# Hydrogen Is Hot: What is really happening here?

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Executive Director

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Hydrogen Council

# 140 Members Cross Sector / Global CEO Council

# Same Hydrogen Different Place

## Industral Gas

- Captive markets
- Behind the fence
- Private ownership
- Industrial Customer
- Traditional Markets
- High user competence
- Long history of practice
- Mostly fossil origin
- Traditional built environment fire & building codes; installation codes, pressure vessel codes

## Hydrogen Energy

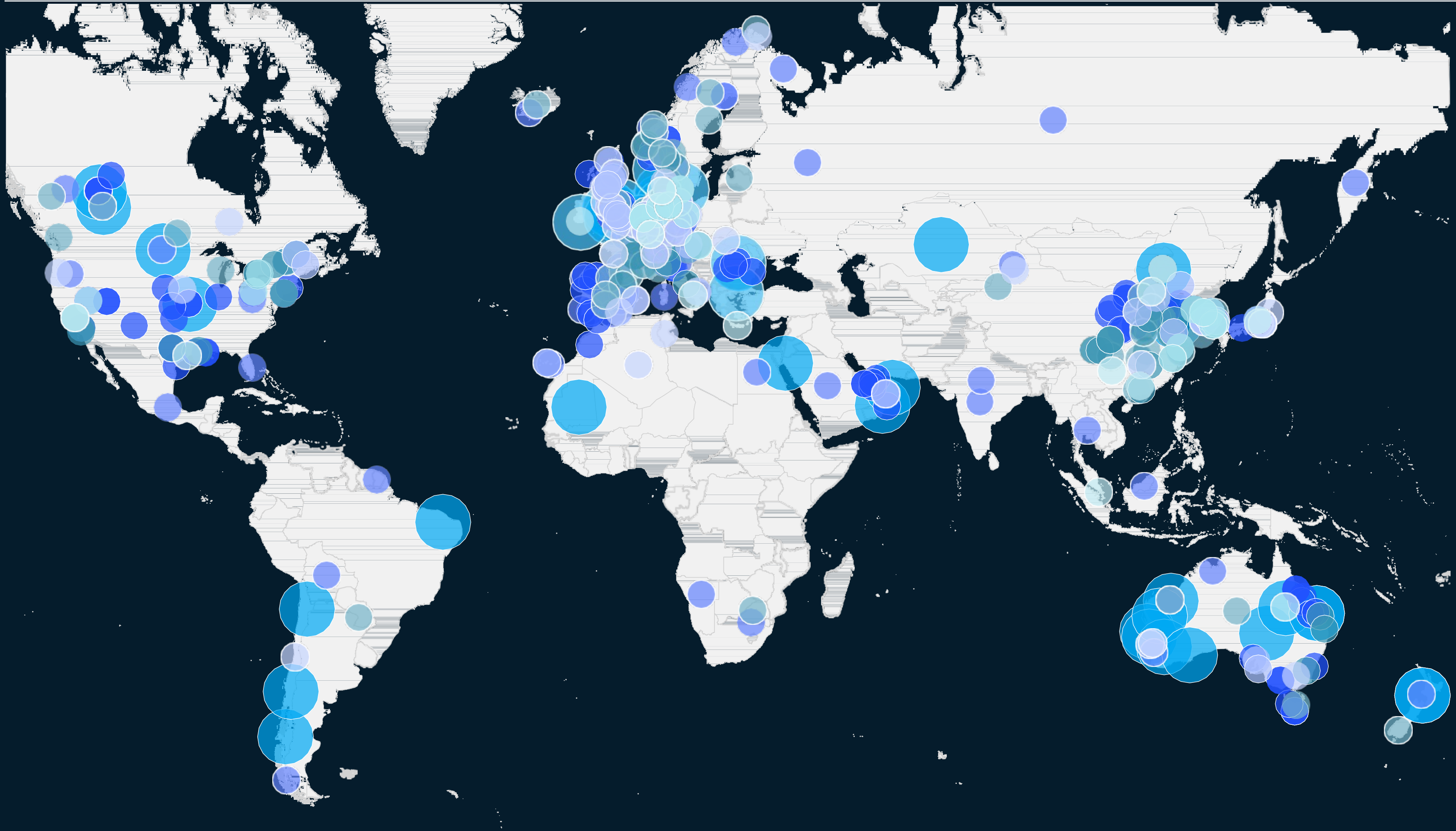
- Public domain
- Outside the fence
- Public project proponent
- Public Customer
- Residential sector
- Public risk profile
- New users / markets
- Energy markets / utility integration
- Environmental / Sustainability attributes

## Implications:

- Mega growth
- International Standards
- Maturing Standards
- Global Tech Regulations
- Extension
- Regulation of new applications space
- Sustainability agenda

# Global Perspective

# Strong momentum globally with more than 520 projects announced



**43**
**Giga-scale production**
Renewable $H_2$ projects >1 GW, low-carbon $H_2$ projects >200 ktpa

**221**
**Large-scale industrial usage**
Refinery, ammonia, methanol, steel, and industry feedstock

**133**
**Transport**
Trains, ships, trucks, cars and other hydrogen mobility applications

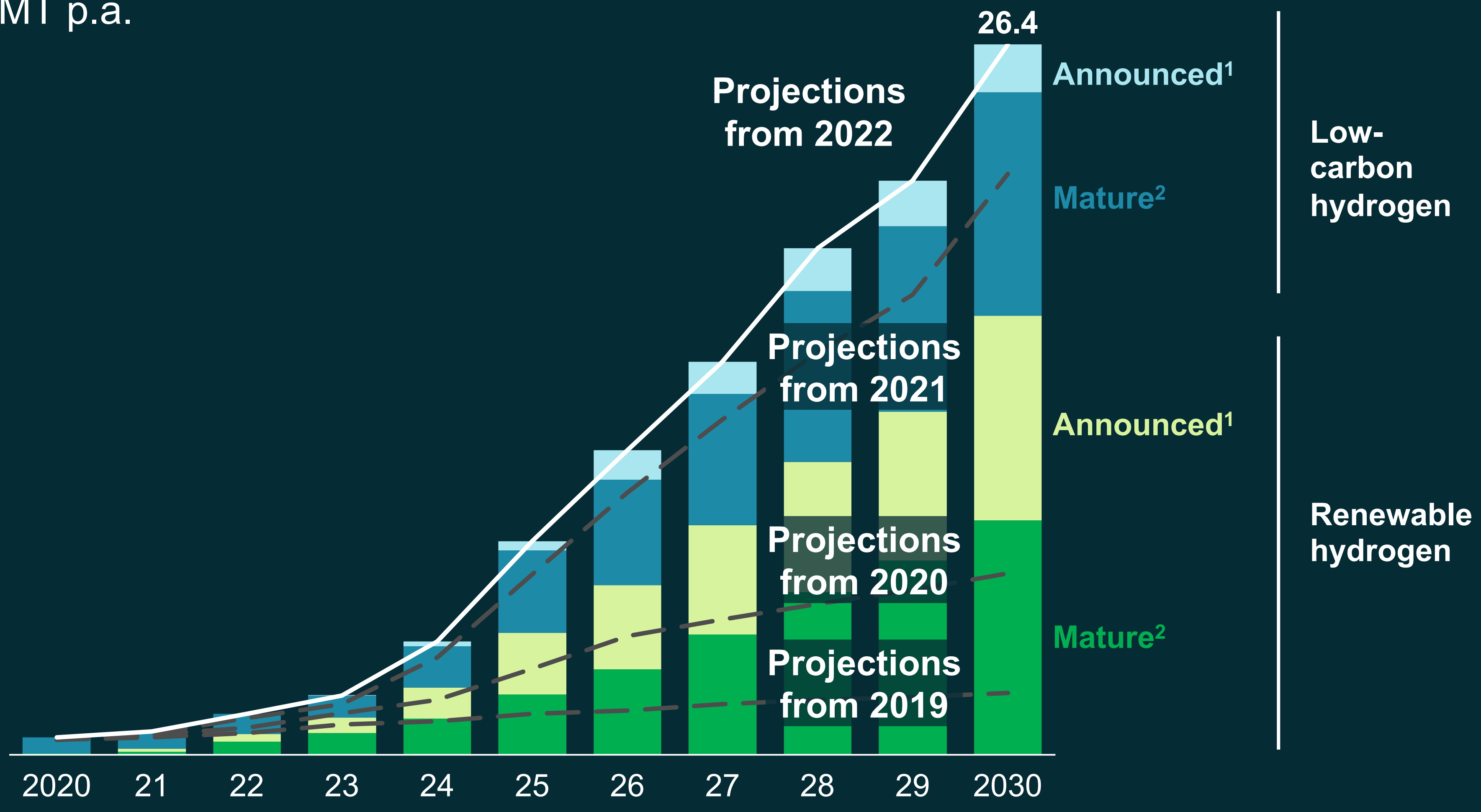
**74**
**Integrated $H_2$ economy**
cross-industry, and projects with different types of end-uses

