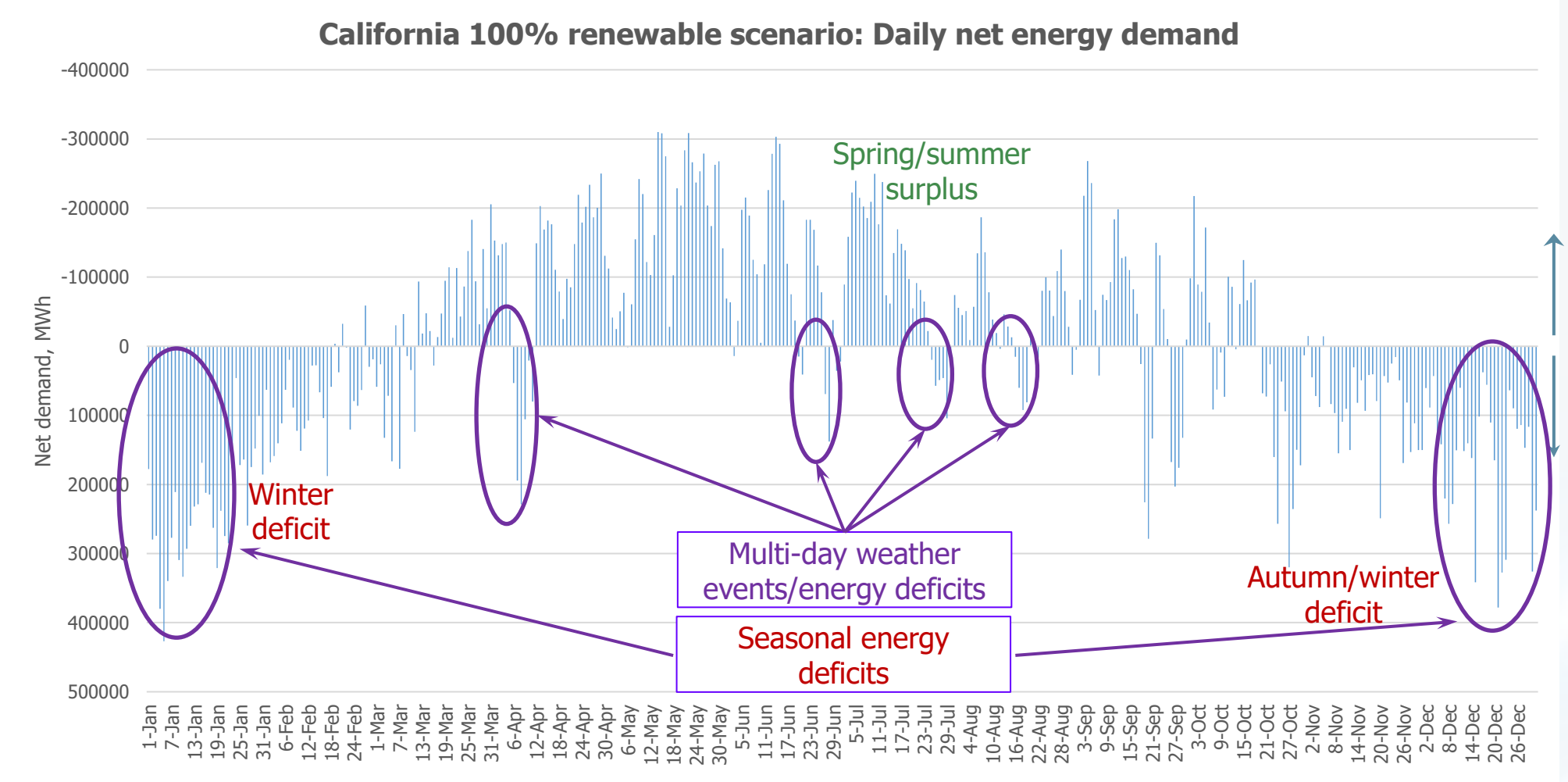
Source: LADWP

…Enabling an affordable & responsible transition

GREEN HYDROGEN COALITION

Achieves 100% Renewables

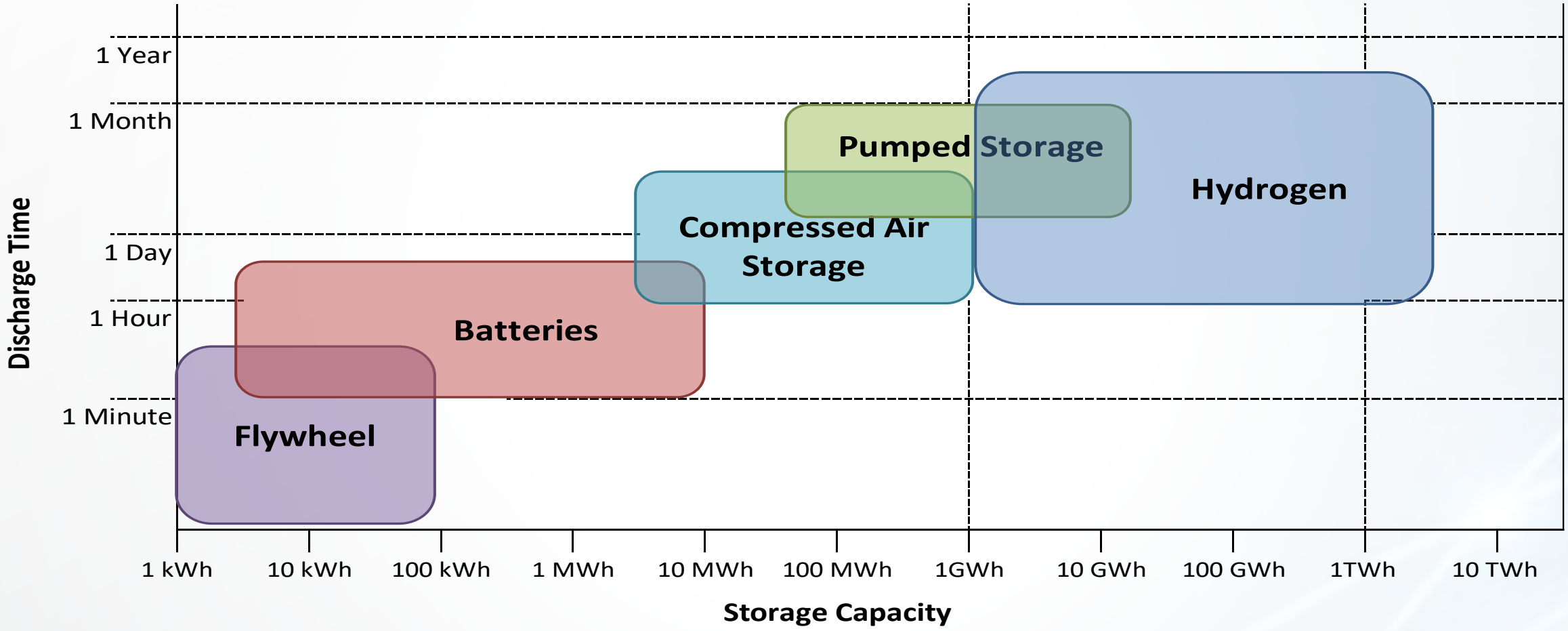
By uniquely providing low cost multi-day and seasonal energy storage



