

PAUL BROWNINGTHIERRY LEPERCQCEO MHPS AMERICASCEO OF SOLADVENT

# **FREE WEBINAR**

# GLOBAL PROGRESS AND MOMENTUM FOR GREEN HYDROGEN





## Today's agenda

- Announcements
- Main Presentations (20 minutes each):
  - Global Progress & Momentum for Green Hydrogen
  - Thierry Lepercq, CEO, Soladvent "The Green Hydrogen Market Shock"
  - Paul Browning, President & CEO MHPS Americas and Chief Regional Officer, Europe, Africa, the Middle East and the Americas Mitsubishi Hitachi Power Systems "Global Progress & Momentum for Green Hydrogen"
  - Moderated by Dr. Laura Nelson, Executive Director, Green Hydrogen Coalition
- Q&A
- Visit <u>www.ghcoalition.org</u>





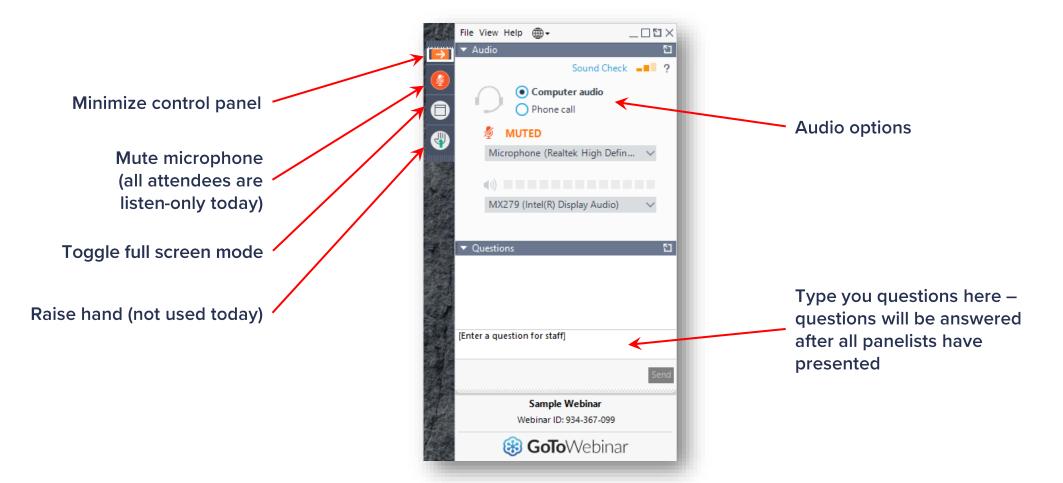
## 

## Moderator: Dr. Laura Nelson

Executive Director, Green Hydrogen Coalition

Vice President Strategen

## Using GoToWebinar



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



<b>Global Progress &amp; Momentum for Green Hydrogen</b>	May 12, 2020
Jpcoming Webinars	
California Energy Storage Alliance VIRTUAL CONFERENCE	May 21, 2020
Past Webinars	
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
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CALIFORNIA ENERGY STORAGE ALLIANCE



# 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.

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



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## **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









## **Thierry Lepercq**

CEO, Soladvent Board Member, Green Hydrogen Coalition





## **Paul Browning**

President & CEO MHPS Americas and

Chief Regional Officer, Europe, Africa, the Middle East and the Americas, Mitsubishi Hitachi Power Systems



PAUL BROWNINGTHIERRY LEPERCQCEO MHPS AMERICASCEO OF SOLADVENT

# **FREE WEBINAR**

# GLOBAL PROGRESS AND MOMENTUM FOR GREEN HYDROGEN













# Global Progress and Momentum for Green Hydrogen

May 12, 2020

Paul F. Browning

President & CEO

Mitsubishi Hitachi Power Systems Americas

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#### **Our Mission in the Americas**

We will provide power generation and storage

solutions to our customers, empowering them to affordably and reliably combat climate change

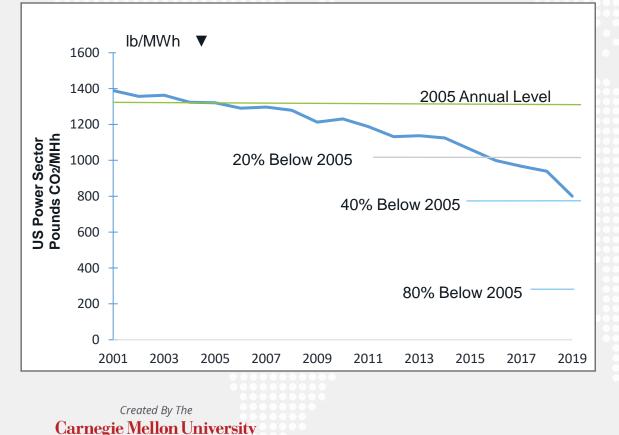
and advance human prosperity.



### **U.S. Decarbonization Past**

# **POWER SECTOR CARBON INDEX**

US POWER SECTOR CO, EMISSIONS INTENSITY



The U.S. Power Sector began decarbonizing in 2001 and the pace of decarbonization has been accelerating.

Scott Institute for Energy Innovation



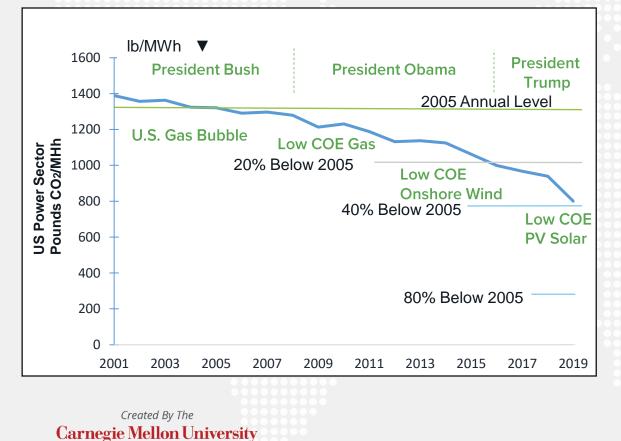
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## **U.S. Decarbonization Past**

# **POWER SECTOR CARBON INDEX**

US POWER SECTOR CO<sub>2</sub> EMISSIONS INTENSITY



The retirement and replacement of coal-fired power plants with: Natural ⊐⊡∠◯́͡,⊐∏ Gas