**51**
**Infrastructure projects[2]**
$H_2$ distribution, transportation, conversion, and storage

1.Focus on projects of >1 MW, including commissioning after 2030, >1000 small scale projects and project proposals not included
2.Includes 9 hydrogen production projects in China without announced end-use

# Announced clean hydrogen production capacity almost quadrupled since YE 2020

**Cumulative production capacity**
MT p.a.




## 3.9x capacity

increase in capacity announced in the past 16 months

## 176 GW

electrolysis capacity by 2030 announced

## +15.2 MT

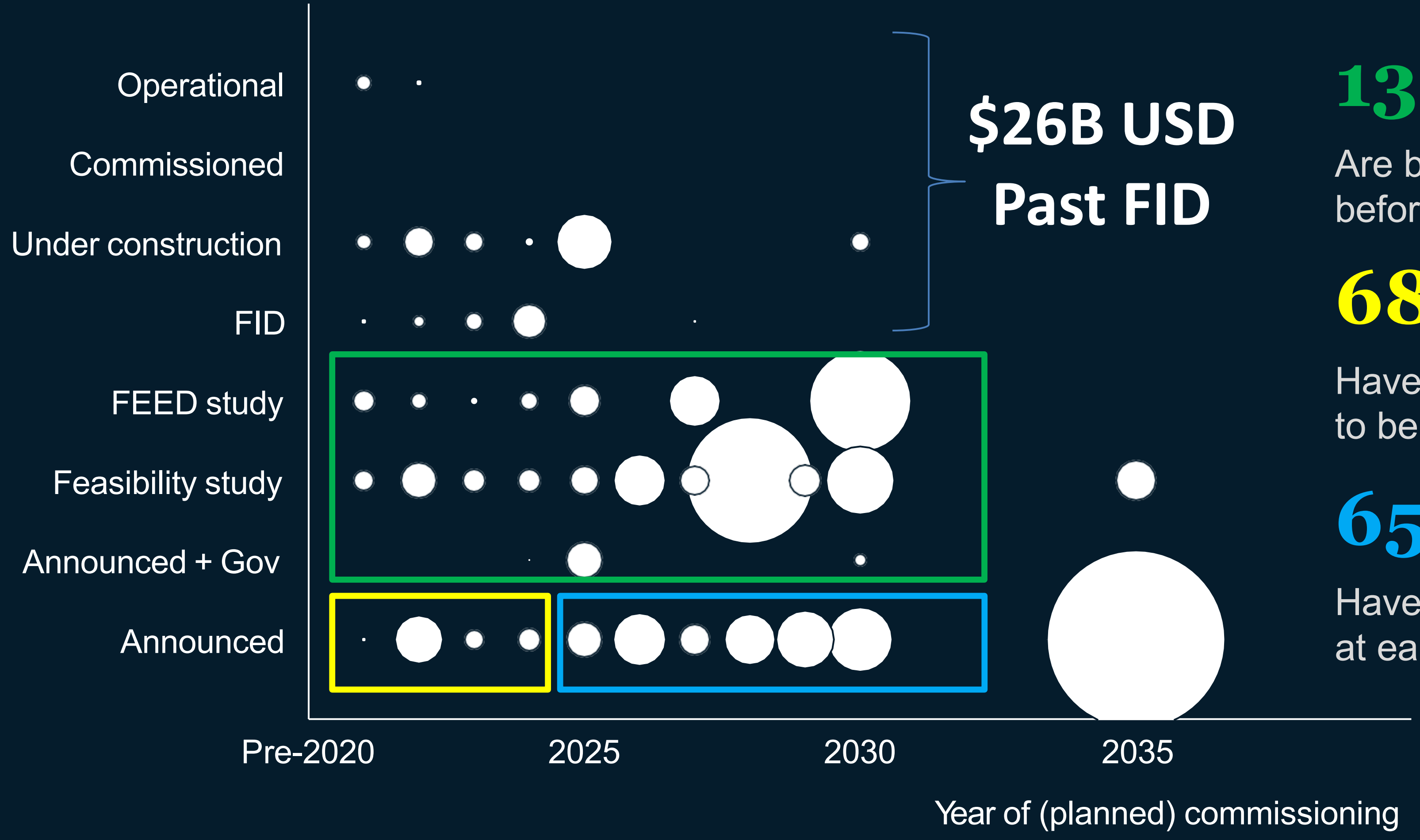
additional capacity (low-carbon and renewable) announced for post-2030

1. Preliminary studies or at press announcement stage
2. Feasibility study, front-end engineering and design stage, final investment decision has been taken, under construction, commissioned or operational

Source: Project & Investment tracker, as of April 2022, McKinsey

# Project sizes are increasing and there are ~78 bn of projects under development, likely to seek funding in the next years

