



H₂ Energy At the heart of the energy transition

Liberum - Future of E-Mobility Conference
December 11th 2019

AGENDA

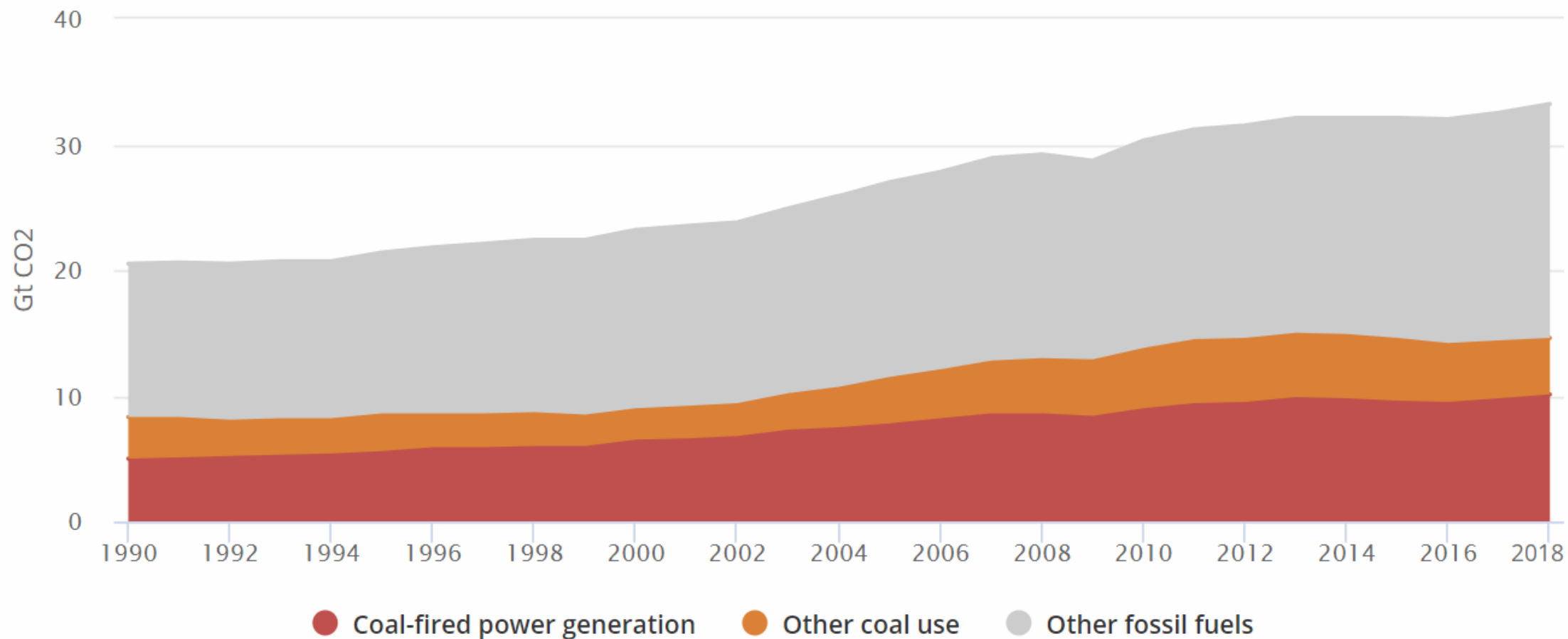
1. The urgency for Energy Transition
2. The role of Hydrogen
3. On-going dynamic
4. The case of Air Liquide
5. Priorities – Hydrogen Council views

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Despite COP21, Emissions continue to rise...

Global energy-related carbon dioxide emissions by source, 1990-2018



The “Kaya” Equation to summarize the issue

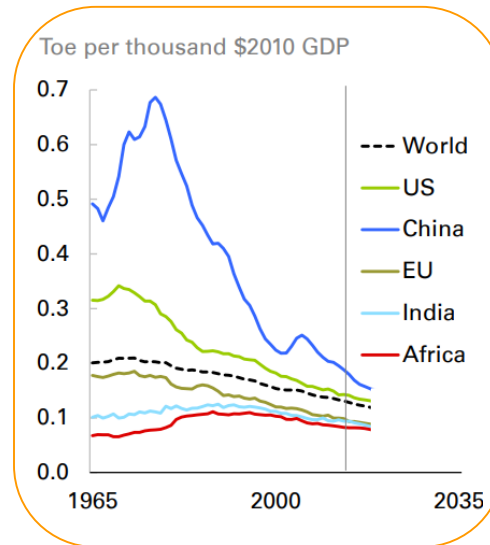
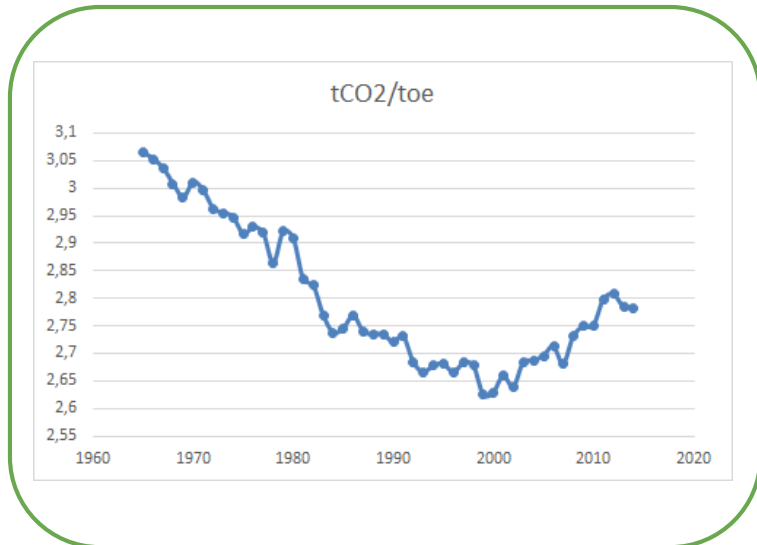
$$\text{CO}_2 = \left(\frac{\text{CO}_2}{\text{Energy}} \right) \times \left(\frac{\text{Energy}}{\text{GDP}} \right) \times \left(\frac{\text{GDP}}{\text{POP}} \right) \times \text{POP}$$