Source: CAISO and Strategen Analysis

Achieves 100% Renewables

Green H_2 is the only commercially viable seasonal storage solution available today



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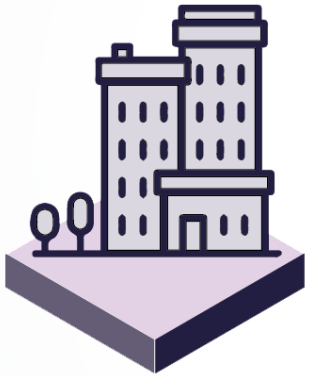
Green Hydrogen has versatile applications

TRANSPORT

POWER



INDUSTY

CHEMICAL

AGRICULTURE

Green Hydrogen has the potential to accelerate multi-sector decarbonization

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GHC's First Initiative: Intermountain Power Plant (IPP)

Convert Large-Scale Thermal Plant to 100% Green Hydrogen & Establish Regional Renewable Reliability Reserve

PROJECT OVERVIEW

Leverage curtailed and low-cost purpose-built wind and solar to produce Green Hydrogen at scale, displacing natural gas at IPP and providing renewable regional reliability (Green Hydrogen stored in purpose-built salt caverns on site)

PROJECT GOALS

1. **Demonstrate large-scale thermal plant conversion to 100% Green Hydrogen**
2. **Leverage IPP project to develop market products & contracting mechanisms to establish a scalable regional renewable reliability reserve for Western US**

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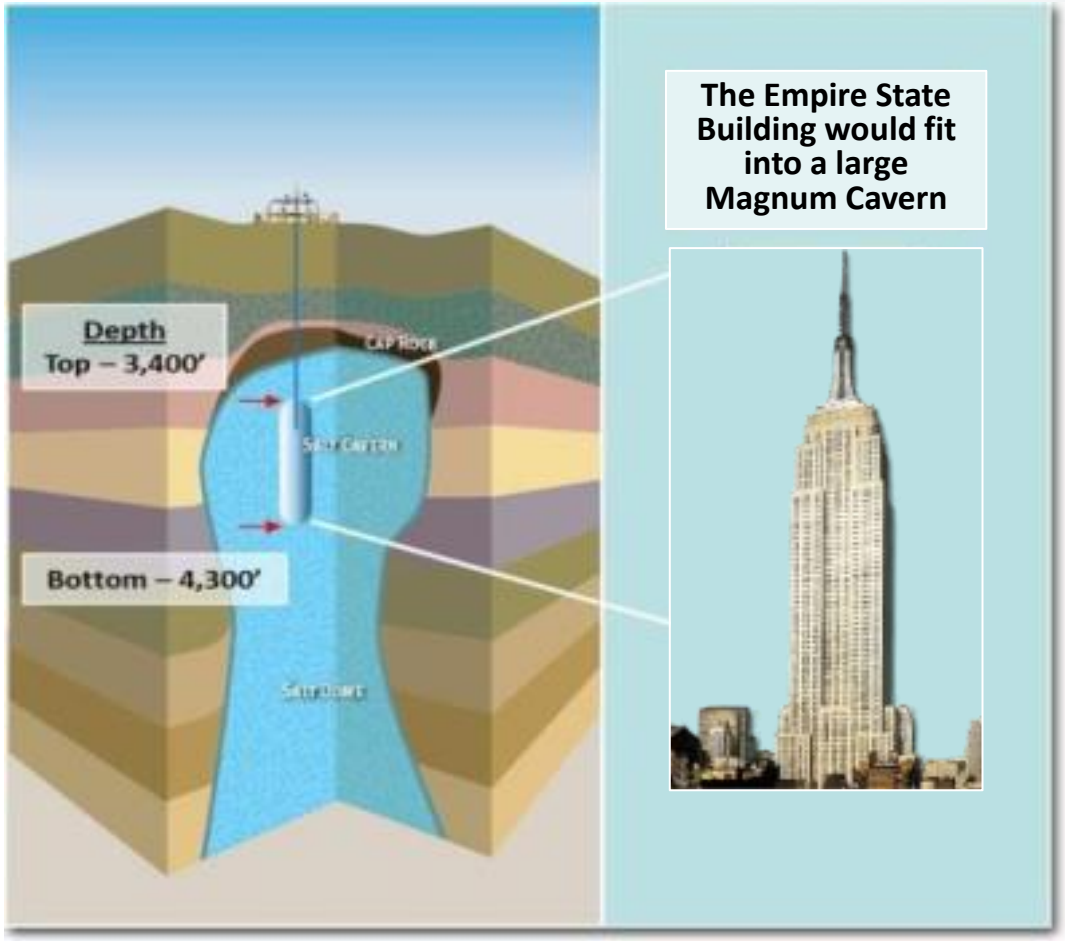
IPP is Sited on Western US Strategic Renewable Reliability Reserve: Hydrogen Storage in Underground Salt Caverns

- A typical cavern size at IPP = 4,000,000 barrels
- 1 cavern = 5,512 tons of H_2 (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 IPP salt dome
- Storing H2 in salt caverns is already done commercially around the world



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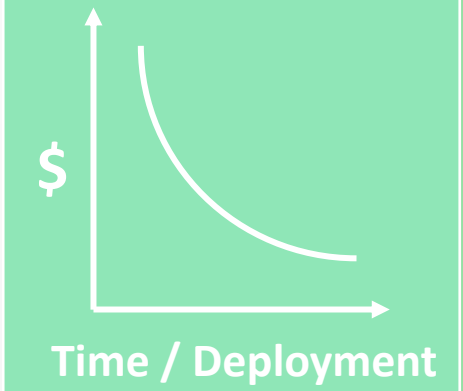
Why Green Hydrogen is a Super Gamechanger

Commercially Viable



Repurposes Infrastructure & Jobs

Decarbonizes Globally Traded Commodity

Decarbonizes Many Sectors

Achieves 100% Renewable Energy Affordably, Flexibly, & Reliably

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Regulatory innovation is the KEY to accelerating and unlocking the potential of green hydrogen

A NEW PARADIGM IS NEEDED

- System-wide transformation
- Planning across sectors
- Valuing benefits, not just costs!