Renewables

Scott Institute for Energy Innovation

**STRATEGEN** 

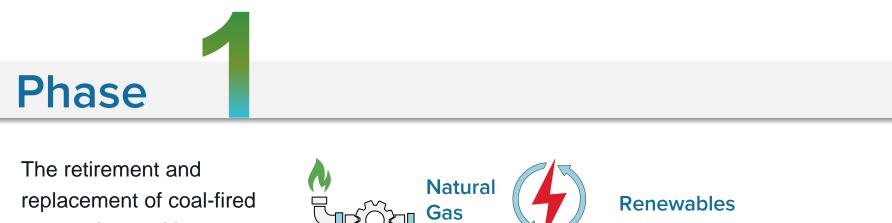


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#### **Power Grid Decarbonization**



replacement of coal-fired power plants with:



## **Power Grid Decarbonization**

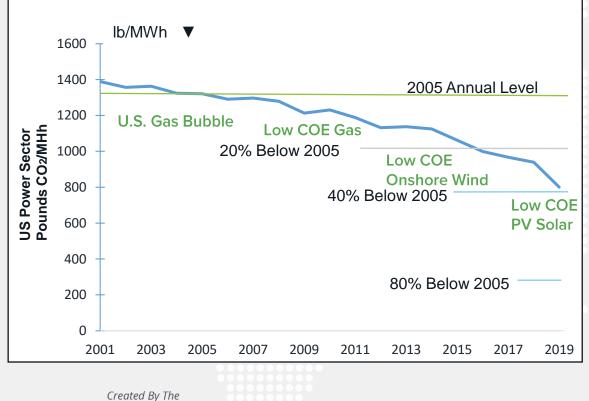
#### Phase The retirement and Natural replacement of coal-fired **Renewables** Gas power plants with: **Different geographies will** navigate the phases at different periods Phase Tackle Long-term Intermittency, currently Energy **Renewables Storage** managed by natural gas power generation:



### **U.S. Decarbonization Past**



**US POWER SECTOR CO, EMISSIONS INTENSITY** 



Carnegie Mellon University Scott Institute for Energy Innovation



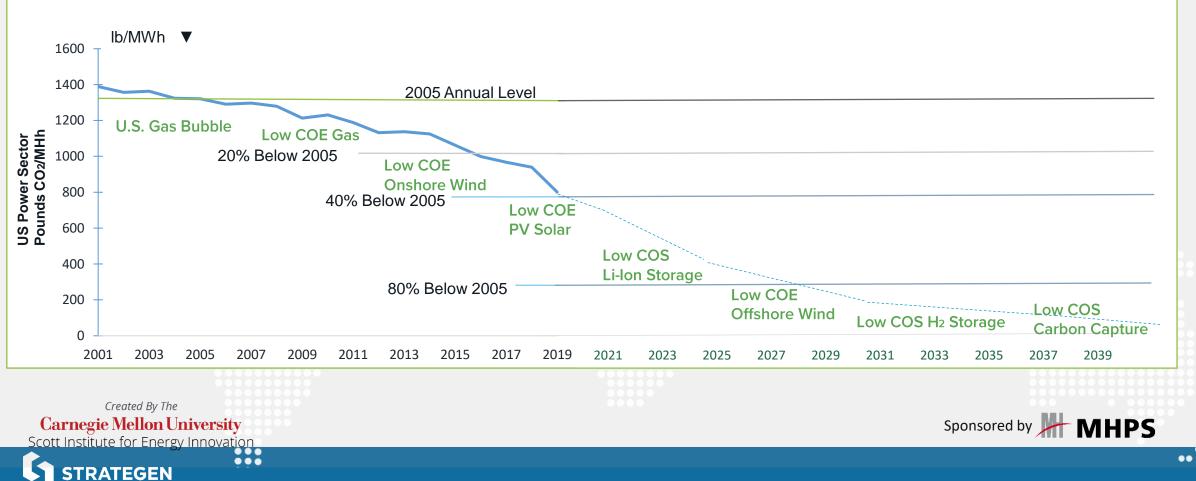


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## **U.S. Decarbonization Past & Future**

# **POWER SECTOR CARBON INDEX**

**US POWER SECTOR CO, EMISSIONS INTENSITY** 



#### Mitsubishi Heavy Industries: Change in Power

Hydrogen Ready Gas Turbines

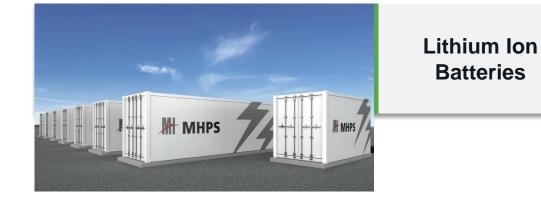






**Offshore Wind** 







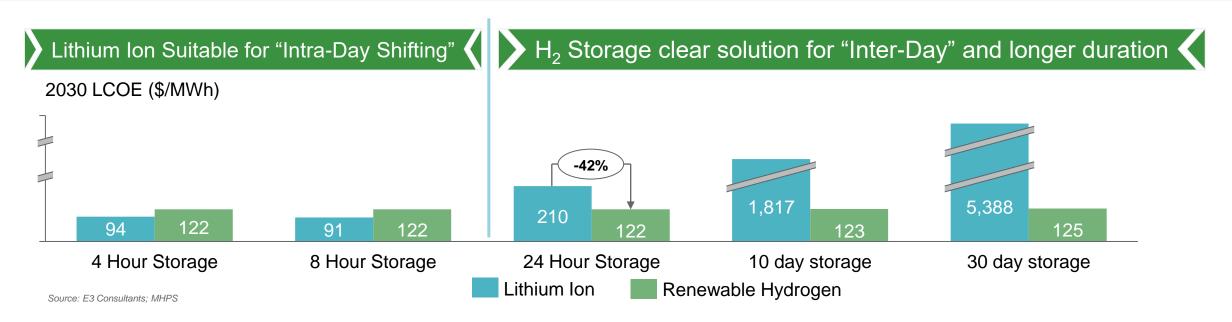
Hydrogen Storage

Carbon Capture, Utilization & Storage



## **Renewable Energy Storage Alternatives**

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

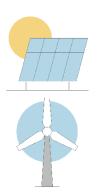


duration need extends	Battery roundtrip efficiency impacted as duration need extends beyond 1-day	Gas turbine capacity factor: 40%
ions	MHPS 2019 electrolyzer and H <sub>2</sub> storage cost with learning curve + CCGT	LCOE includes solar cost

## Assumptions

RATEGEN

#### Why Now for Renewable Hydrogen in Power Generation?



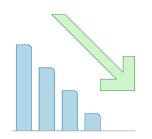
#### Need For Storage

Does your power grid have enough intermittent renewable power that curtailments are becoming a problem?