Carbon Content of Energy

Energy Efficiency of the Economy

Economic Welfare

Population



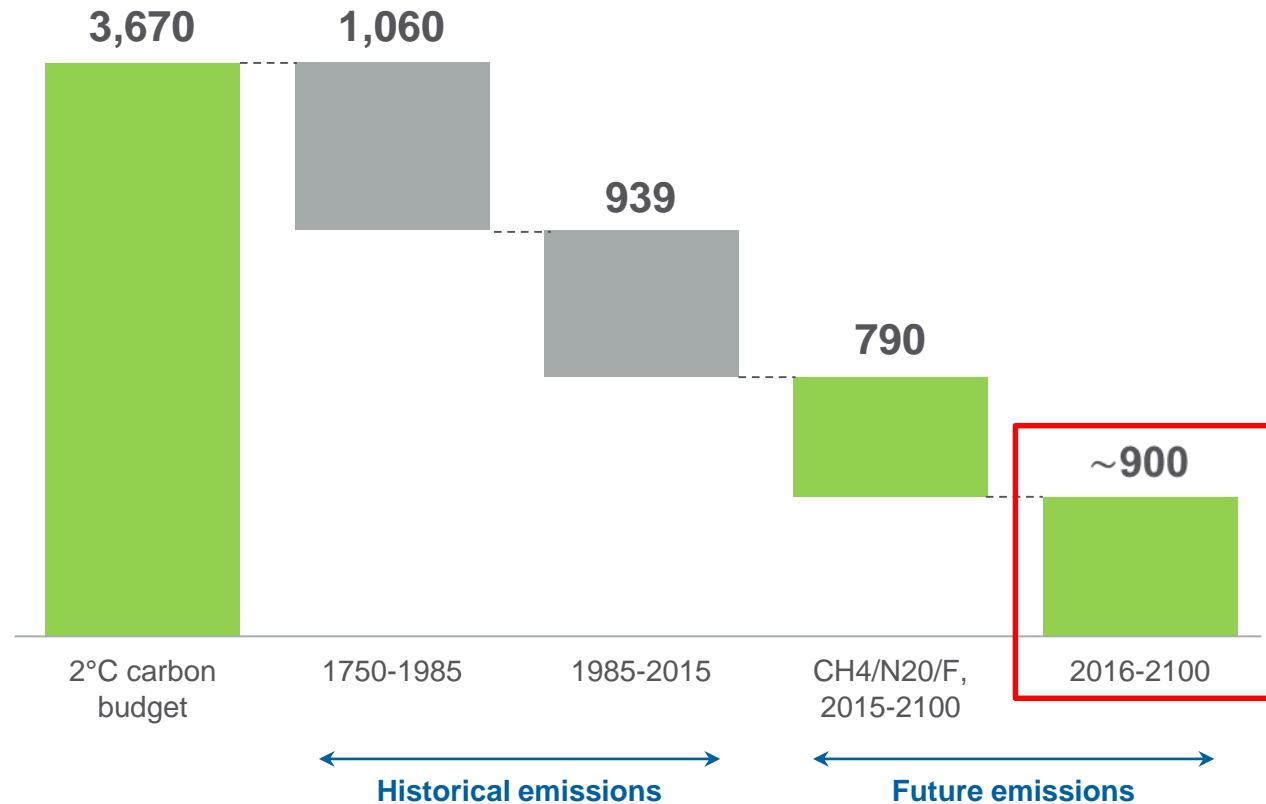
World	10
China	8
US	57
FR	37
Philippines	3
Senegal	1

7.6 today
8.6 2030
9.8 2050

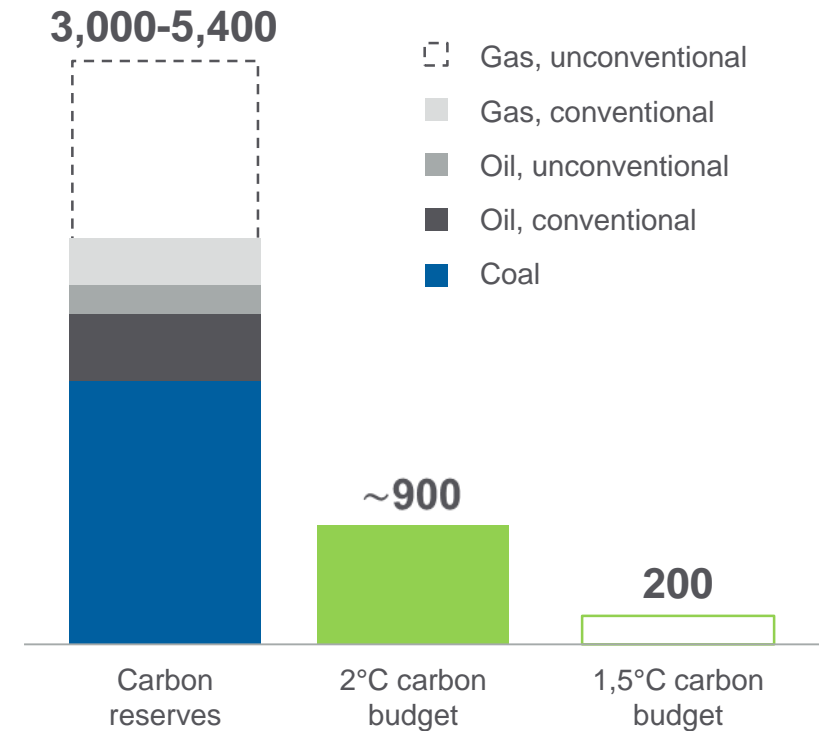
Small remaining budget not to exceed +2°C