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Infrastructure planning and regional market design must recognize and compensate the value provided by green hydrogen

Market design

+

Capital + Infrastructure Investment

=

Progress + Impact (and more innovation)

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GHC will address key barriers…

- Build broad stakeholder support for green hydrogen use cases
- Establish planning, evaluation & procurement framework for the costs/benefits of green hydrogen, including use cases that span jurisdictions
- Reduce the cost of physically moving green hydrogen from supply sources to demand centers
- Establish pricing, emissions benefits accounting and development of new market products for green hydrogen production and uses

…that span jurisdictions

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Importance of Leadership Alignment and Learning By Doing – California Energy Storage Regulatory Innovation Example

2009

Governor Jerry Brown sees need for energy storage as part of high renewable future – sponsors AB 2514

2010

Assembly member Nancy Skinner authors AB 2514, despite strong opposition bill was signed into law

2011

CPUC implements the bill via Storage Rulemaking, under Carla's leadership

Multi stakeholder process

2013

1,325 GW Storage mandate adopted

Historic SCE LCR procurement

261 MW

Case Study #1

2014

First Biennial ES RFO procurements

10 MW+

2016

Multiple procurements in second biennial ES RFOs and preferred resource RFOs

PG&E (165 MW)

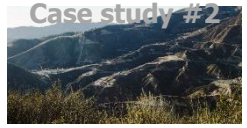
SCE (115 MW)

SDG&E (83.5 MW)

2017

Aliso Canyon procurement 104.5 MW installed + commissioned < 8 months

Case study #2



California Department of Emergency Services

2018

MUA decision

Calpine gets cold feet over proposed California gas plant, Utility Dive, 2018

PG&E Moorpark Calpine RMR procurement

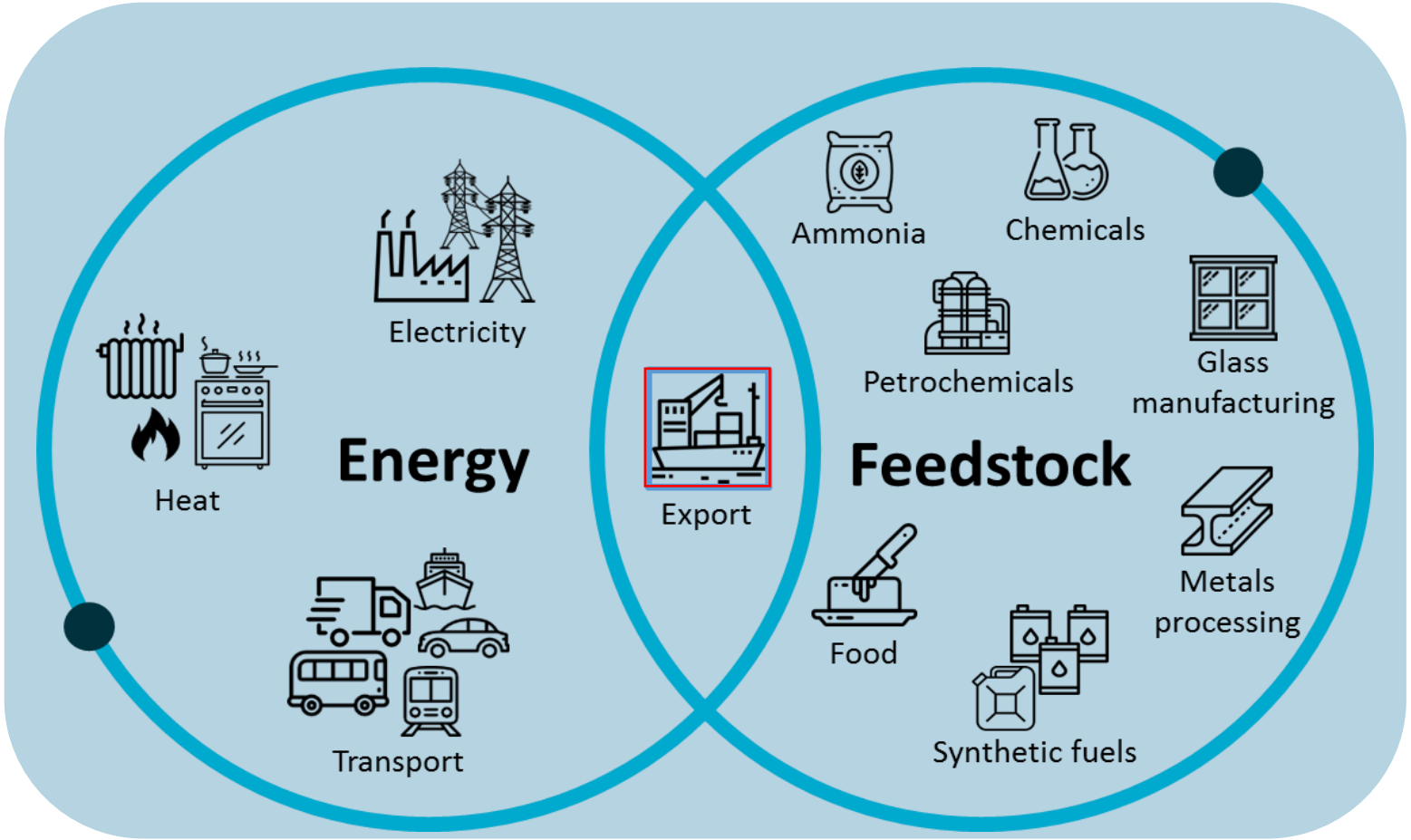
567.5 MW

Case study #3

Future

Leadership Imperative for Green Hydrogen

How to drive progress *across* sectors in CA?