**Average estimated investment of announced projects[1]**




**135 projects, 78 bn**

Are being developed and will seek funding before 2030

**68 projects, 19 bn**

Have been announced for < 2025, but need to be developed

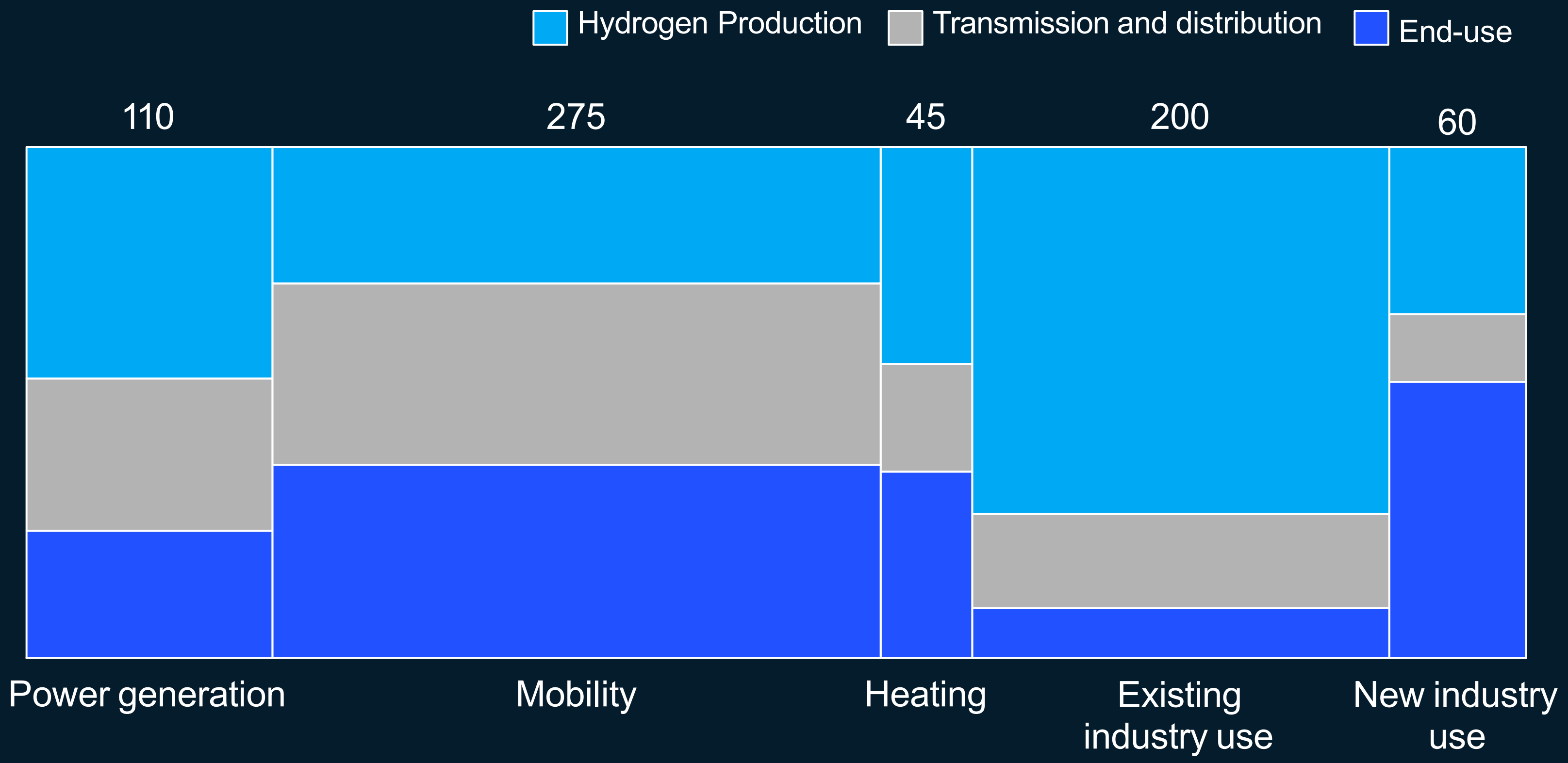
**65 projects, 49 bn**

Have been announced for 2025-30 and are at early stage

1. Estimated deployed investment by 2030. Projects with commissioning date post-2030 show full investment

# Step-up of investments to ~700bn needed until 2030

**Global hydrogen investment requirement by 2030**
(direct investment, by sector),
USD bn




## USD 300 bn

Required for hydrogen production (excluding new-build renewables)

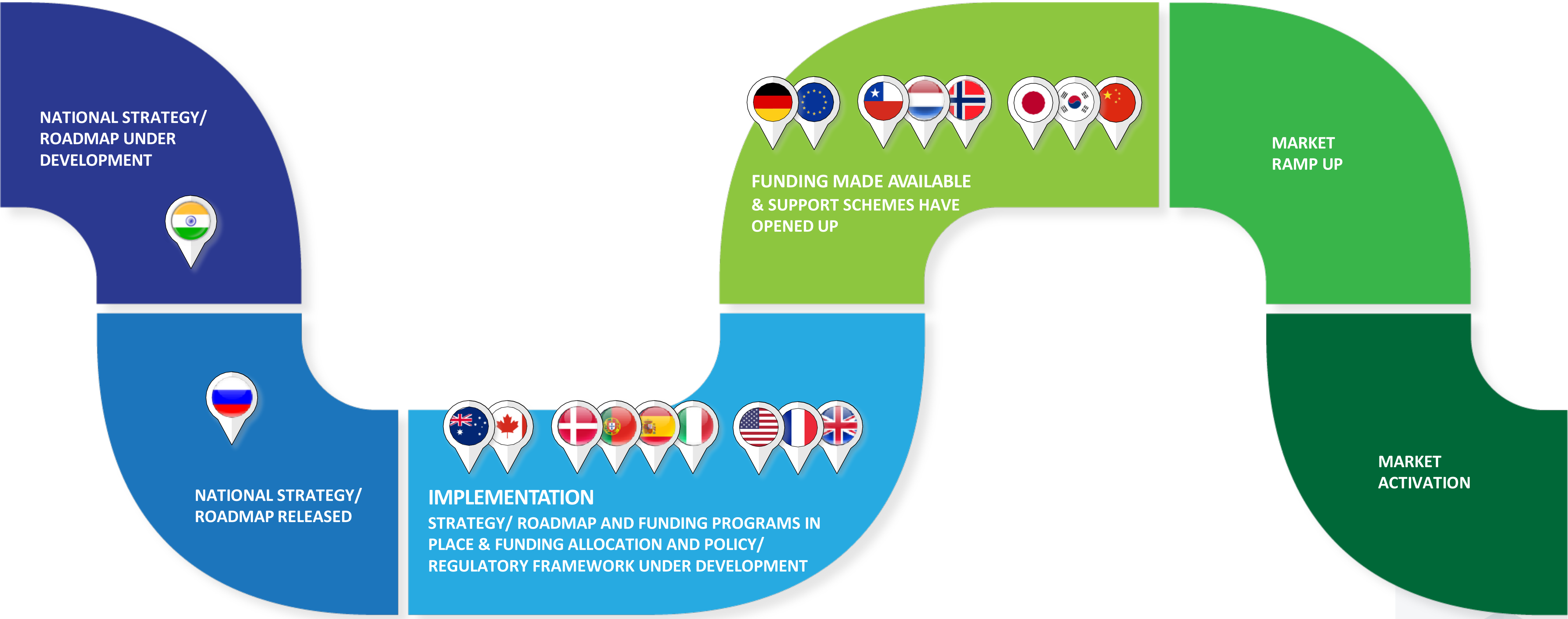
## USD 200 bn

required to build out global hydrogen shipping, pipelines, local distribution and conversion

## USD 200 bn

for hydrogen end-use applications, e.g. industrial plants, vehicles, refuelling stations etc.