Billion tonnes of CO₂-eq

2°C Carbon budget emissions to 2100

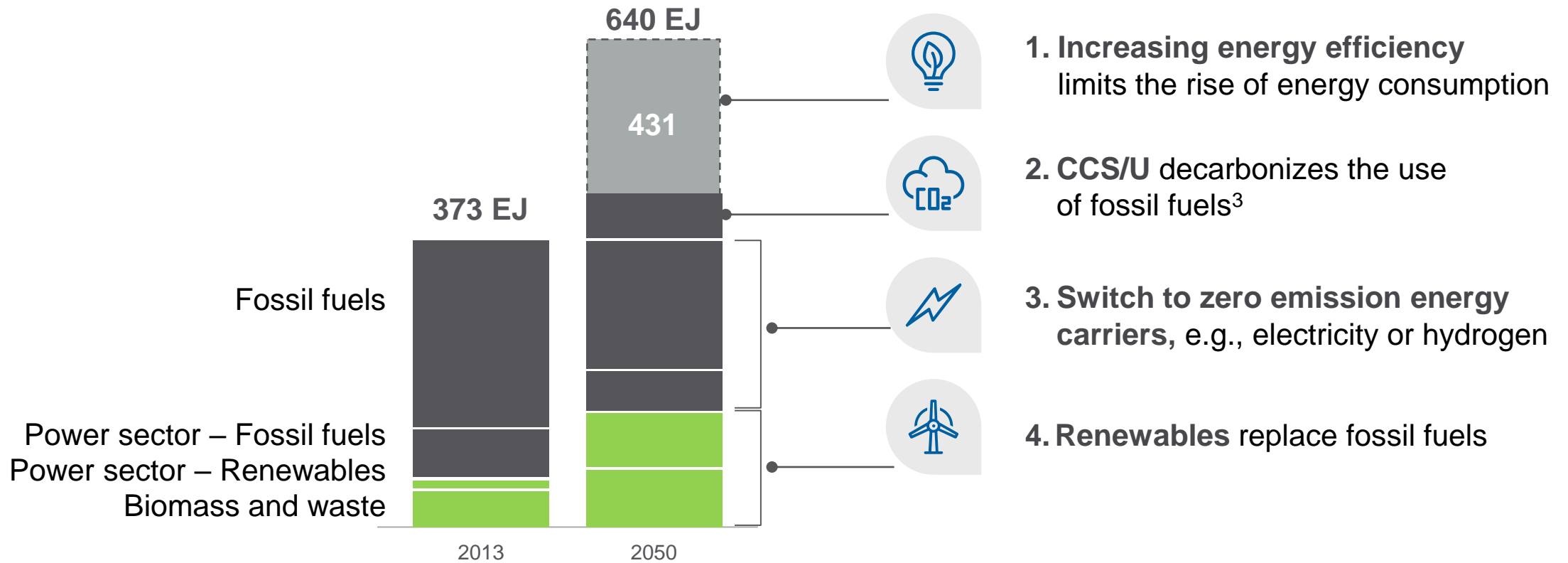


Carbon budget compared to carbon reserves



Four major levers to enable the energy transition

Final energy consumption 1,2, 2013 and 2050, in EJ



1 Final energy consumption within the 2DS of the IEA

2 Increase of energy demand is determined via the relative increase of CO₂ emissions w/o energy efficiencies

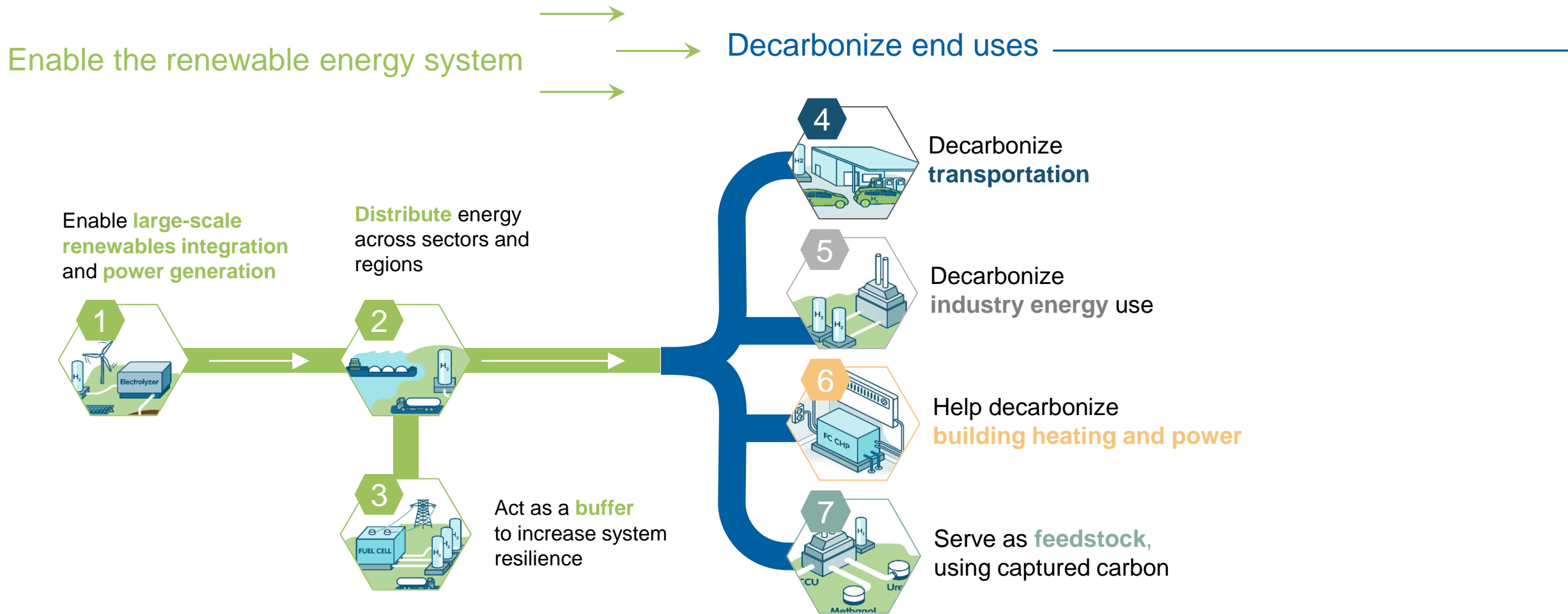