Source: CSIRO

GHC Reco: CARB-led multi-agency task force

GHC has a different approach than other hydrogen-focused organizations…

1. The GHC is an educational and advocacy non-profit with a focus on building top-down momentum for Green Hydrogen
2. The GHC will leverage multi-sectoral opportunities to concurrently scale production and demand for Green Hydrogen.
3. The GHC will facilitate policies and practices to create compensation pathways and other market mechanisms to enable Green Hydrogen project development that spans multiple sectors
4. The GHC will have a global focus, demonstrating the technical and business feasibility of Green Hydrogen for domestic use and as a valuable export commodity

…and is committed to working collaboratively with all stakeholders

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GHC Membership

Leadership Circle

8minute Solar Energy

Intersect Power

LA DWP Los Angeles Department of Water & Power

MAGNUM Development

MHPS

Visionary Circle

SoCalGas
A Sempra Energy utility®

Champion Circle

Bloomenergy®

PHOTOSOL US

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GHC Advisory Committee

MARTIN ADAMS

- General Manager & Chief Engineer at the LADWP

TOM BUTTGENBACH

- President & CEO of 8minute Solar Energy

SHELDON KIMBER

- CEO & Founder of Intersect Power

ROB WEBSTER

- Co-Founder & Chief Strategy Officer of Magnum Development

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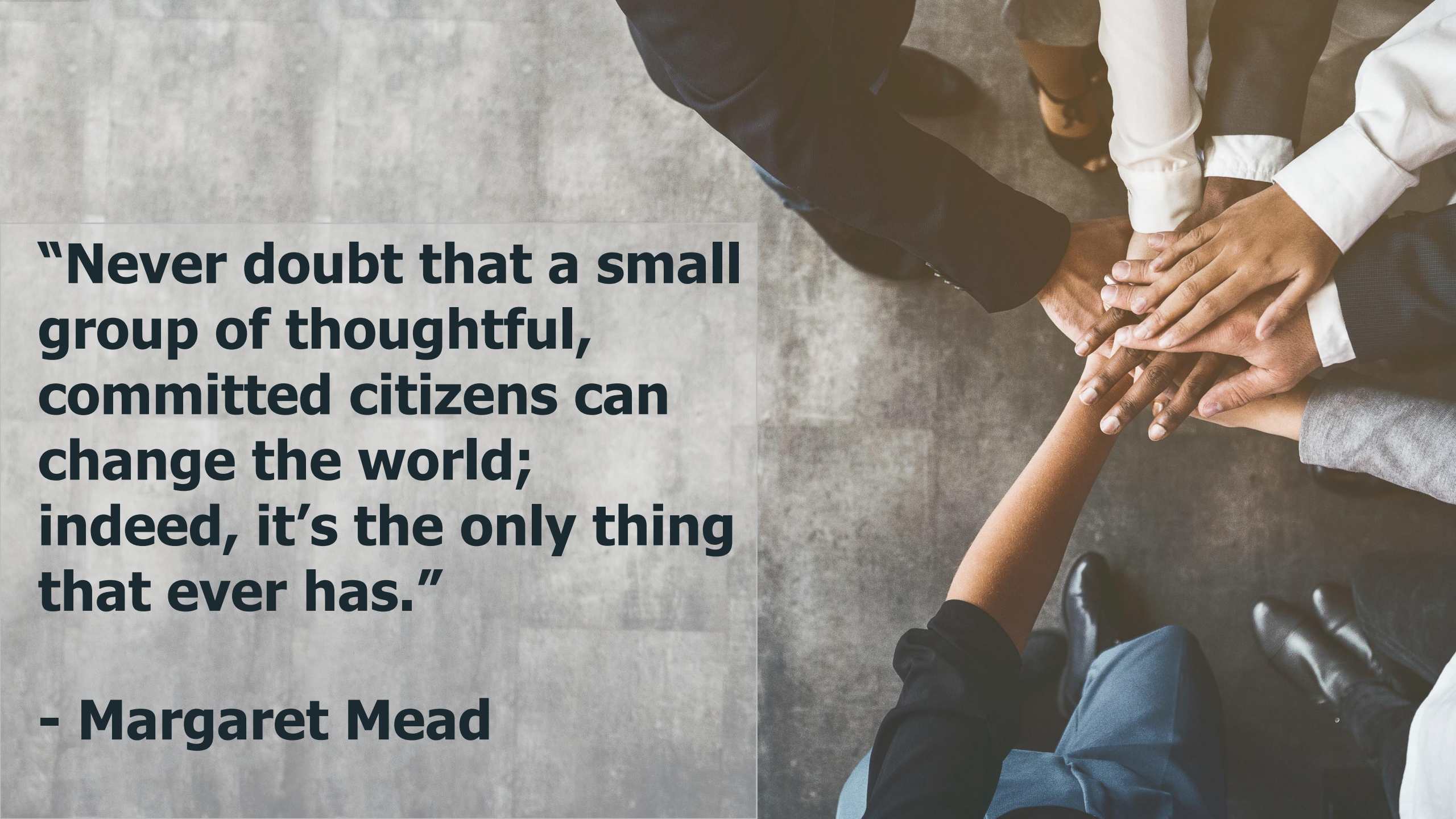
“Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it’s the only thing that ever has.”
- Margaret Mead

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APPENDIX

- Webinars and Events
- Global Drivers for Green Hydrogen
- Global Green Hydrogen Projects
- The Intermountain Power Project (IPP)

STRATEGEN WEBINARS

FREE WEBINAR

RE-IMAGINING THE ENERGY ECOSYSTEM WITH GREEN HYDROGEN

www.ghcoalition.org

APRIL 14

11:00 AM (PT)

STRATEGEN WEBINARS

PAUL BROWNING
CEO MHPS AMERICAS

THIERRY LEPERCQ
CEO OF SOLADVENT

FREE WEBINAR

GLOBAL PROGRESS AND MOMENTUM FOR GREEN HYDROGEN

www.ghcoalition.org

MAY 12

10:00 AM (PT)