Does the regulatory and legislative environment exist to promote zero carbon targets?

#### H<sub>2</sub> Production & Storage



Is the cost of renewable hydrogen low enough to be the economic alternative for long duration storage?

#### Technology

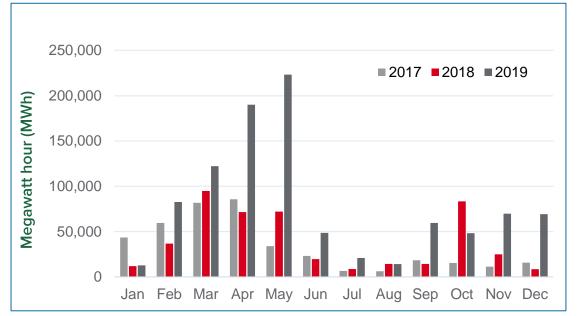


Is there a reliable, affordable and scalable solution to convert hydrogen back to electricity?



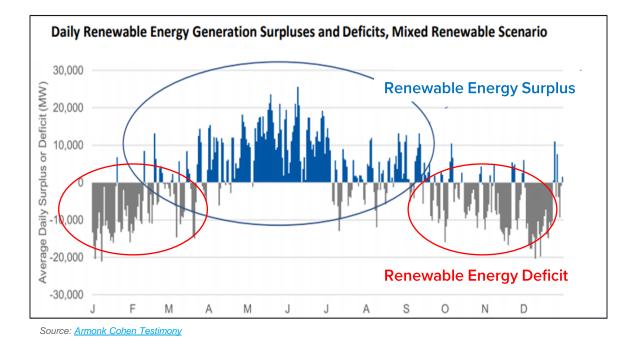
## Surplus and Deficit Signal the Need for More Storage Options

California wind and solar curtailments hit record high in May 2019 California surplus and deficit patterns under a 100% renewable energy scenario



Source: CAISO Data compiled January 2020 http://www.caiso.com/informed/Pages/ManagingOversupply.aspx

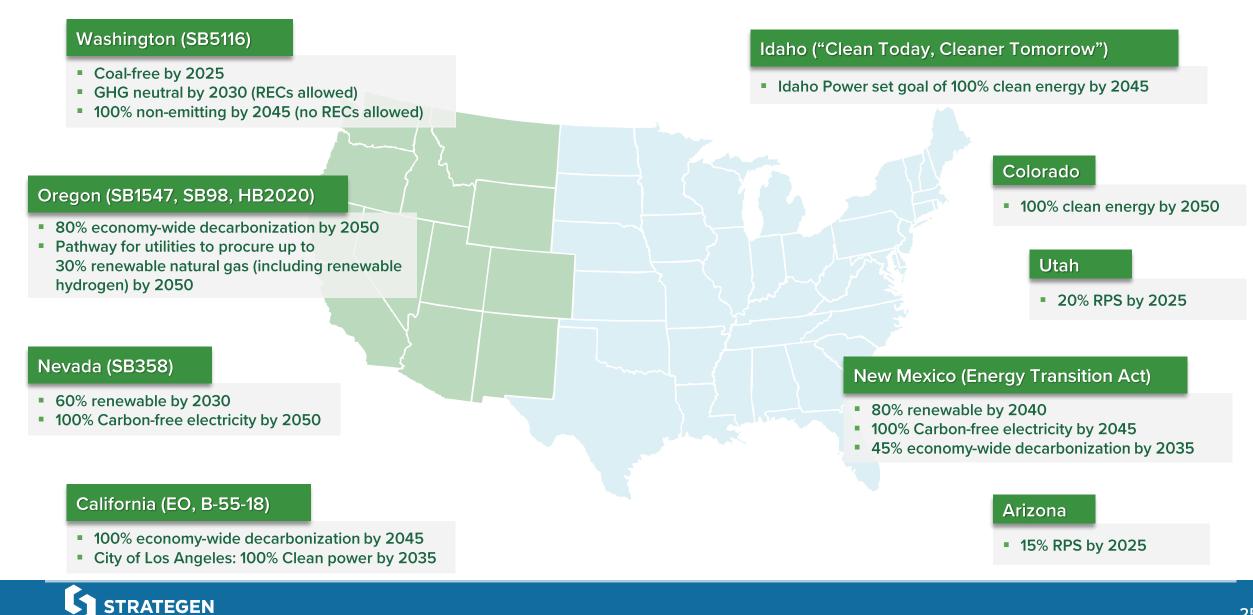
**STRATEGEN** 



At just 30% renewable integration, Peak monthly curtailment exceeds 200,000 MWh

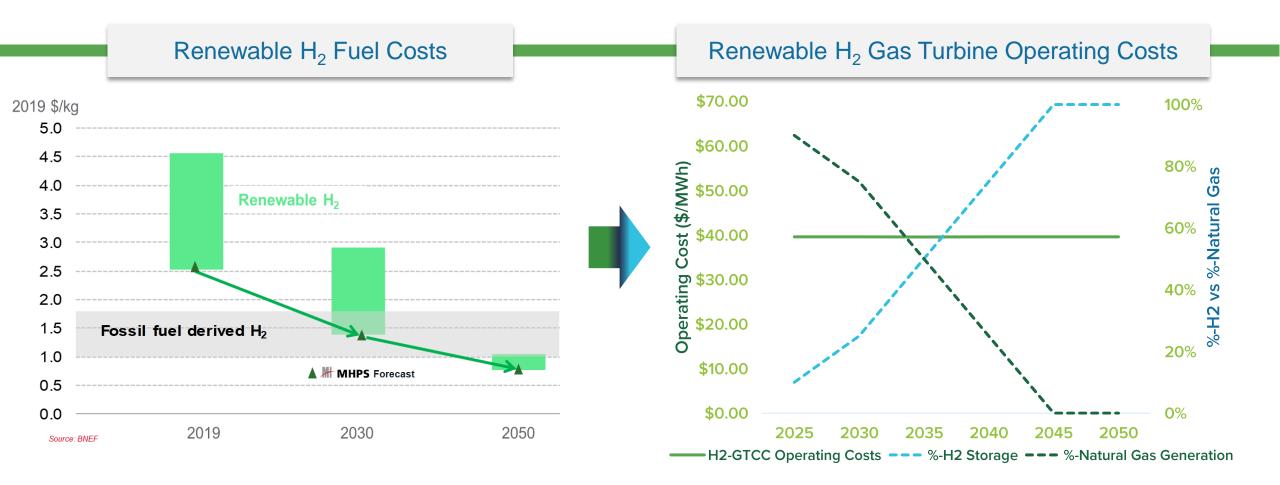
Accumulated yearly surplus equals 35.9 Million MWh