# Implementation Progress Tracking

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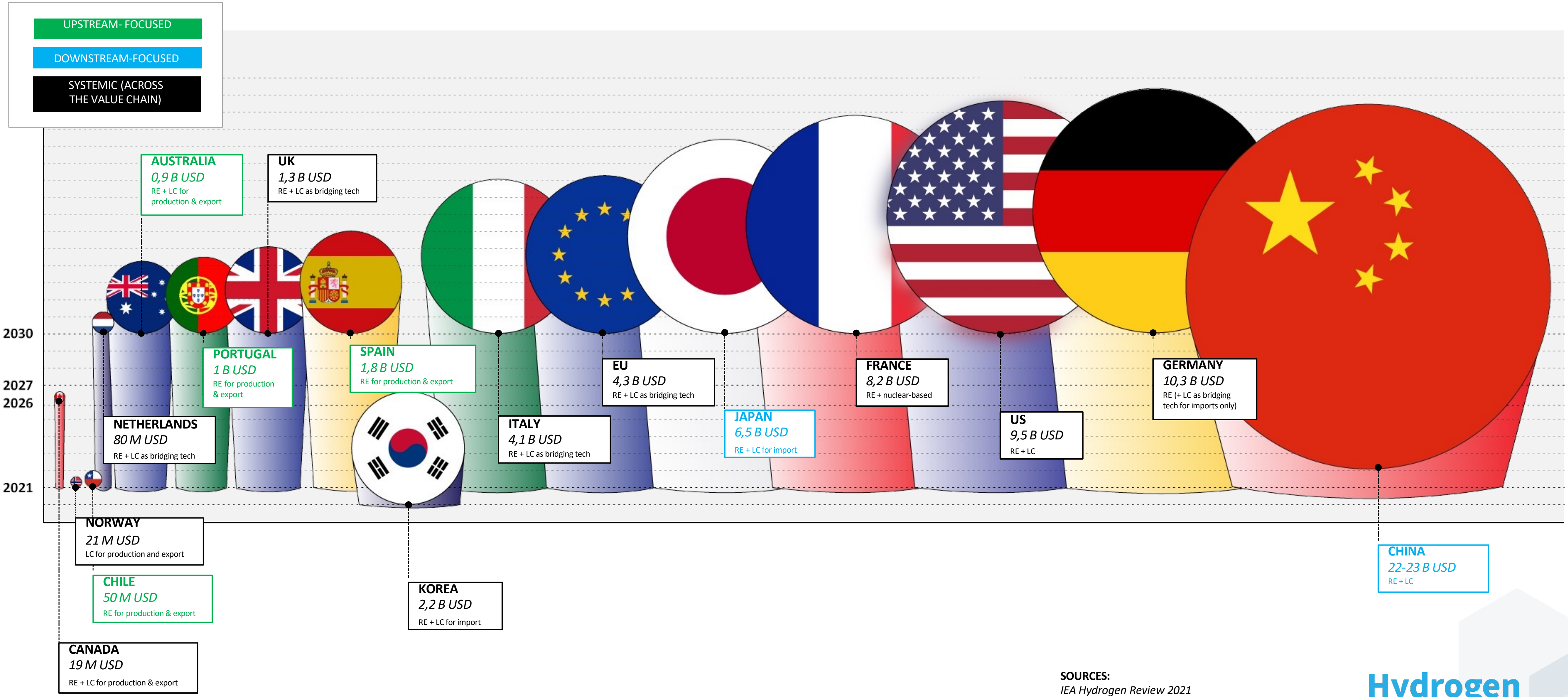
# Status of Hydrogen Funding




SOURCES:
*IEA Hydrogen Review 2021*
*Hydrogen Europe Clean Hydrogen Monitor 2021*
*National hydrogen strategies*

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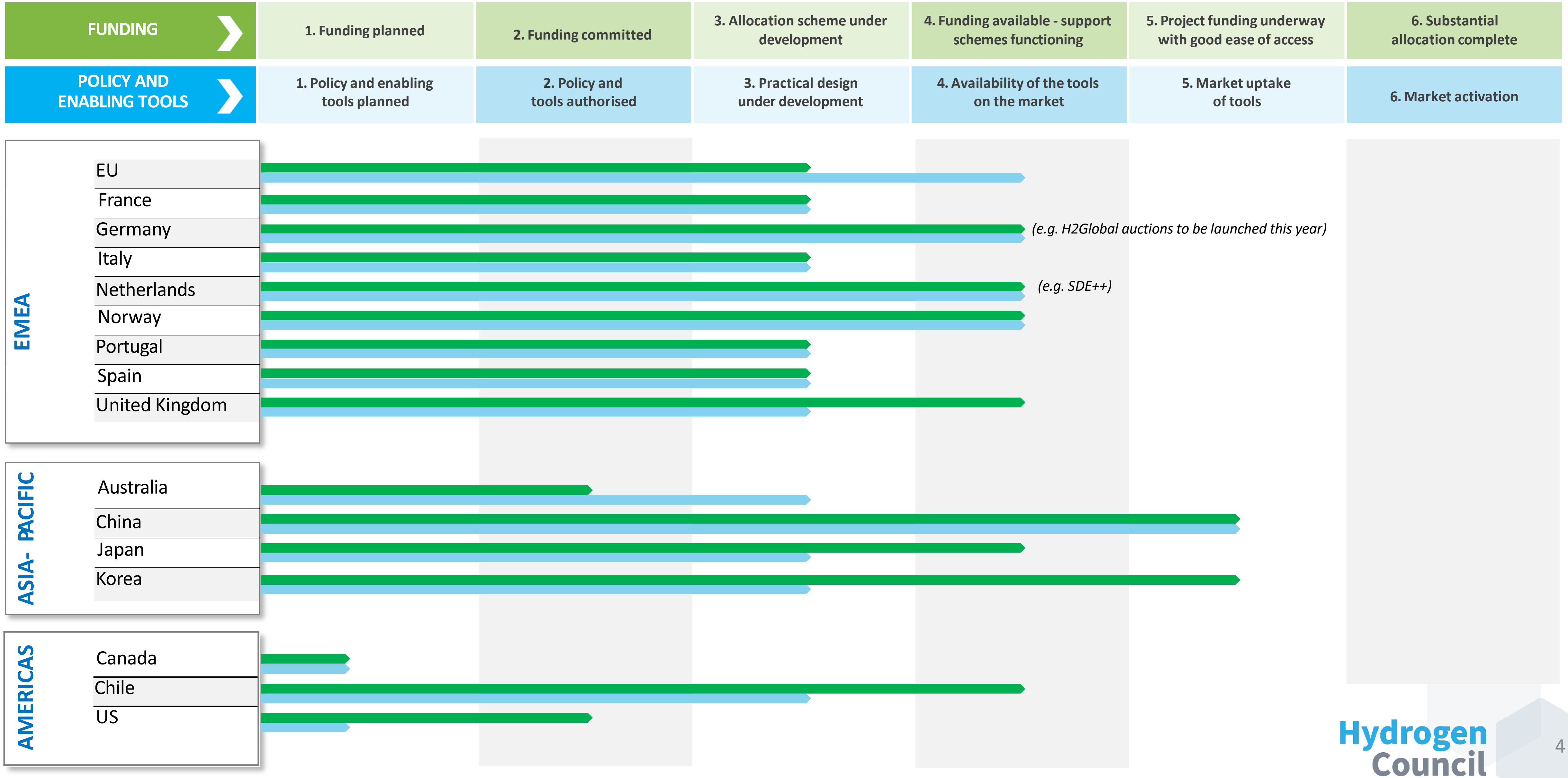
# Funding & Policy Implementation Progress