HYDROGEN COALITION

VIRTUAL CONFERENCE

CONNECTING THE ENERGY STORAGE INDUSTRY

THURSDAY, MAY 21, 2020

FREE & PUBLIC

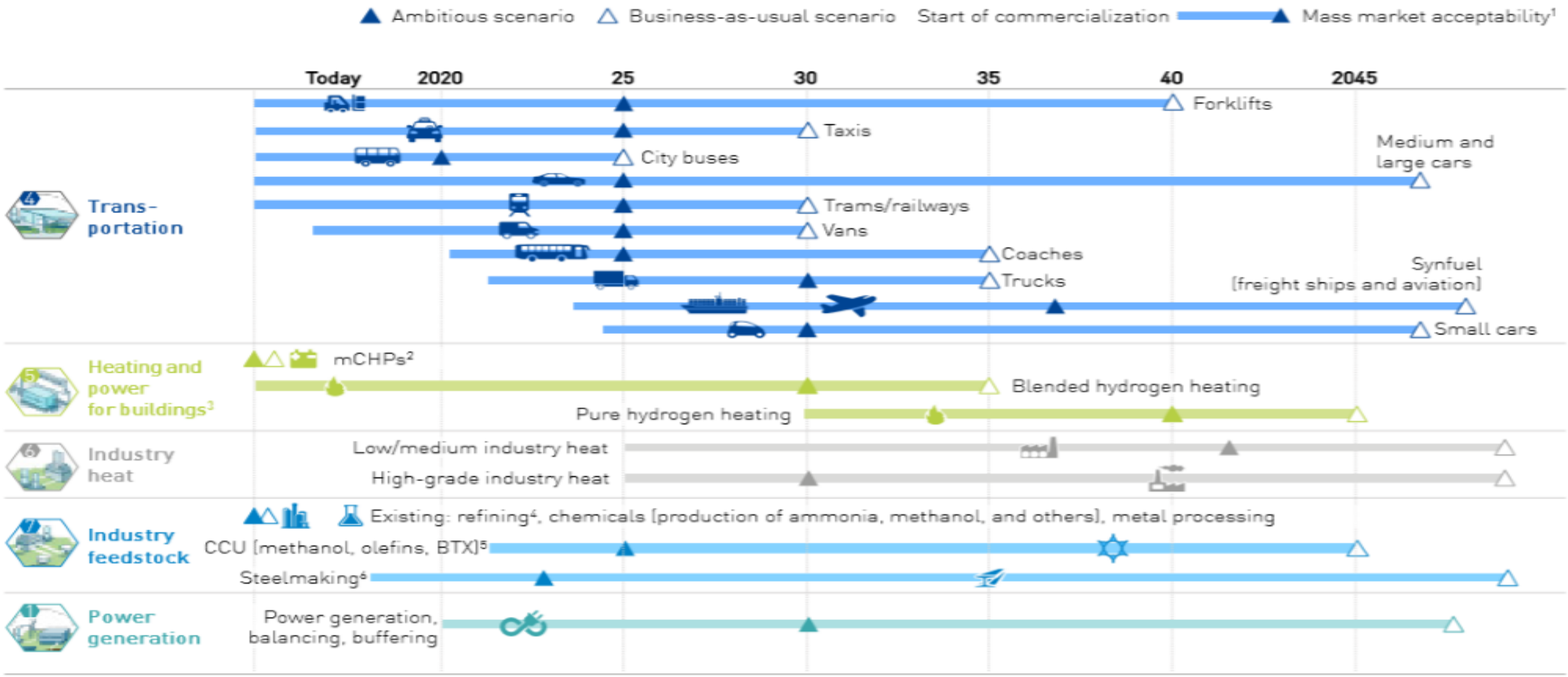
CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Long Duration Energy Storage · Energy Storage Grid Modeling Tools · Lithium Ion 101 · Artificial Intelligence