#### Most States in the Western US Have Aggressive Decarbonization Policies



#### **Electrolysis, Storage and GT Combined Cycle Economics:**

Cost Effectively Converting from a Generation Resource to a Storage Resource Over Time



Critical Energy Infrastructure can be built today to reliably and affordably produce electricity While converting to a Renewable Storage resource as market needs require

**STRATEGEN** 

#### Intermountain Power Project: Retiring CA's Only Remaining Coal-Fired Boilers

March 10, 2020 - MHPS contract award and FNTP \$1.9B Investment Announced by IPA

The 1<sup>st</sup> Advanced Class Gas Turbine project specifically designed for renewable hydrogen fuel

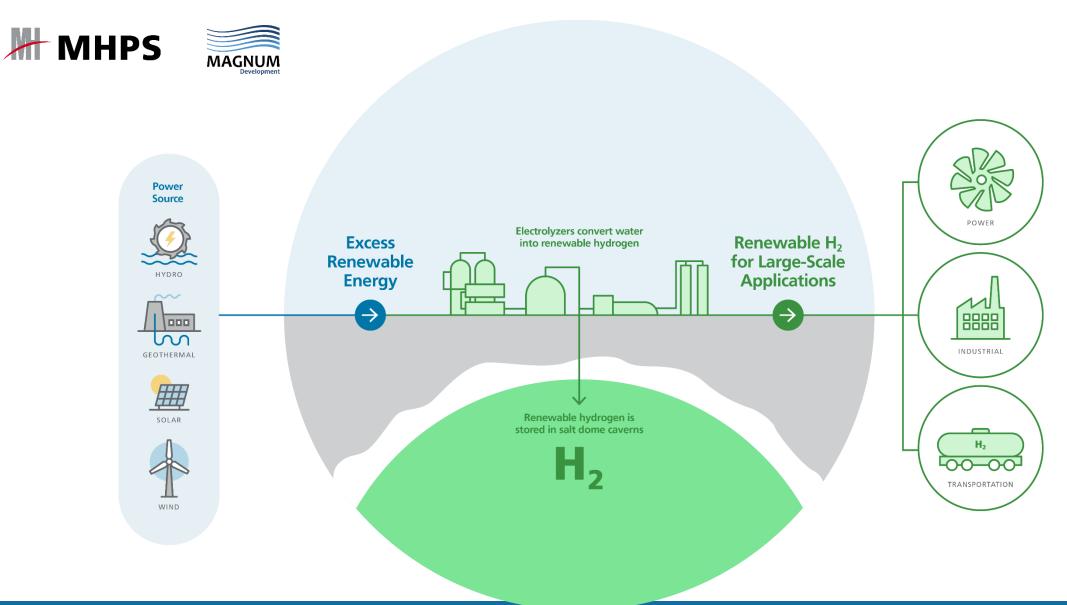
Providing 840MW of reliable energy to Los Angeles and municipalities in other parts of California and Utah

Commercial Operation in 2025 using mix of 30% hydrogen & 70% natural gas fuel

No later than 2045, capability will be increased to 100% Renewable Hydrogen

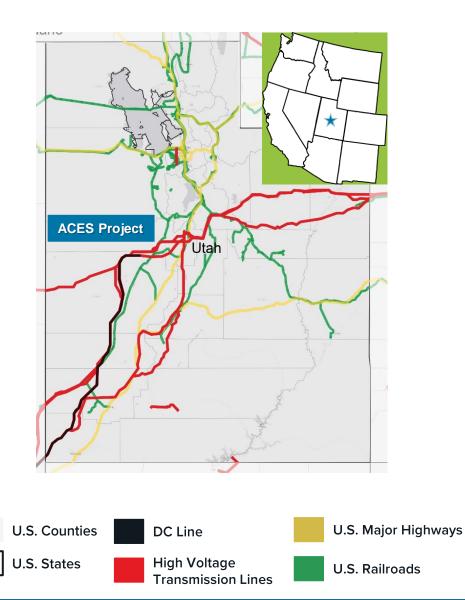


#### ACES: Hydrogen Storage Using Salt Caverns & Gas Turbines





#### Renewable Hydrogen Regional Solution – Advanced Clean Energy Storage (ACES)



RATEGEN

#### ACES has exclusive rights to Delta Salt Dome

- Only known "Gulf Coast" style domal-quality salt in the west capable of large caverns
- Large-scale storage necessary for the west coast to decarbonize via renewable hydrogen

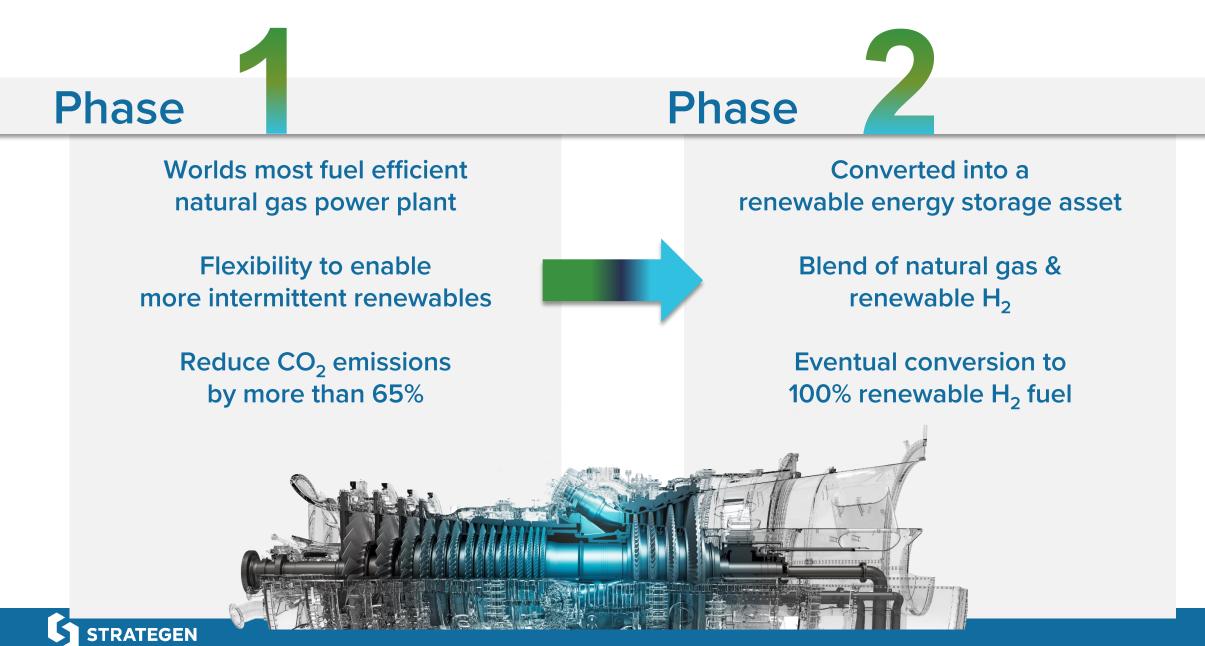
#### ACES site Centrally Located to WECC