3 The fossil fuels amount processed using CCS/U was determined to be 25% of the total amount of fossil fuels by relating the CO₂ emission reduction compared for the 2DS and 6DS

4 The fossil fuel power sector also includes nuclear energy

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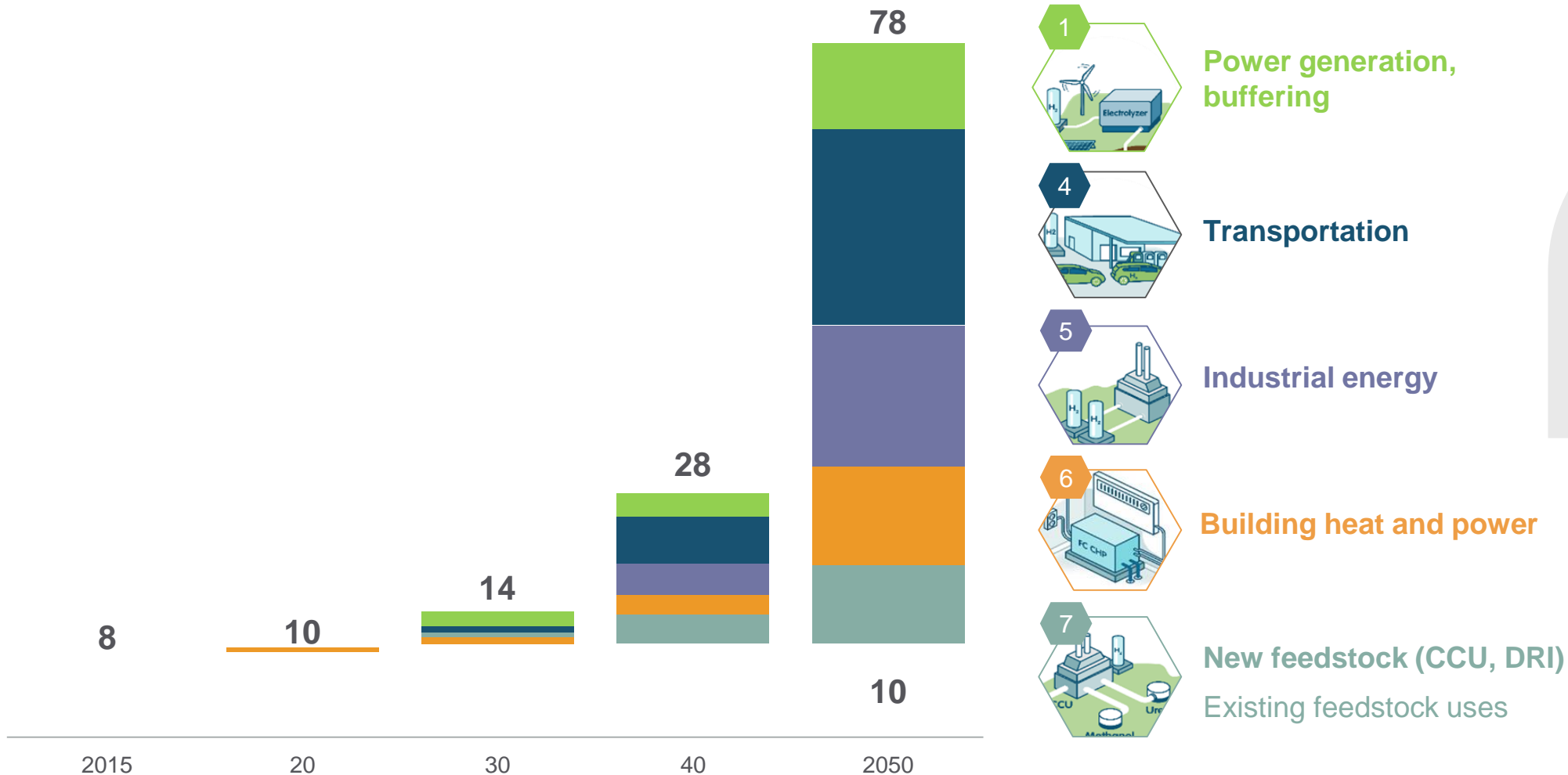
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The 7 roles of hydrogen in the energy transition