REGISTER: www.storagealliance.org/virtual-conference

Global Drivers for Green Hydrogen:
A Roadmap to 100% Clean Energy

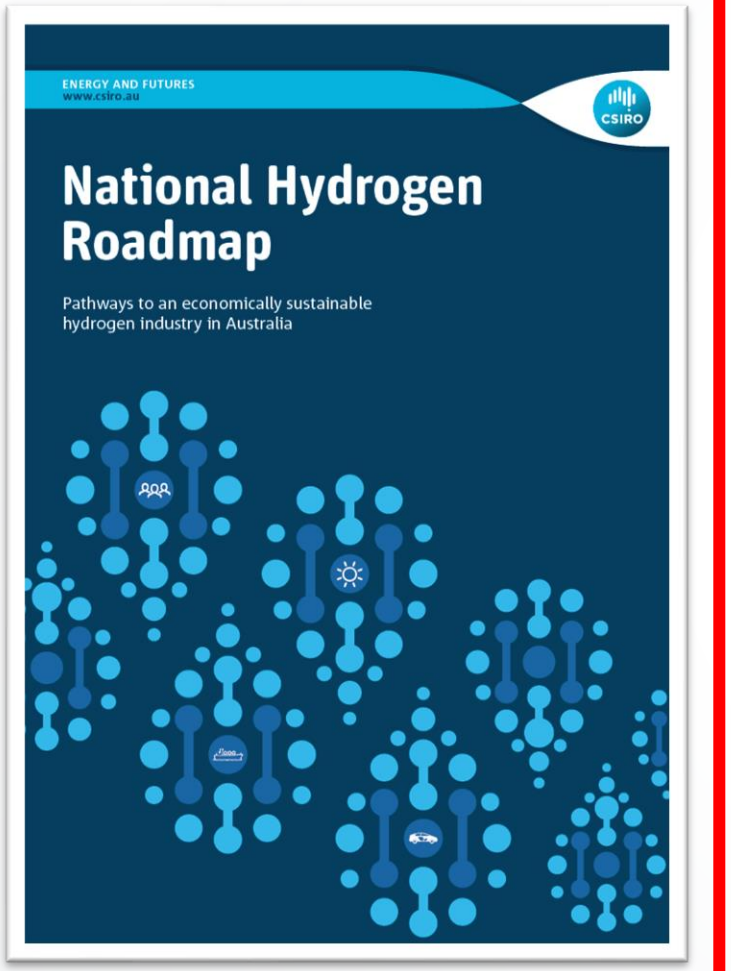
EXHIBIT 20: HYDROGEN TECHNOLOGY EXISTS AND IS READY FOR DEPLOYMENT

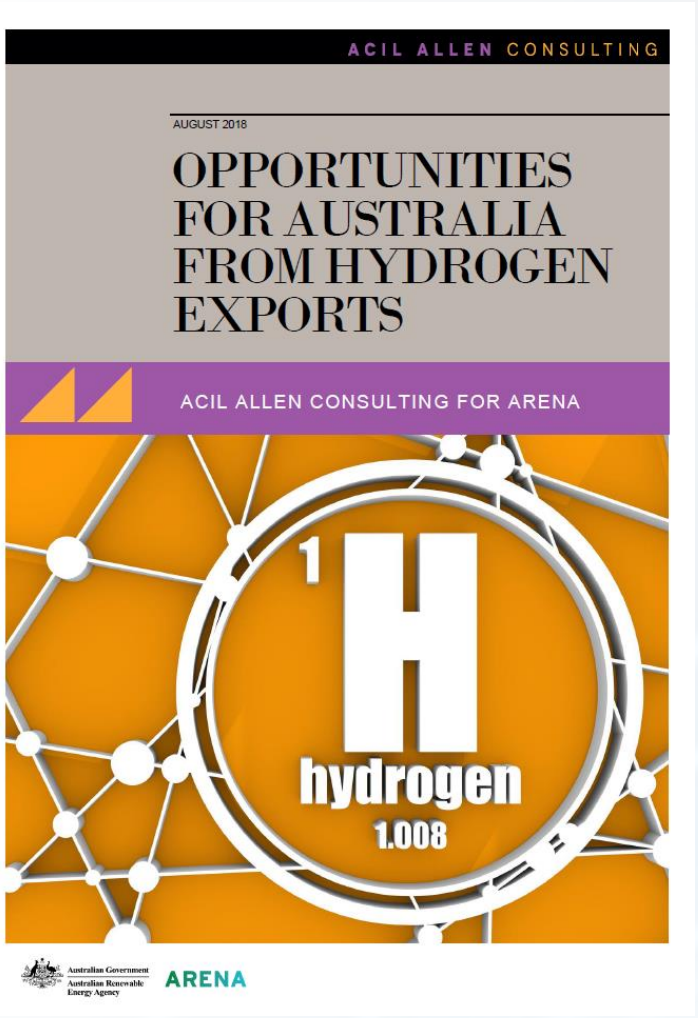


1 Defined as sales >1% within segment 2 mCHPs sales in EU independent of fuel type (NG or H_2) 3 Pure and blended H_2 refer to shares in total heating demand
4 Refining includes hydrocracking, hydrotreating, biorefinery 5 Market share refers to the amount of production that uses hydrogen and captured carbon to replace feedstock 6 CDA process and DRI with green H_2, iron reduction in blast furnaces, and other low-carbon steelmaking processes using H_2

Source: Hydrogen Roadmap Europe 2019

Global Drivers for Green Hydrogen:
Jobs and Economic Development Opportunity





Source: CSIRO Energy

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May 2019: Heide Oil Refinery in Germany - Westkust 100 700MW off-shore wind electrolysis project

- **Description:**
  - Green hydrogen production from offshore wind energy to produce aviation fuel
- **Project Plan:**
  - 2019 – Proposal to Federal Ministry of Economics
    - Initial: 30 MW electrolysis plant to gather information on operation, control
    - Scale-up: 700MW electrolysis plant
- **Goal:**
  - Continuous stream of green hydrogen for industrial use

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https://www.heiderefinery.com/en/press/press-detail/cross-sector-partnership-green-hydrogen-and-decarbonization-on-an-industrial-scale/

November 2019: World's largest green-hydrogen steel plant began operation in Austria - 6MW renewable electrolysis project

- **Description:**
  - Researching the industrial production of green hydrogen as a means of replacing fossil fuels in steel production over the long term.
- **Project Plan:**
  - Built in 2019, currently in operation
- **Goal:**
  - Test whether green hydrogen is suitable for industrial-scale use in the steel industry, refineries, and other industrial sectors requiring large volumes of hydrogen

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https://www.powerengineeringint.com/2019/11/19/worlds-largest-green-hydrogen-pilot-begins-operation-in-austria/

January 2020: Belgium, Port of Oostende 4 GW

- **Description:**
  - Plant that produces green hydrogen from the electricity produced at Belgium's offshore wind farms
- **Project Plan:**
  - 2020 – Demonstration phase with shore-based power, 2.26 GW wind
  - 2025 – Commercial green hydrogen plant completed, 4MW off-shore wind
- **Goal:**
  - CO_2 reduction of 500,000-1,000,000 tons/year

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https://www.offshorewind.biz/2020/01/27/deme-oostende-port-and-pmv-launch-offshore-wind-to-hydrogen-project/

January 2020: Canada Chetwynd Hydrogen 3% pipeline injection

- **Description:**
  - Coupled electrolysis plant and wind farm to produce green hydrogen to inject into natural gas pipelines at 3% concentration
- **Project Plan:**
  - Build dedicated wind farm as well as the electrolysis plant
  - Negotiate agreement to inject hydrogen into natural gas pipeline
- **Goal:**
  - 22,000 tons green hydrogen produced/year

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https://fuelcellsworks.com/news/canada-macquarie-capital-to-finance-new-200-plus-million-renewable-hydrogen-plant-in-chetwynd

February 2020: Netherlands NortH2 Project 10 GW

- **Description:**
  - Shell plans to have 10GW of turbines off the Netherlands coast to power green hydrogen production
- **Project Plan:**
  - 2027 – start with 3-4 GW
  - 2040 – 10 GW target
- **Goal**:
  - 800,000 tons of green H2 produced/year

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https://www.rechargenews.com/wind/shell-unveils-worlds-largest-offshore-wind-plan-to-power-green-hydrogen/2-1-763610

May 2020: Infinite Blue Energy secures $300 million for largest green hydrogen project in Western Australia

Description:

- The Arrowsmith Hydrogen Project will produce 25 tons of green hydrogen daily using wind and solar energy
- This project will reduce CO2 emissions by 78,000 tons annually

Project Plan:

- Construction start date by mid 2020
- Operational by 2022

Goal

- Part I of a series of green hydrogen installations in Australia by Infinite Blue Energy
- Develop export market for green hydrogen, specifically targeting Japan and South Korea

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GHC Priority #1:
Conversion of Intermountain Power Project (IPP)

IPP History and Plan

- Located in Delta, Utah
- Two coal-fired units operating since 1986 with 1,800 MW net capacity
- Two Transmission Systems:
  - STS To Southern California
    2400 MW HVDC System
  - NTS To Utah & Nevada
  - Interconnected to 370MW of Wind Generation
- 35 Project Participants, 6 from Southern California
- Coal Units to be retired by 2025; IPP conversion to 840 MW natural gas combined cycle gas facility
- Day 1: run on 30% blend of green hydrogen ramping up to 100% over time