- California through HVDC Transmission Line
- Major WECC Utilities through AC Tie
- TransWest Express Transmission Line will tie site into WY and Las Vegas

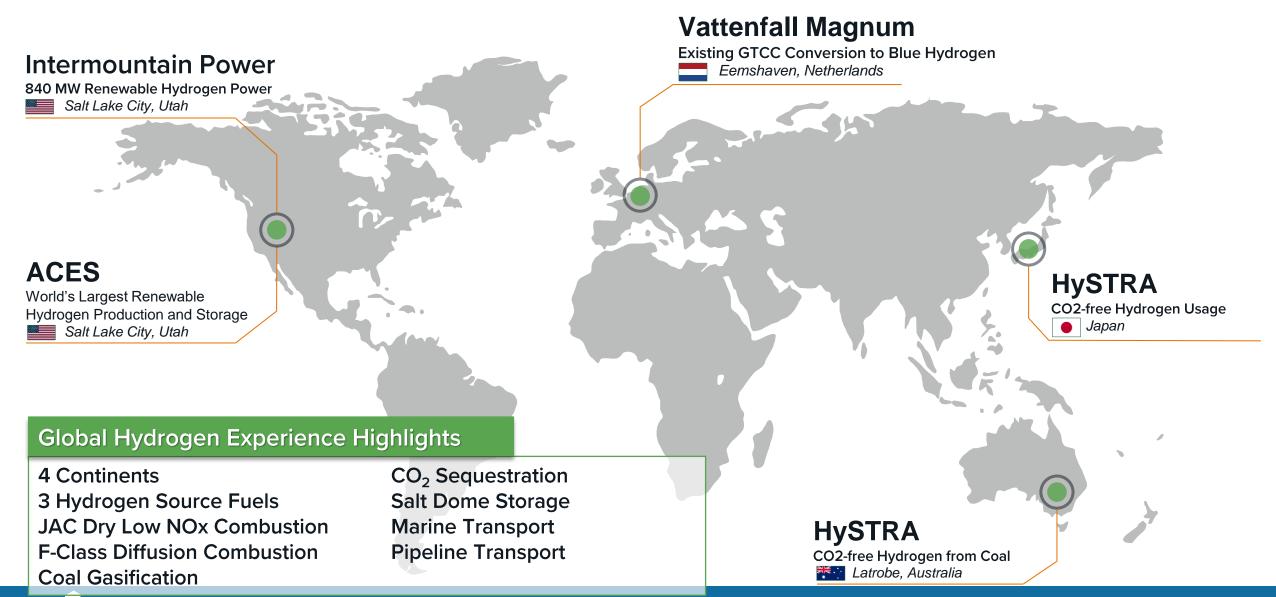
#### H<sub>2</sub> Infrastructure to Decarbonize "Hard to Electrify" Verticals

- Transportation (Heavy Duty/Long Haul Vehicles, Rail, Aircraft, Maritime)
- Datacenters
- Military
- Industrial and Manufacturing
- Ammonia and Derivatives
- Pipeline Injection
- Shipping and Exports (including to Asia)

#### JAC Gas Turbine: A Total Solution for Today and Tomorrow



## MHPS Worldwide Hydrogen Strategy: Learn by Doing





# MHPS

# CHANGEING A CHANGEINN POWER

Learn more about the Hydrogen Effect

ChangeInPower.com/TopFive



Mitsubishi Hitachi Power Systems Americas

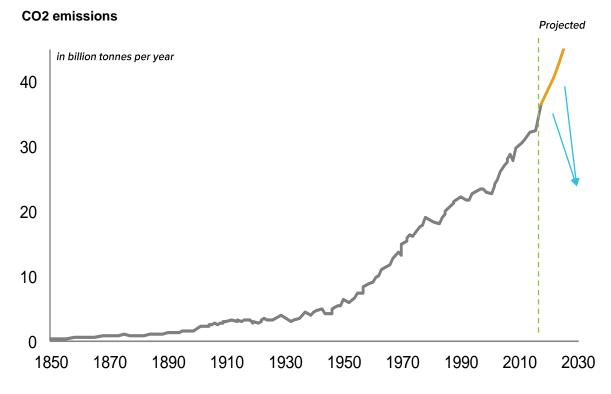


# The Green Hydrogen Market Shock

May 12<sup>th</sup> 2020



## Climate emergency (1): the hairpin paradigm



Source: Global Carbon Project

- The climate hairpin paradigm, devised by Pr. Patrice Geoffron:
- The IPCC's Paris-compatible threshold of 45% cut in CO2 emissions by 2030 (from 2010 level) requires an ever steeper reduction rate as emissions keep growing (-7.6% annual now according to UNEP).