Potential demand for H2 in a +2°C Scenario

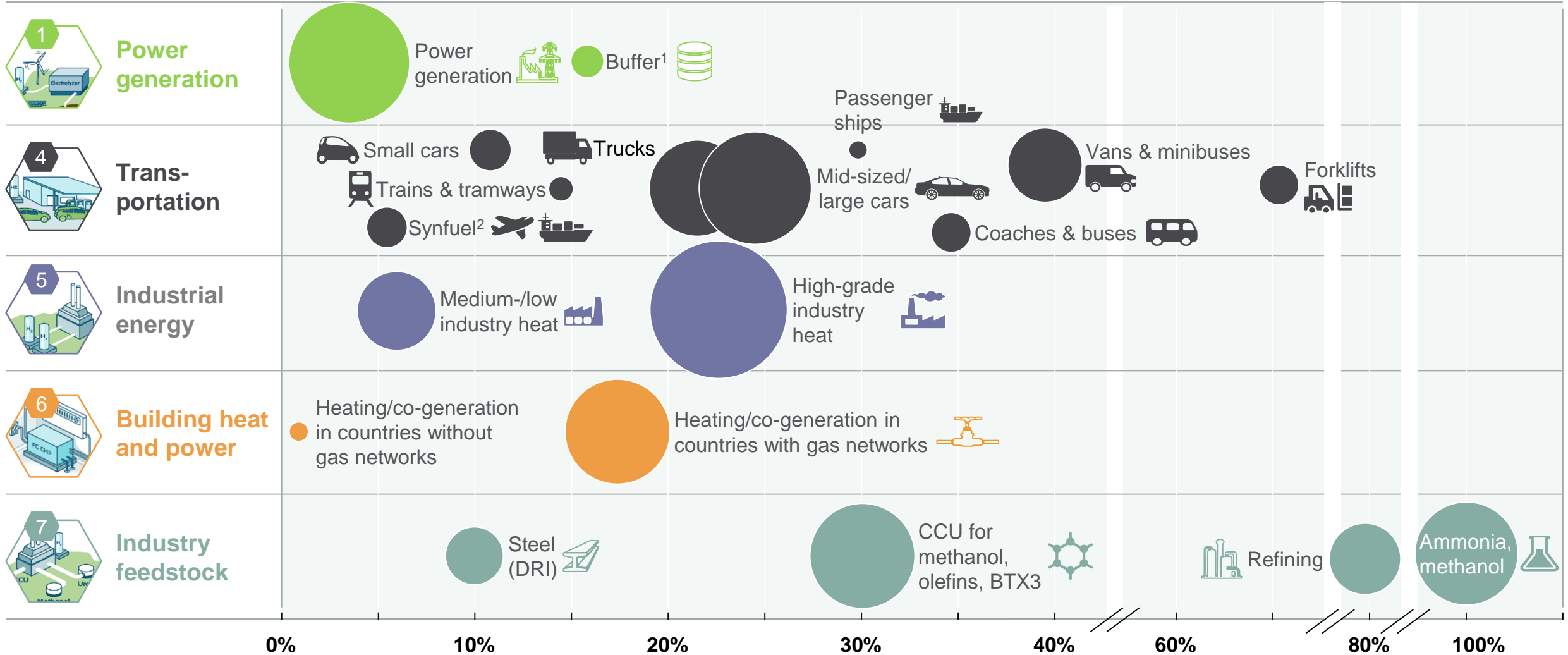
Potential global energy demand supplied with hydrogen, Exajoule (EJ)