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Hydrogen-Fired Generation

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

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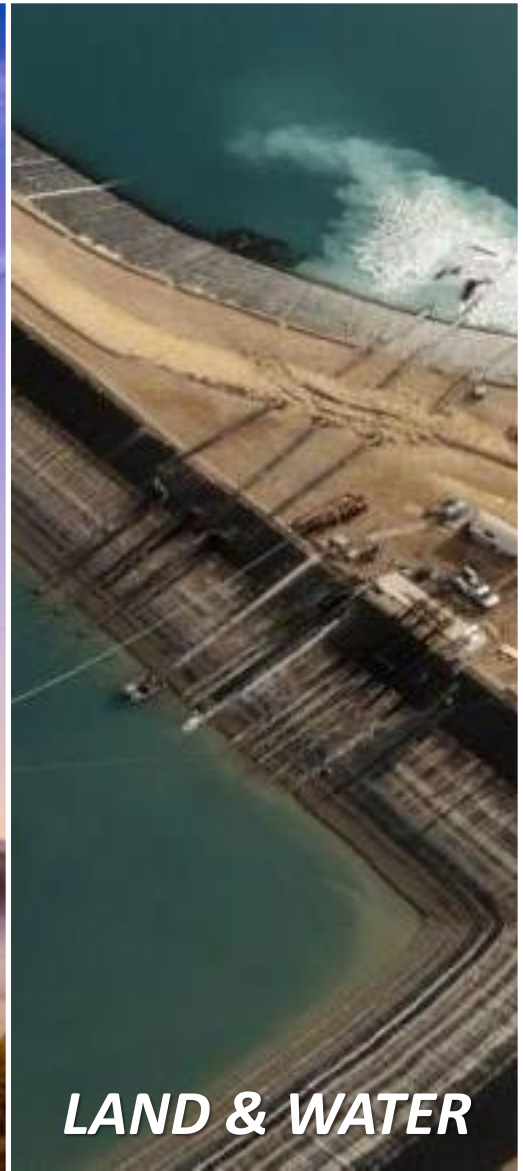
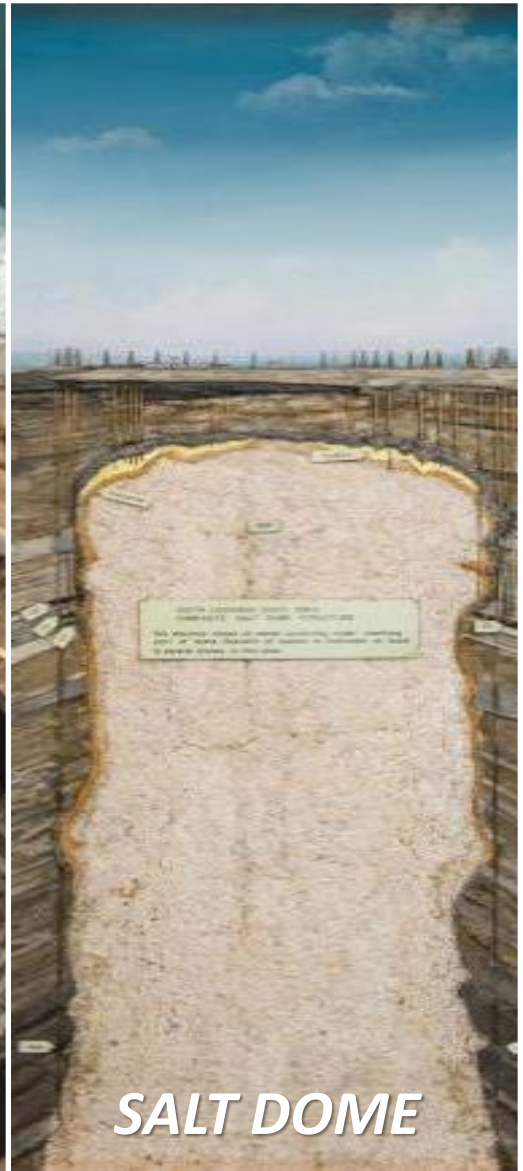
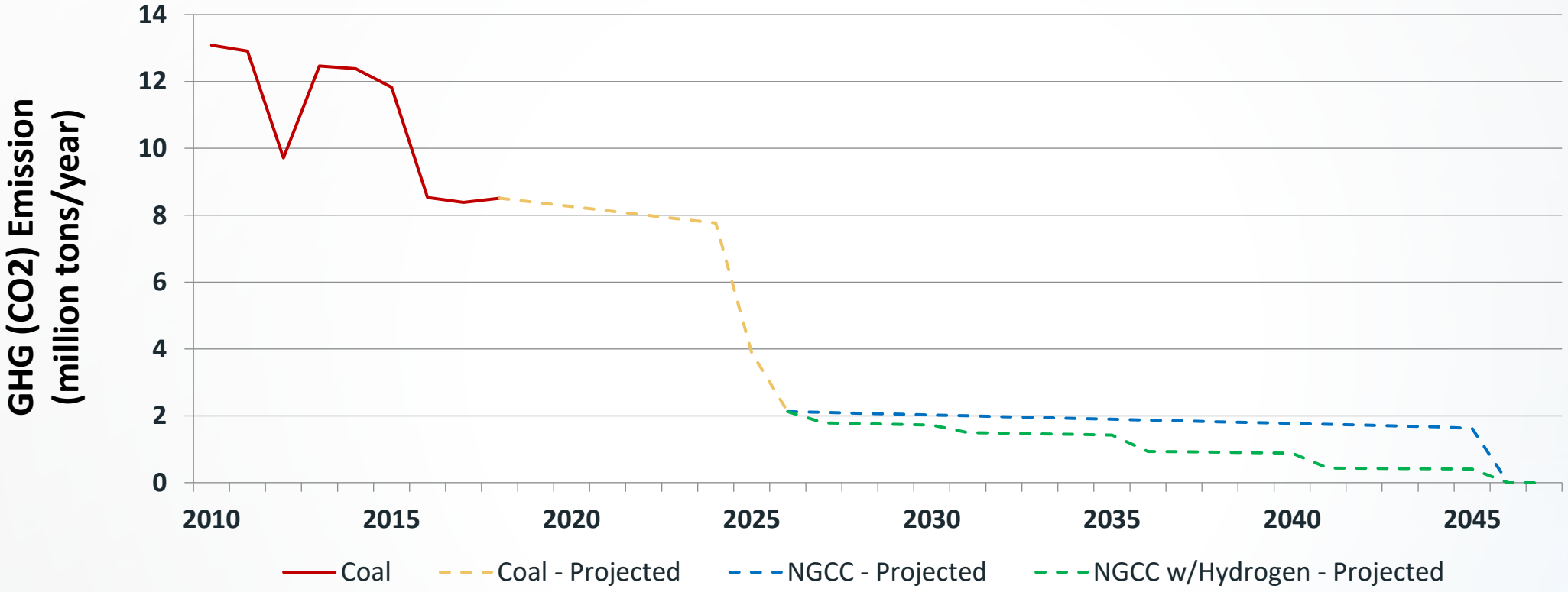
Unlocking IPP Green H_2 Potential