## Climate emergency (2): net-zero policies

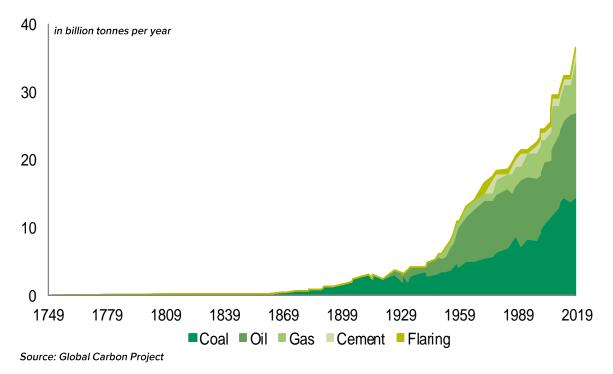


- Civil society pressures are mounting fast.
- 15 countries have adopted net zero emissions targets between 2030 and 2050, and so have a large number of cities and territories.
- The European Union has launched its own "Green Deal".



## Climate emergency (3): exiting fossil fuels, now

#### CO2 emissions by fuel type



- CO2 emissions are mostly caused by coal, oil and natural gas.
- The hairpin paradigm commands to initiate a massive and immediate phase-out of fossil fuels.



# Climate emergency (4): there is no alternative to green hydrogen

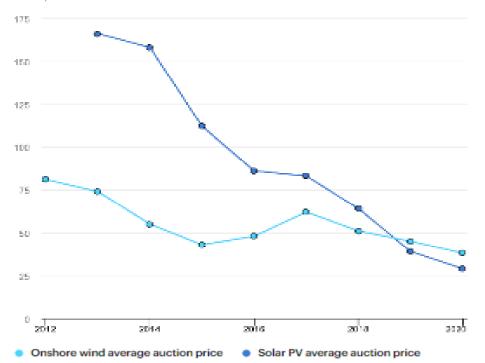
- Achieving net zero means finding a proper zero-carbon substitute for the 11,744 million tons of oil equivalent of coal, oil and natural gas consumed in 2018 globally (source: BP Statistical Review), providing a comparable level of energy security and affordability.
- Electrification with low-carbon sources (renewables and nuclear) is wholly insufficient, as the IEA forecasts a share of electricity of only 23% by 2040. The limited resource, persistently high costs and environmental impact of biofuels constrain their development. CCS only covers 0.1% of current emissions and has no business model except at prohibitively high carbon prices.
- There is no alternative to a product which can duplicate all the benefits of oil and gas without the carbon content: mass-scale, competitive green hydrogen.



### Upstream (1): solar and wind costs

### Announced wind and solar PV average auction prices by commissioning date, 2012-2020

Last updated 18 Dec 2019

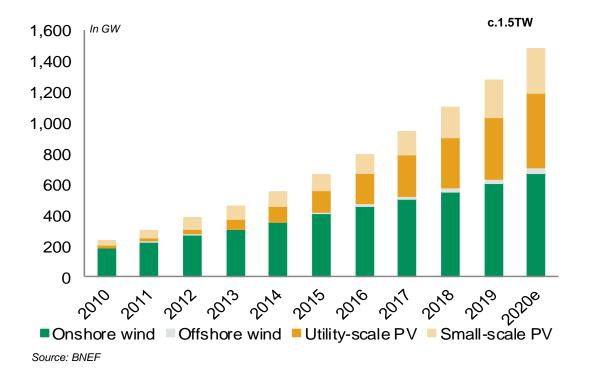


 Solar and wind are now the cheapest sources of power for new installations with prices as low as 15 \$/MWh in the US, Mexico, Brazil, Chile, the UAE and Portugal.



### Upstream (2): solar and wind volumes

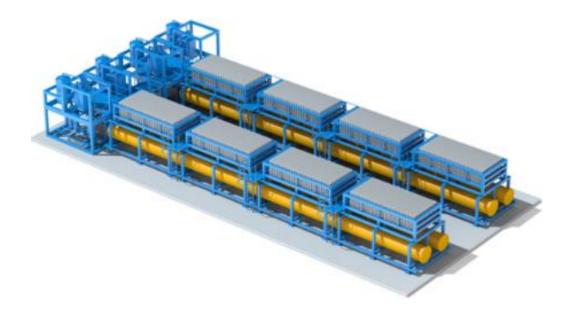
Global wind and solar installations



 Low costs have set off an exponential growth of solar and wind across the planet. In just one country (Spain) there are over 200 GW of solar projects.



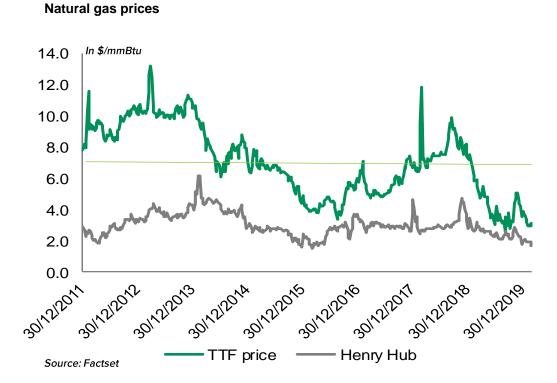
### Upstream (3): the ramp-up of alkaline and PEM electrolysis



- Electrolysis costs are collapsing with the ramp up of mass-scale electrolyzer production.
- Vertical integration and just-in-time manufacturing can cut costs to 200 \$/kW.



### **Upstream (4): reaching LNG parity**



 Mass-scale green hydrogen production at 1 \$/kg matches the long term LNG breakeven price in Europe (7.5 \$/mmBTU), opening up fossil fuel parity.



### Upstream (5): the 1 \$/kg green hydrogen disruption

- Solar and wind are quasi-infinite, well distributed energy resources around the planet. They have crossed the competitiveness threshold with conventional power generation sources and their costs keep falling: the 10 \$/MWh threshold should be achieved before 2025.
- Volumes have skyrocketed on the basis of market-based mechanisms (auctions, PPAs, merchant) and are testing the limits of power grids and markets. The electrolysis of water and brine for the production of ammonia and caustic soda has been practiced at industrial scale for over a century.
- Alkaline electrolysis is the most tested technology, and offers 70% efficiency.
- Thanks to the game changer of 15 \$/MWh power, hydrogen can be mass-produced without subsidy for as low as 1 \$/kg or 25 \$/MWh (equivalent to 43 \$/barrel of oil).