# Industry Evolution

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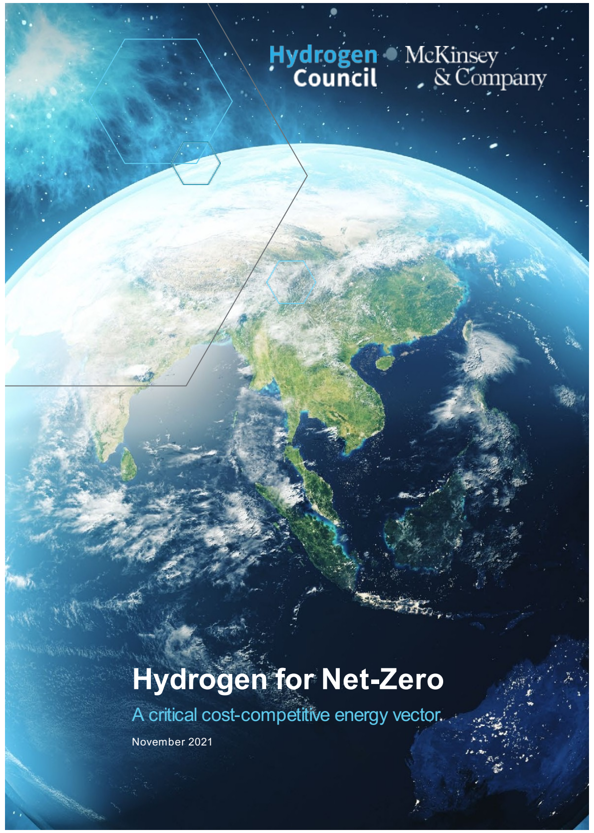
# Hydrogen Council's latest reports presented at COP 26

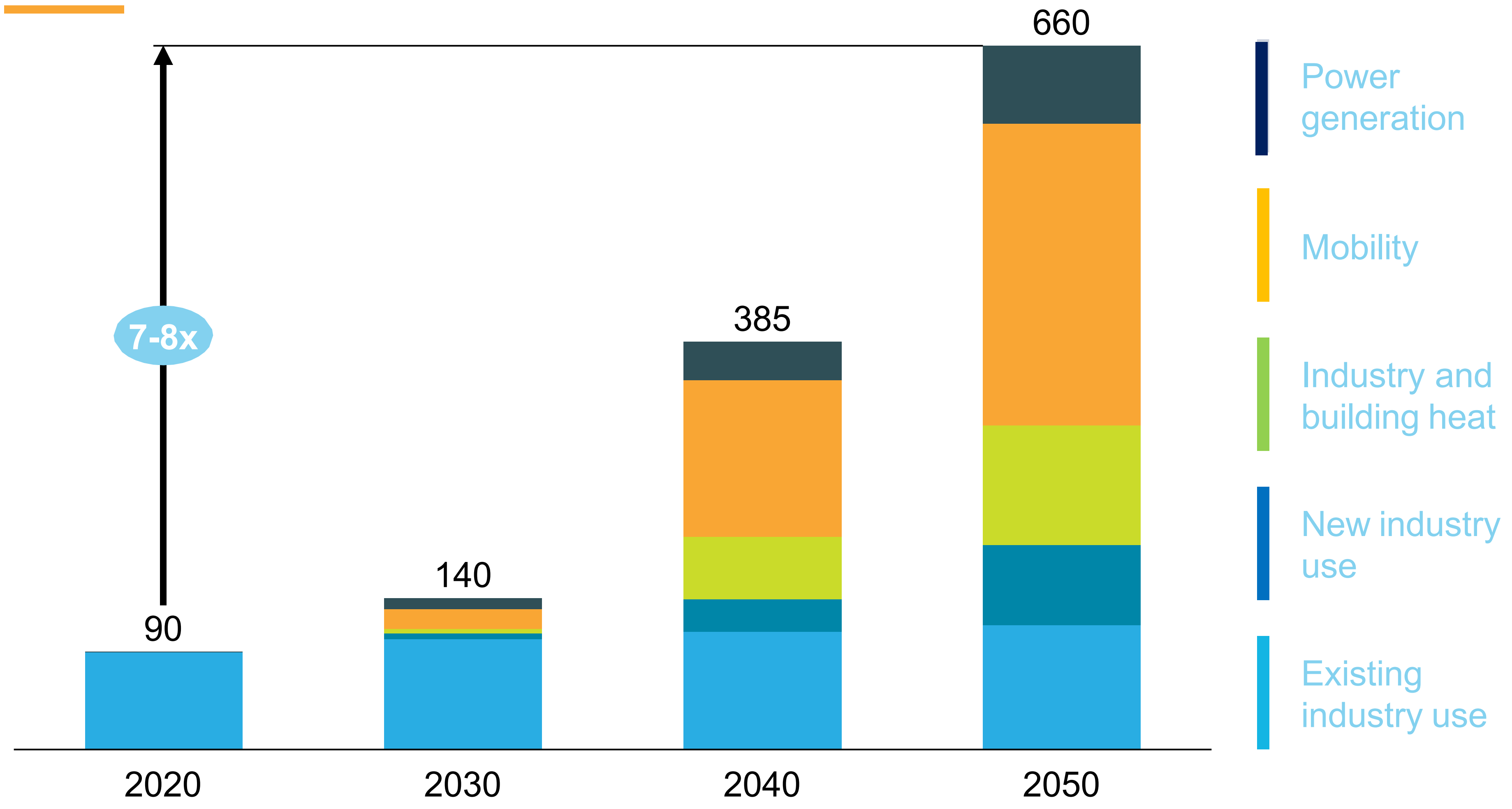
- Hydrogen For Net Zero - exploring the carbon abatement potential of hydrogen by 2030 and by 2050
- Policy Toolbox for Renewable and Low Carbon Hydrogen - setting outs key pillars of efficient policy design to underpin the enabling frameworks for hydrogen (covering the entire value chain and different stages of market maturity)
- Roadmap towards zero emissions in transport - exploring the complementary role of BEVs and FCEVs




# 1. Insights from the Hydrogen Council's *Hydrogen for Net Zero* report

# Hydrogen is essential to achieve net-zero long-term

- Hydrogen end-use demand by segment, MT $H_2$ p.a.




22%

of global final energy demand[1]