IPP Emissions Reduction Profile



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

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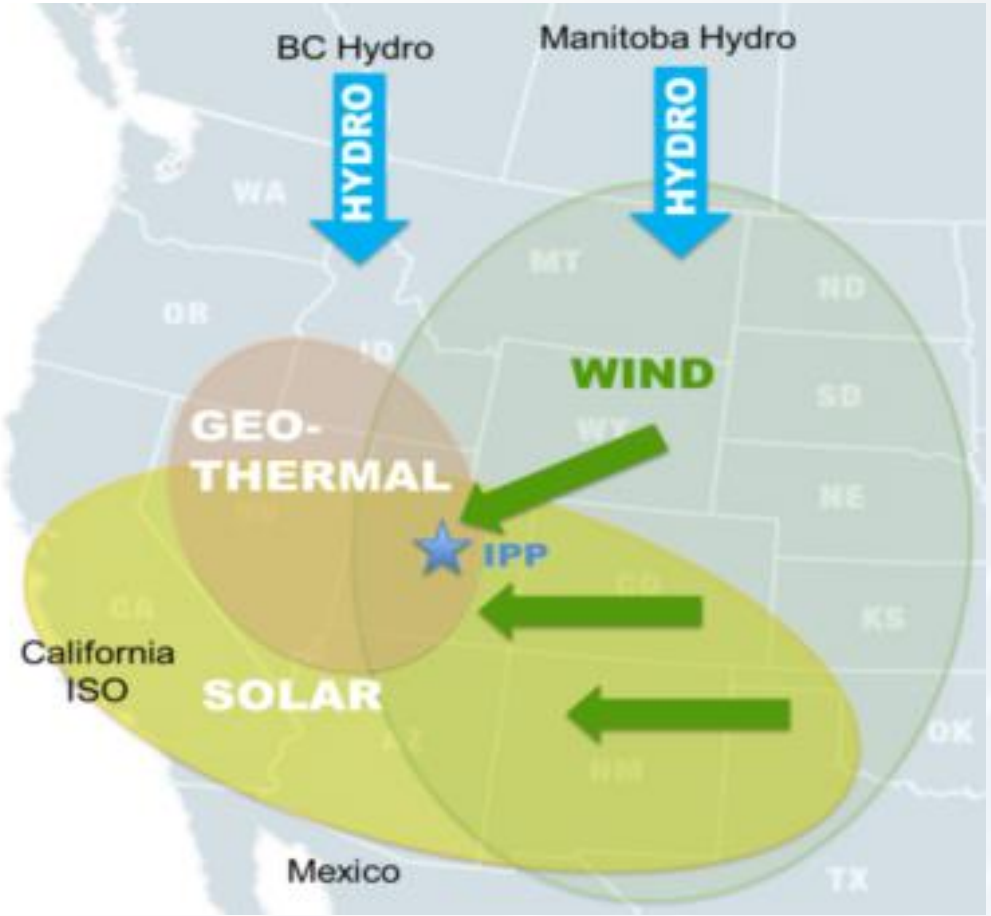
Utah's Renewable Hub

- 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



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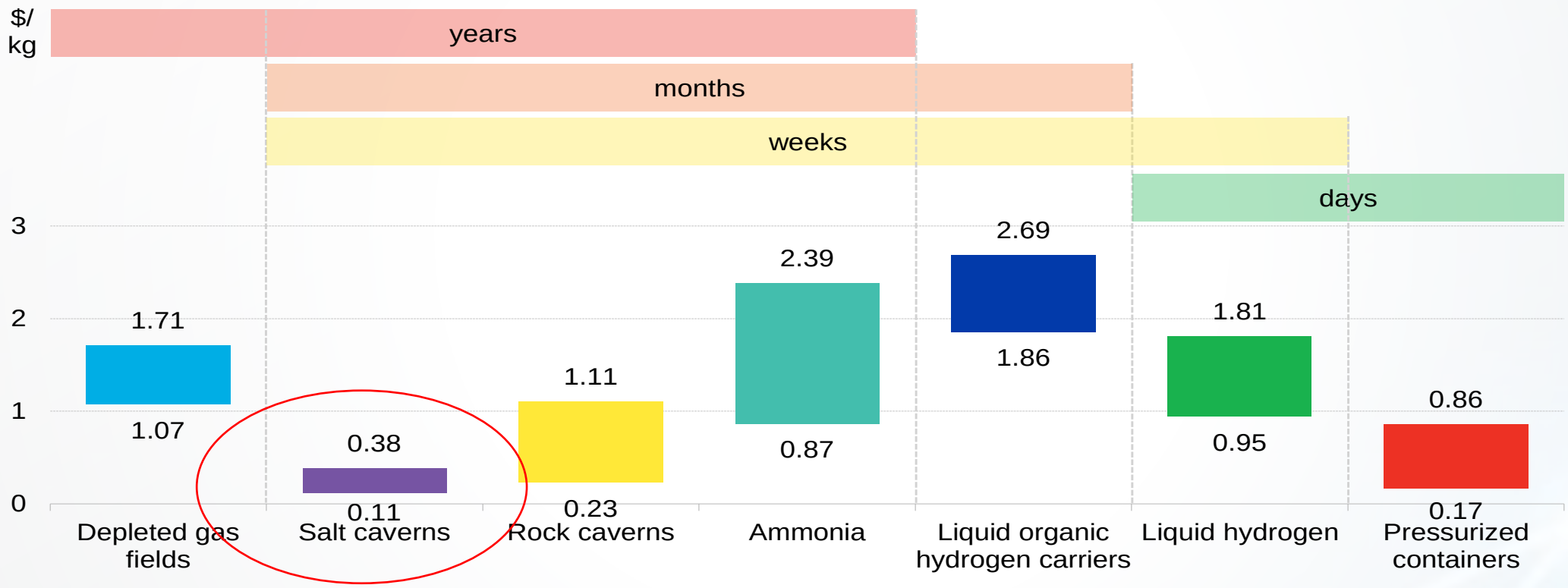
IPP Can Help Drive Global Reductions in Hydrogen Electrolyzer Capex & Operations

Source: BloombergNEF

Levelized Cost of Hydrogen Storage
FUTURE BEST CASE



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Source: BloombergNEF

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Thank you!

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