18%
of final energy
demand

Potential of Hydrogen across all applications

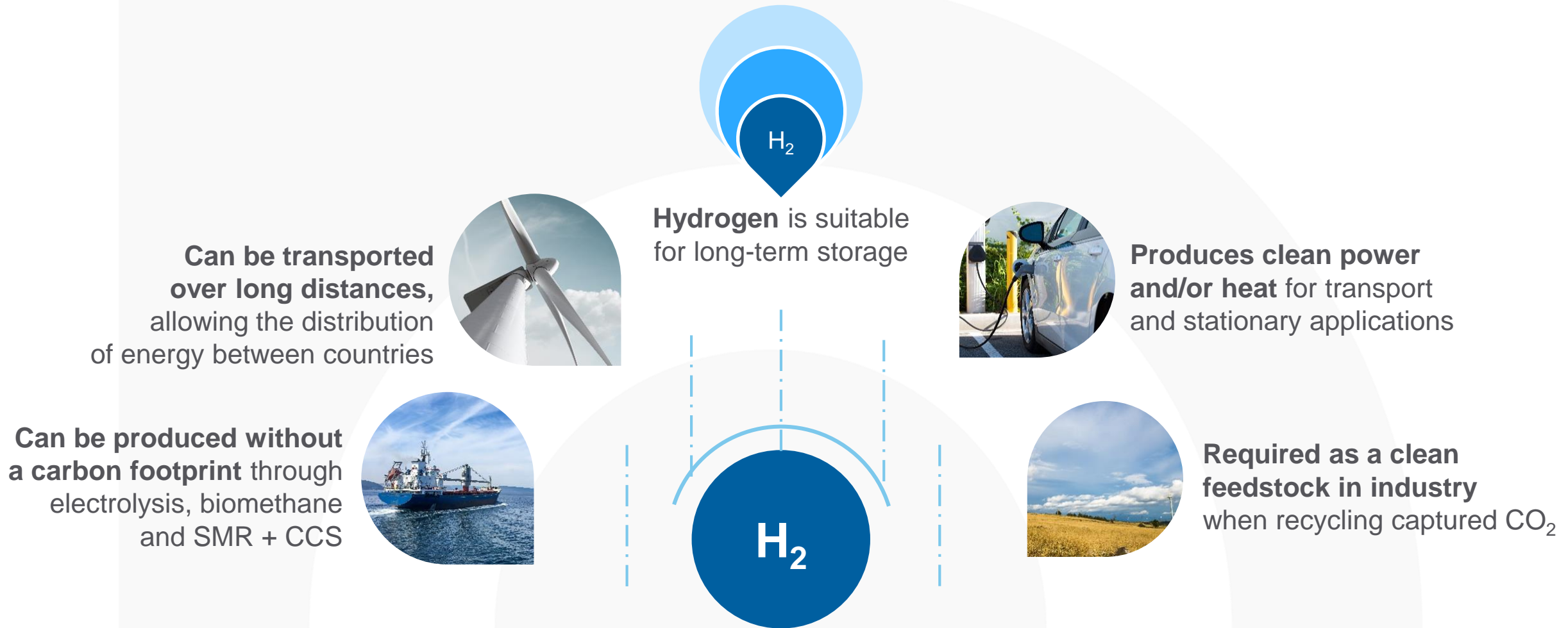
○ Bubble size indicates hydrogen potential in 2050 in EJ (1 EJ)



Source: McKinsey & Hydrogen Council 2017

Relative importance by 2050
Market share potential in segment

Hydrogen: a clean, safe and versatile energy carrier



Hydrogen mobility markets: Ready to scale TODAY

Ferries
1 T/day



Cruise ships
10 T/day



Material handling vehicles
100 kg/day
per site



Trucks
100 kg/day
per truck



Individual cars
100-200 kg/day
per station

Buses
20 kg/day
per bus



Trains
150 kg/day
per train



Drones



Airplanes Applications



Bicycles & scooters



Low carbon hydrogen pathways

Biomethane



Electrolysis
low carbon electricity



Natural Gas +
Carbon Capture
and Storage (CCUS)



Hydrogen for industry

H₂

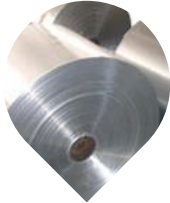
Existing industrial usages of H₂



Refining



Ammonia



High grade heat

Objective:
Shift to low carbon H₂

New H₂ markets



Steel production



Chemical products



Recovered CO₂

Objective:
Develop new applications for H₂
to replace fossil fuels

Air Liquide to deliver hydrogen for thyssenkrupp's pioneering project for lower carbon steel production

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The Hydrogen Energy World today - widely shared view

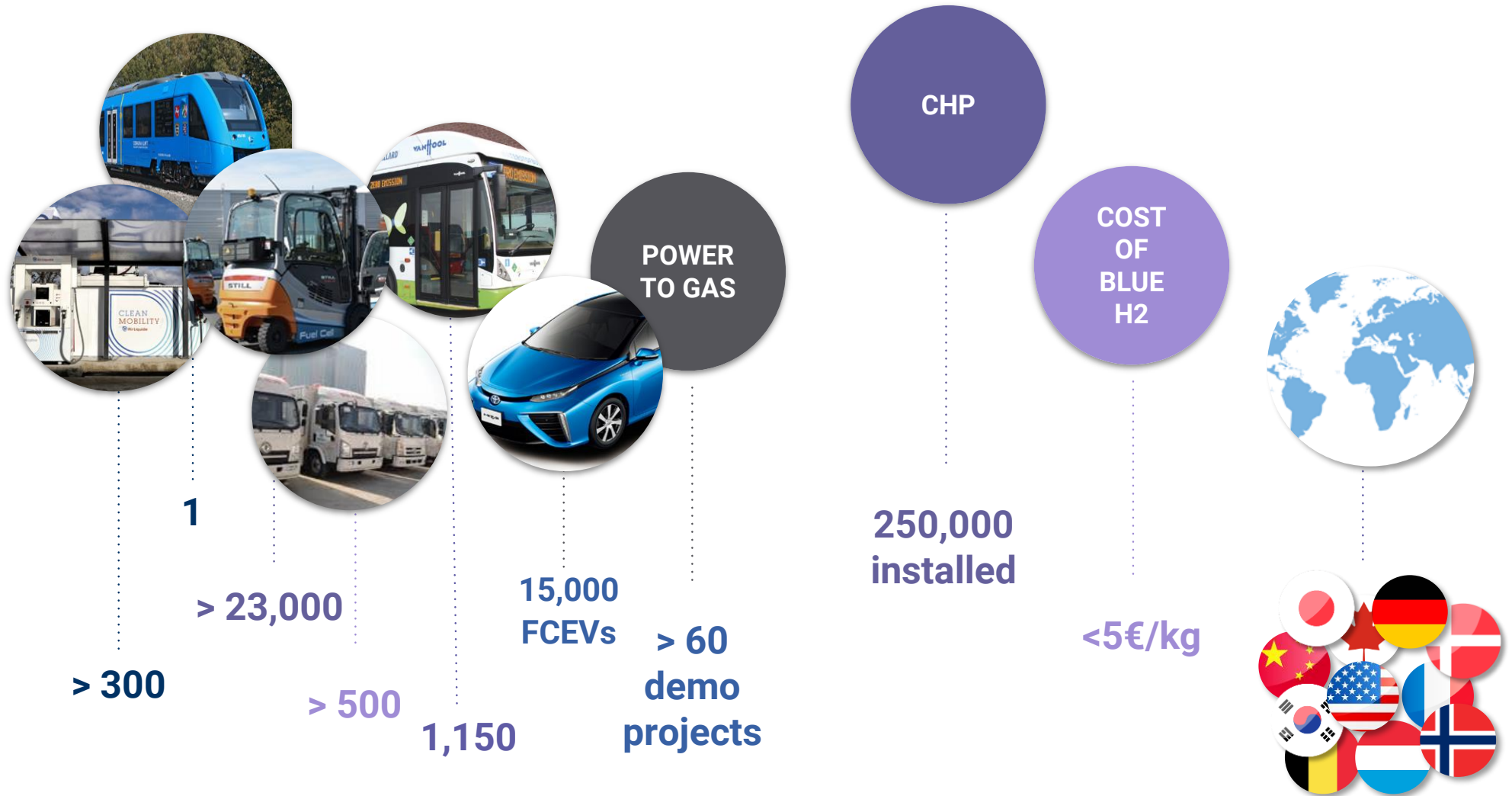
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QUADRUPLED MEMBERSHIP IN 18 MONTHS