660 MT

hydrogen required p.a. in 2050 for net-zero

1. IEA net-zero scenario with 340 EJ final energy demand in 2050. HHV assumed. Excluding power.

Source: IEA Net Zero by 2050

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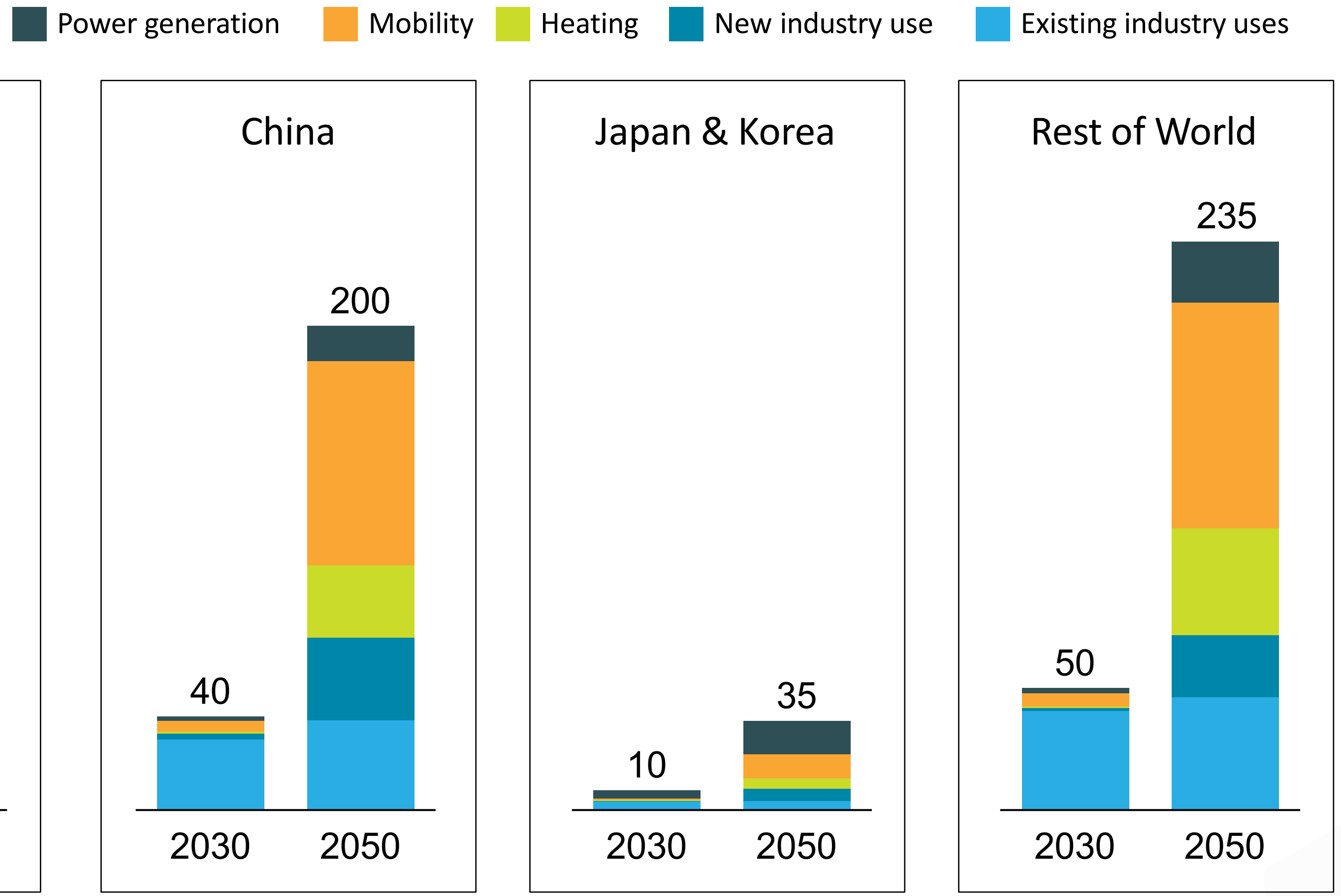
# China, Europe, and North America will be the largest hydrogen markets in 2050

- Hydrogen end-use demand by region, MT $H_2$ p.a. in 2030 and 2050

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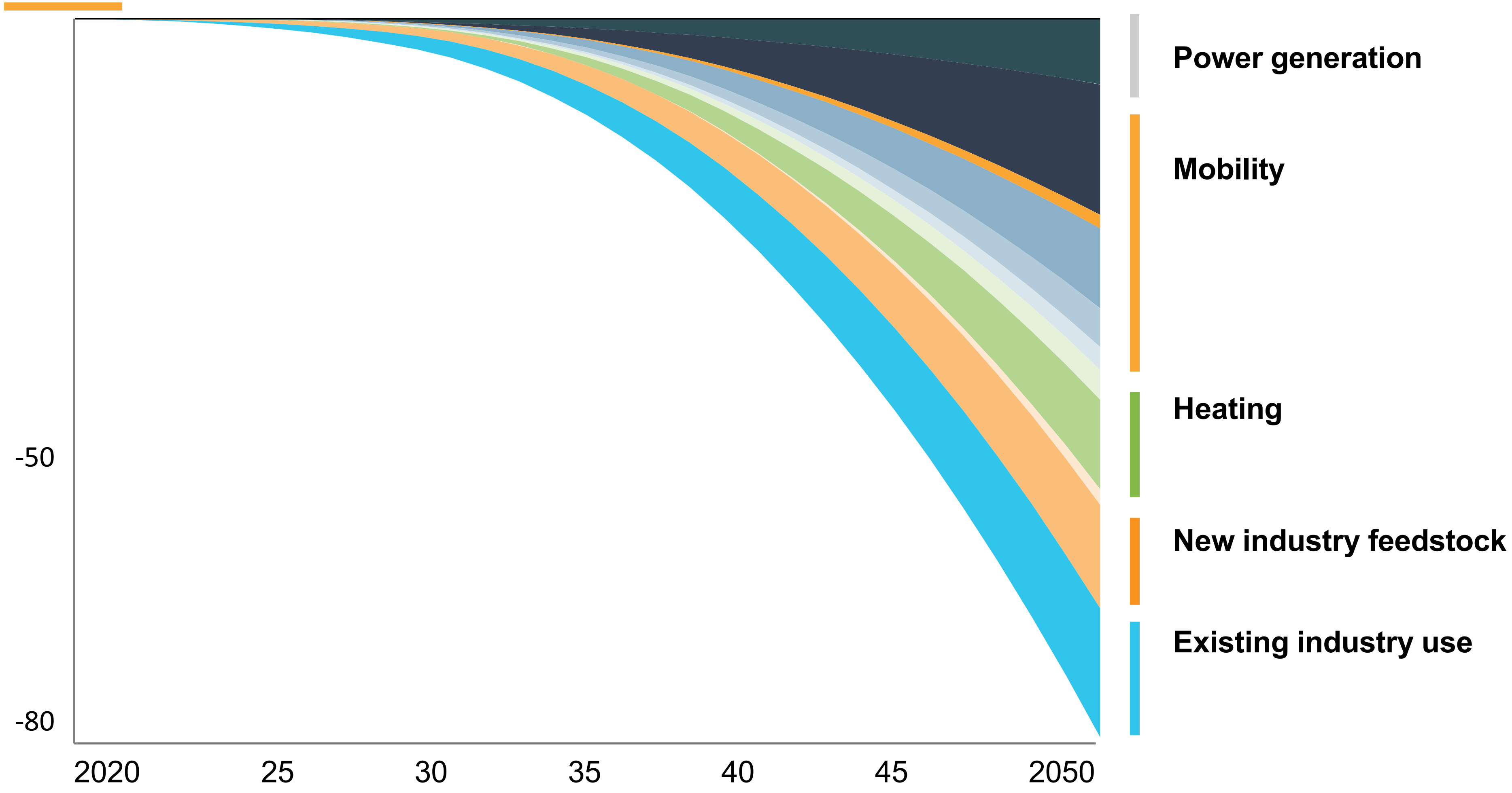
# Clean hydrogen can abate 80 GT $CO_2$ until 2050

**$CO_2$ abated from hydrogen end-use,** gigaton $CO_2$ cumulative until 2050




## 80 Gt

cumulative abatement by 2050 - or ~11% of total abatement required to remain within the carbon budget[1]

## 20%

of annual emissions avoided due to H2 in 2050 (current trajectory ~35 Gt $CO_2$ emitted p.a. in 2050)