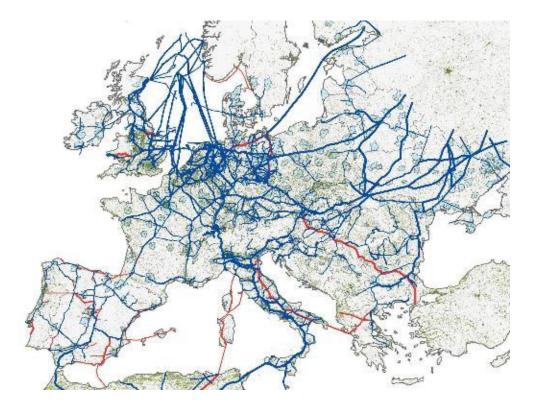
### Midstream (1): hydrogen is a tried and tested product



 The use of hydrogen in gas grids is not new: town gas, produced from coal, which provided energy to buildings and factories from 1850 onwards, was composed of hydrogen and carbon monoxide in equal parts.



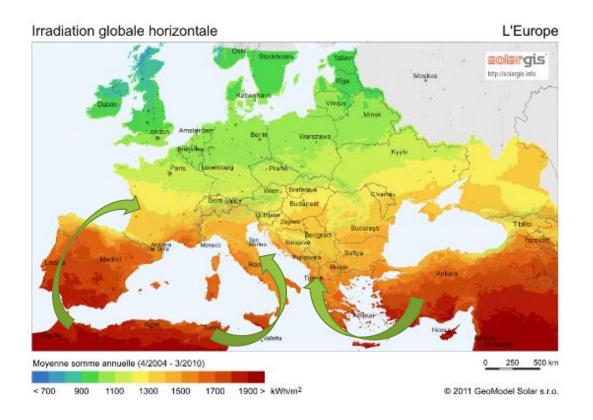
### Midstream (2): transmission and storage infrastructure can be reused



 Studies from some of Europe's largest TSOs such as Enagás, SNAM, OGE and Gasunie have showed that the vast majority of existing gas transmission and storage (salt caverns) can be reused for hydrogen (blended with natural gas or pure) with very limited investment.



### Midstream (3): Mediterranean resources are accessible



 Hundreds of GW of solar generation from Southern Europe and Northern Africa stand ready to flood European energy markets leveraging on legacy gas infrastructure.



### Midstream (4): reinventing natural gas infrastructures

- The use of natural gas grids for the transmission and storage of hydrogen is a key enabler. Europe's gas transmission capacity is 8 times larger than its power transmission capacity and costs are 10 times cheaper.
- Gas storage capacity is also a magnitude bigger: natural gas storage (mostly underground) in France is 130 TWh, compared to 0.06 TWh for pumped and battery storage (which is expected by BNEF to reach only 52 minutes globally by 2040).
- Gas TSOs have a strong motivation to convert their grids to hydrogen as net zero policies threaten to strand their asset bases. Provided hydrogen is transmitted in large-diameter, existing pipes, transmission costs can be as low as 0.1 \$/kg, making it possible to cheaply and reliably deliver millions of tons of green hydrogen to users everywhere.



### **Downstream (1): industry**



 For industry users, green hydrogen is a substitute for grey hydrogen (from fossil fuels) in the production of ammonia and methanol. It can also replace coking coal for the production of steel.



### **Downstream (2): energy and buildings**





• For energy users in industry and buildings, hydrogen can replace natural gas and coal to produce 24/7 fully dispatchable heat and power either through blending of refurbishing of existing turbines, a well-known process with offers from key vendors.



### **Downstream (3): transportation**



 For transport users, hydrogen can replace gasoline and diesel in trucks (rather than cars, where batteries make more sense), buses and trains. Shipping can substitute heavy fuel oil through green ammonia.



### **Downstream (4): full substitution of fossil fuels**

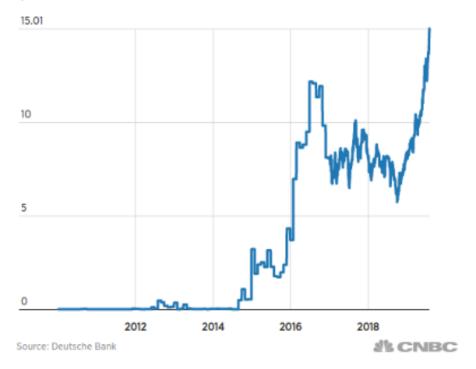
- Industrial, energy and transport users are clamoring for a zero-carbon energy source or feedstock which can match the performance of oil, natural gas and coal in terms of energy security and affordability. Green hydrogen, fitting in existing oil and gas transmission and storage infrastructure, can meet this requirement, unlike variable renewable power or expensive bio-fuels.
- The supply of subsidy-free 25 \$/MWh green hydrogen means no extra costs for users in energyimporting regions such as Europe and Asia, assuming 15 \$/MWh (or 5 \$/mmBTU) breakeven LNG prices and 10 \$/MWh carbon value.
- Substituting fossil fuels at no extra cost allows users to address the existential threat of carbon risk, enhance competitiveness, explore new markets and satisfy communities and stakeholders.



### Financing (1): the opportunity of negative interest rates

#### Total negative debt in world

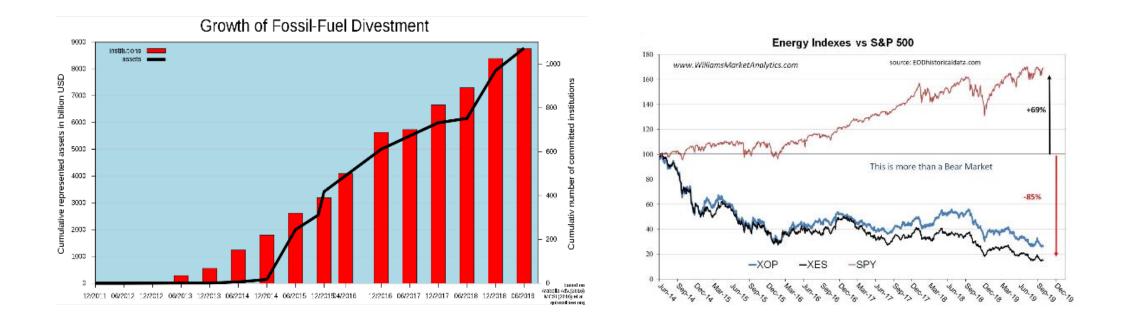
\$ trillion



- Institutional investors are being confronted with the challenge of negative interest rates, with over 15 Tn\$ of negative yielding assets.
- Infrastructure investments (especially energy) offer an alternative with steady yields.