The Hydrogen Energy World

Promising market developments in many areas, going beyond mobility



First large scale projects at sight

A change in scale of projects



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Hydrogen - 40 years of development for industries

Production & Supply chain

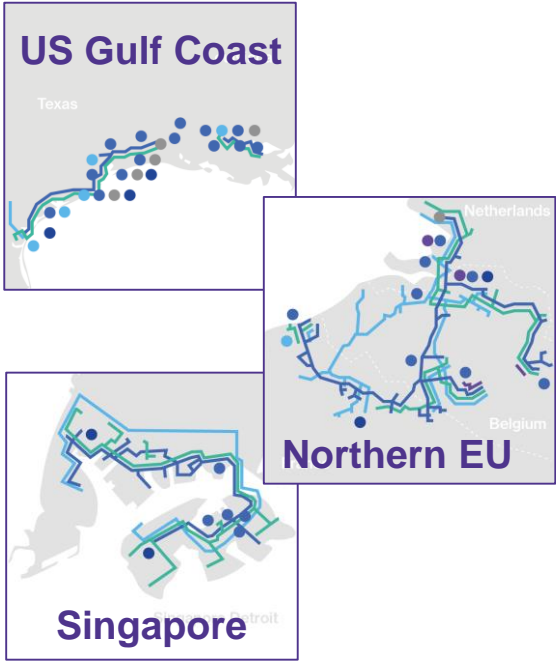
Production



Supply-chain



Distribution Networks



Markets Segments

Process industries

Oil & Gas



Steel, Glass



Electronics



Transportation Space



Key Figures

- > 14 bn m³/yr
- > 1,850 km H₂ pipeline
- > 46 large H₂/CO plants
- > 40 electrolysers in operation
- > 2 bn € sales

Air Liquide already started to invest



Mobility
for Professionals
US+EUROPE
9 HRS



Mobility
for Consumers
US North-East
12 HRS
+ Supply chain



Mobility
for Consumers
California
4 HRS



Mobility
for Consumers
Japan
9 HRS



Mobility
for Consumers
Dubai
1 HRS



Mobility
for Consumers
Korea
2 HRS



Power to Gas
Denmark
4 HRS
+ 1 Electrolyzer



Mobility
for Consumers
Germany
11 HRS



Mobility
for Consumers
Paris, Brussels
and Rotterdam
6 HRS



14 bn m³/yr

1,850 km H₂ pipelines

46 large H₂/CO plants

40 electrolyzers

in operation

2 bn € sales

More than 120
Hydrogen recharging
stations (HRS) installed
by Air Liquide
in the world in which
58 directly invested
and operated
by Air Liquide

H2 Council...



We call on governments to build a global alliance that will help us deliver on

an ambitious goal of decarbonizing 100% of hydrogen fuel used in transport by 2030.