1. Assumes annual emissions gradually decline to 35 GT in the year 2050 in current trajectory and a $CO_2$ budget 420 GT

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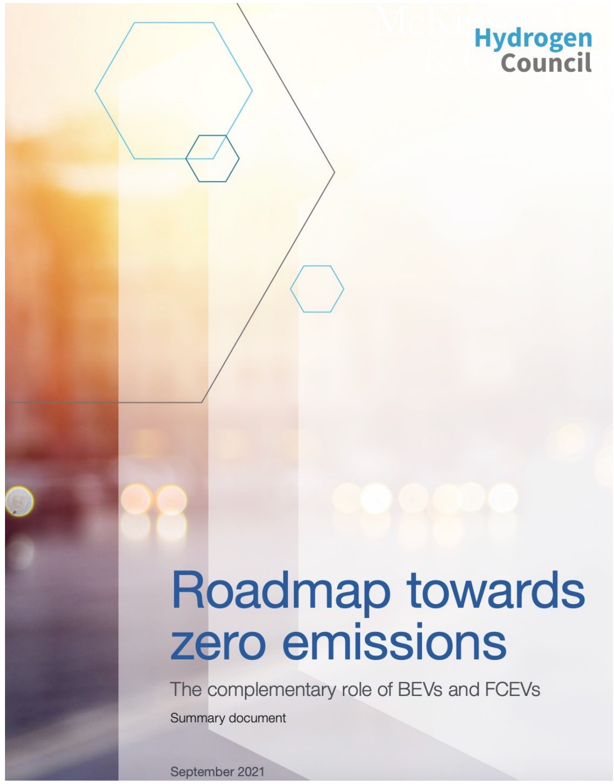



# 2. *Roadmap towards Zero Emissions:*
# *The Complementary Role of BEVs and FCEVs*

# Transport accounts for a large share of emissions and needs to contribute

Road transport accounts **for more than 20% of final energy** consumption[1].

Here, **fossil fuels today account for even more than 95% of the energy** supply.

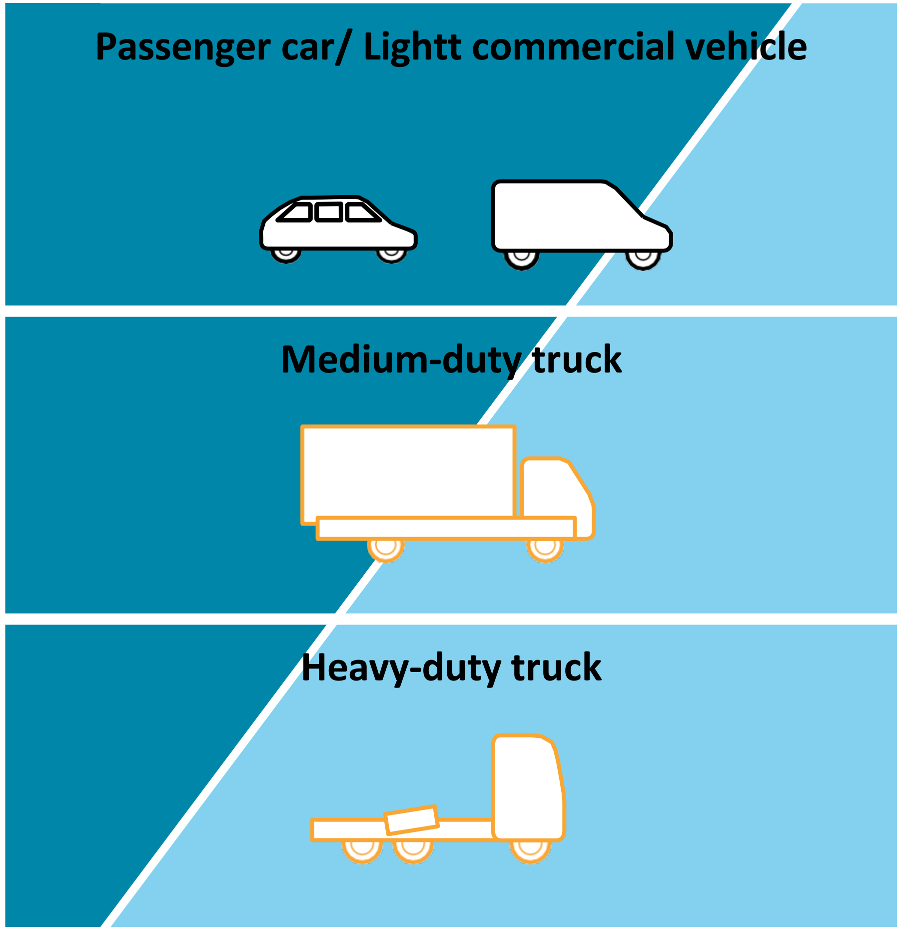
Thus, road transport will need to contribute massively to the **global decarbonization** race.

**Total global CO2 emissions**, 2020 (Gt)


1. IEA Net Zero by 2050 Report

# In road transport, Hydrogen augments direct electricity use – both BEV and FCEV are needed

| **Battery** (BEV) | **Relevance in segment** (illustrative) | **Fuel Cell** (FCEV) |
|---|---|---|




BEVs are vital for **enabling fast decarbonization** of transport and will be **mainstream** in **many use cases**

For **important segments** of road transport, **hydrogen** is the best option:

- Regions with **constrained renewables** or **grid capacity** in the mid-to-long term
- **High power and energy demand** vehicle segments
- Use cases and customer segments with a preference for **long range and refueling**

# 12 facts about the complementary role of BEV and FCEV

- Why a "combined world" will be greener, faster, and cheaper

## Greener

**1 Comparable systemic efficiency**
In a systemic view, BEVs and FCEVs have comparable "wind/sun-to-wheel" efficiencies

**2 Similar $CO_2$ life-cycle**
BEVs and FCEVs similarly beneficial in CO2 life-cycle assessment

**3 Storage & import**
Hydrogen can store local RE across seasons and enable RE import from optimal production locations

**4 Resource demand reduction**
Lower total resource demand due to re-use of recycled platinum and reduced Nickel, Cobalt, Lithium mining

## Faster

**5 Independence from electricity mix**
One path is not enough: Faster decarbonization can be combined with a low carbon energy system independent from electricity mix

**6 Additional capacity**
Transition towards decarbonized transport just kicking off, BEV and FCEV needed to accelerate

**7 Building momentum**
Greater momentum on hydrogen than is visible on the road

**8 Convenience & flexibility**
Convenience and flexibility are key customer needs, which FCEV can meet with long range, fast refueling

**9 Situational benefits**
Optimal choice is not black-and-white, varies by location and context of use

## Cheaper

**10 $H_2$ cheapest option**
Getting from A to B with hydrogen will be the cheapest option in many road transport segments already in this decade

**11 Infrastructures complement each other**
Two infrastructures are cheaper than one: hydrogen supply can reduce peak loads and thus reduce necessary grid upgrades