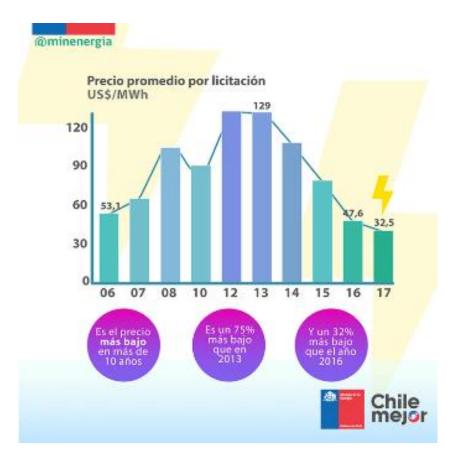
### Financing (2): the financial oblivion of fossil fuels



• The fossil-fuel divestment movement is growing fast, powered by powerful trends: ethical pressures stemming from the growing awareness of the climate emergency, the collapse of fossil fuel shares and the stranded assets paradigm.



### Financing (3): the non-bankability of variable renewables



 As shown by the collapse of wholesale power prices in Chile following the exponential growth of solar, investors in variable renewables are set to be confronted with massively devalued asset values after PPAs or FiTs expire.

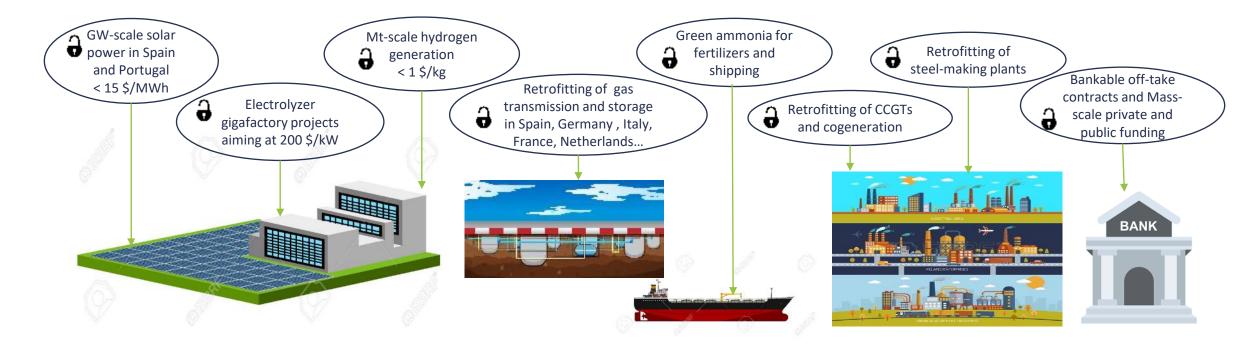


## Financing (4): green hydrogen, the trillion-dollar investment opportunity

- Carbon risk, negative interest rates, falling oil & gas shares, stranded fossil fuel assets and devalued variable renewable assets (as non-dispatchable solar and wind profiles lose value fast with the growth of variable renewables) are major threats to institutional portfolios globally.
- Green hydrogen assets (upstream (solar, wind and electrolysis) and midstream (transmission, shipping and storage)) potentially offer very attractive opportunities, acting as an insurance policy against carbon risk.
- The association of competitive, dispatchable, transportable and storable energy assets and long term agreements (through consortium or government-backed PPAs) with bankable off-takers offer investors a trillion-dollar opportunity and the perspective of sound long term cash flows with attractive returns.



# Unlocking the potential of mass-scale green competitive hydrogen: a preview of European projects (1)







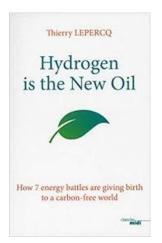
# Unlocking the potential of mass-scale green competitive hydrogen: a preview of European projects (2)

- It is necessary to bring together key stakeholders to unlock the flow of mass-scale green hydrogen to feedstock and energy users.
- The objective should be to open the market by engineering the mass-scale production of green hydrogen at LNG breakeven level prices (< 1 \$/kg), enabling the transformation of existing transmission, storage, shipping and turbine infrastructure to hydrogen and securing long term off-take contracts with bankable counterparties, the key to financing.
- One should aim at securing such distinct advantages such as scale, systematic cost cutting approach and value chain optimization. Projects are being initiated across Europe as part of the EU's "Green Deal", based on the IPCEI industrial policy framework.



# Soladvent: vision and experience to incubate mass-scale hydrogen





Soladvent is a professional service and investment company founded by Thierry Lepercq. After a 15-year career in technology finance, Thierry Lepercq founded Solairedirect in 2006, a pioneer of competitive solar globally (France, India, US, Mexico, Brazil, Chile, South Africa...) with 3 GW+ built and project prices as low as 20 \$/MWh. The company was acquired in 2015 by energy giant Engie, and Thierry Lepercq joined its Executive Committee in charge of research, technology and innovation. He then established Engie Fab, an incubation unit for mass-scale projects in the areas of shared and electric mobility, digital energy platforms, dispatchable renewable power and green hydrogen. Thierry Lepercq left Engie in October 2018 to launch Soladvent. He is the author of "Hydrogen is the New Oil", a book published in March 2019 in French, English and Spanish, which describes how seven energy revolutions are opening the gates to a zero-carbon world based on hydrogen. The book has received significant media coverage and critical acclaim, in a context of fast mounting public interest for hydrogen.

Since October 2018 Soladvent has mobilized a dozen professionals and several consulting firms to conduct strategic analysis an modeling, investigate the technical and regulatory challenges of mass-scale green hydrogen, and to design business models. The team includes professionals from Europe and Asia with senior backgrounds in the following areas: renewable energy development, hydrogen and industrial gases, oil & gas projects and infrastructures, energy market platforms, chemical industry research and technology, structured financing and M&A, public affairs...





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## **FREE WEBINAR**

## GLOBAL PROGRESS AND MOMENTUM FOR GREEN HYDROGEN





## **Pathways for Collaboration**

### **Objective**

### **Pathway for Collaboration**

•	Shape market design for green hydrogen project development, obtain latest news, information and global best practices about green hydrogen market development	• Membership – join GHC!
•	Non profit and government organizational collaboration – information sharing, messaging, events and networking	Become a GHC Supporting Partner
•	Learn about green hydrogen pathways and innovation. Stay informed, at a high, level on green hydrogen news and market developments	Attend GHC events, sign up for newsletter



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



"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



## **GHC Membership**





"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

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





## VIRTUAL CONFERENCE

CONNECTING THE ENERGY STORAGE INDUSTRY

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CALIFORNIA ENERGY STORAGE ALLIANCE

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## Thank you!

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