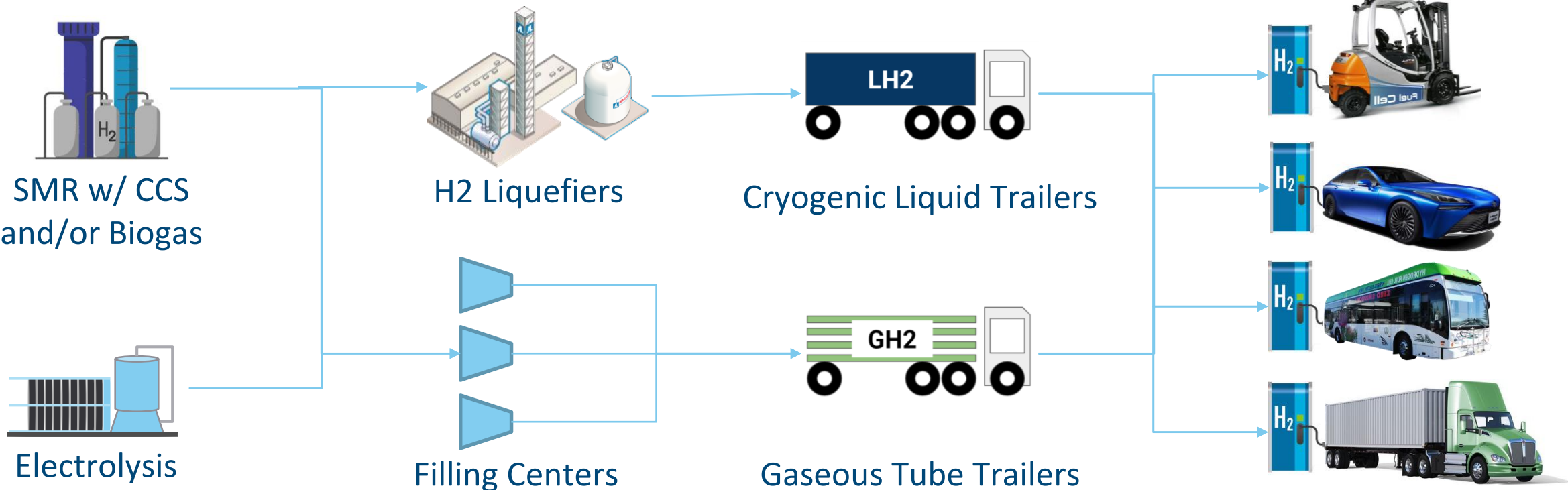
Transport may be our first target—but with the right level of support, we will see positive effects across many sectors.



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AIR LIQUIDE: A catalyst for new markets, to enable the development of core activities



H2 Production

H2 Conditioning

H2 Distribution

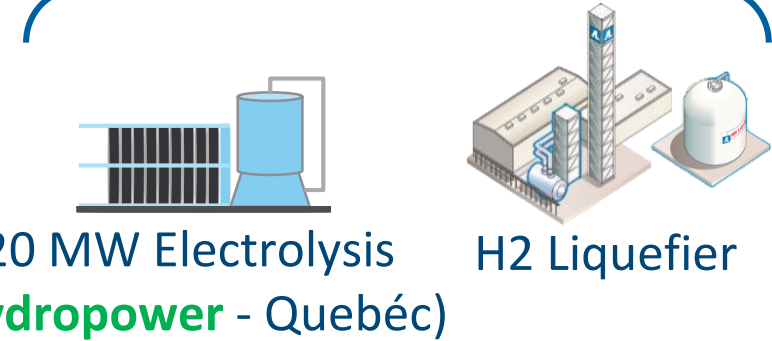
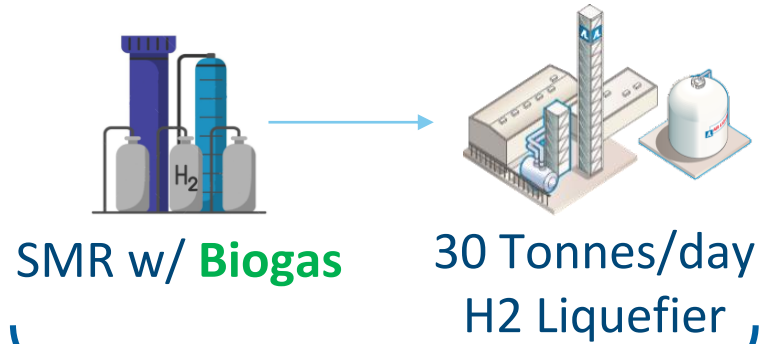
Dispensing and Retail

Build – Own - Operate

Minority Stake

Technology / Know-how / Expertise

TWO MAJOR INVESTMENTS to enable growth of Fuel-Cell Vehicles in North America



150 MUSD

Air Liquide to build new hydrogen production plant in Las Vegas

By Joanna Sampson | 9 October 2019

Air Liquide to construct PEM electrolyser for carbon-free hydrogen

By Molly Burgess | 25 February 2019

HYDROGENICS
SHIFT POWER | ENERGIZE YOUR WORLD



H2 Production

H2 Conditioning

H2 Distribution

Dispensing and Retail

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2nd Hydrogen Energy Ministerial

Tokyo, Japan
25 September 2019

KEY STEPS NEEDED TO SUCCESS



SHARED VISION BETWEEN KEY COUNTRIES



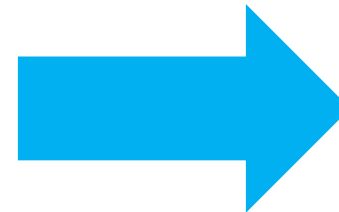
ARCHETYPE DEPLOYMENTS ALONG THE VALUE CHAINS



CLEAR REGULATIONS FAVOURING COMPETITIVE DEPLOYMENTS



SUPPORTING SCHEMES TO BRIDGE GASP TO COMPETITIVENESS



ONGOING



ONGOING



SCATTERED



MISSING

CONCLUSIONS

- HYDROGEN TECHNOLOGIES ARE READY FOR SCALE UP



- VOLUME WILL BRING COST DOWN



- REGULATIONS WILL BRING VOLUME



- URGENCY FOR ENERGY TRANSITION AND ITS INVESTMENT POTENTIAL SHALL CAUSE REGULATIONS TO COME



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