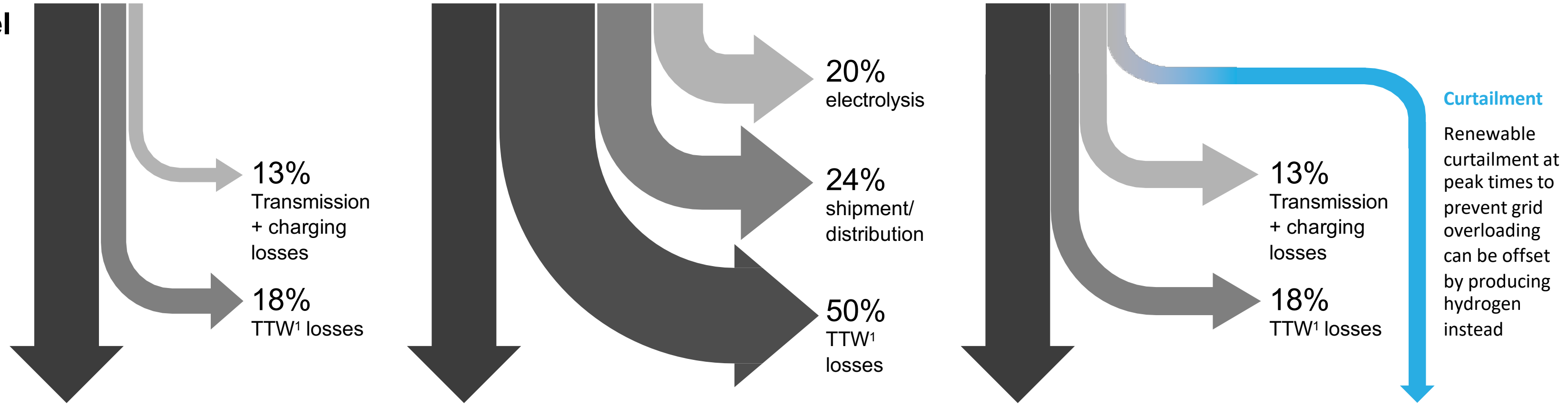
**12 De-risking by hedging**
Hedging our bets on two pathways de-risks the most significant transition in the automotive industry's history

# 1 In a systemic view, BEVs and FCEVs have comparable "sun-to-wheel" efficiencies: case Germany

- Illustrative pathway example: Exact efficiency of each component can vary depending on context

| | BEV charged using local PV panel | FCEV powered with imported renewable hydrogen from PV in Middle East | BEV charged using local PV panel; peak supplies renewable H2 for FCEV fueling |
|---|---|---|---|
| Sun-to-Wheel | 1 kW Solar panel Germany X 11% Load factor | 1 kW Solar panel Middle East X 25% Load factor | 1 kW Solar panel Germany X 11+2% Load factor |
| | 950 kWh | 2,200 kWh | 950 + 200 kWh |

**Well-to-Wheel**




| | | | |
|---|---|---|---|
| | 680 kWh | 660 kWh | 680 + 70 kWh |
| **Passenger car km/year from 1 kW renew-able source** | ~6,100 | ~5,900 | ~6,100 + ~600 |

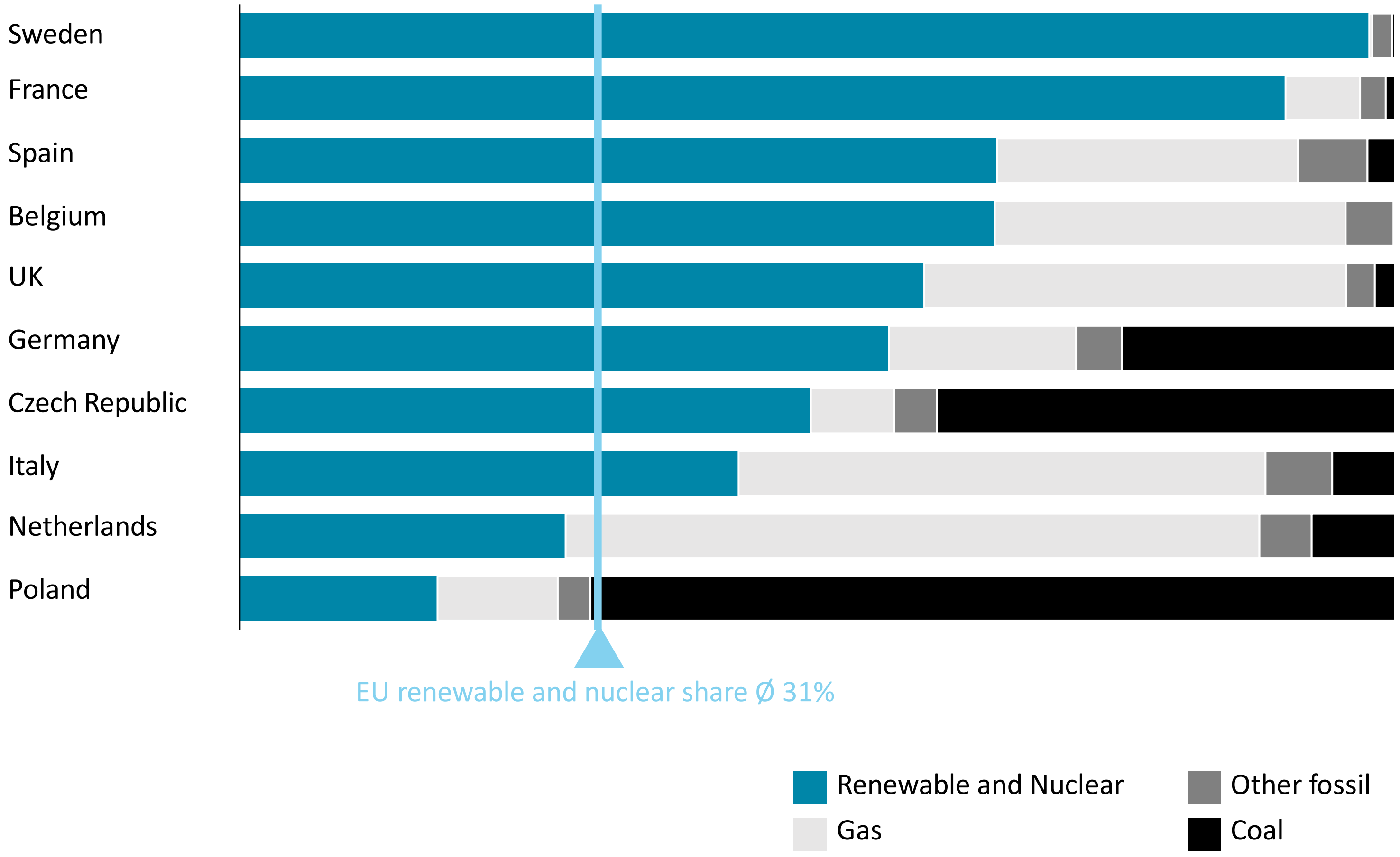
1. Tank-to-wheel losses; 4% Battery, 7% power electronics, 4% motor drive electronics, 4% gearbox; FCEV stack 39%; FCEV BoP 10%; FCEV addtl. recuperation -10%

Note: There are additional effects along the life cycle that can bring further energy balance benefits to FCEV
Assumptions: 11,2 kWh/100km WLTP consumption at wheel (Tesla Model 3 Std. Range); 20% curtailment losses forecasted for a steady-state German renewable electricity scenario
Source: Expert interviews; Kim et al. (2020); Nedstack (2019); Lohse-Busch (2019); NREL; Büchi et al. (2005); Eberle & Helmolt (2012); Sun (2010; Besselink et al. (2010), H2 Council Cost Roadmap

- Easy **storage and long-distance shipment** of Hydrogen from optimal regions
- Renewables can be used more effectively
- **Increased total amount of energy available** from same renewable installation
- Local H2 generation not subject to **demand fluctuation or grid constraints,** thus avoids curtailment

# 5 One path is not enough: Every FCEV contributes to decarbonization on top of the shift in the electricity grid

**Grid electricity by source in Top 10 EU countries** % of generation, 2020

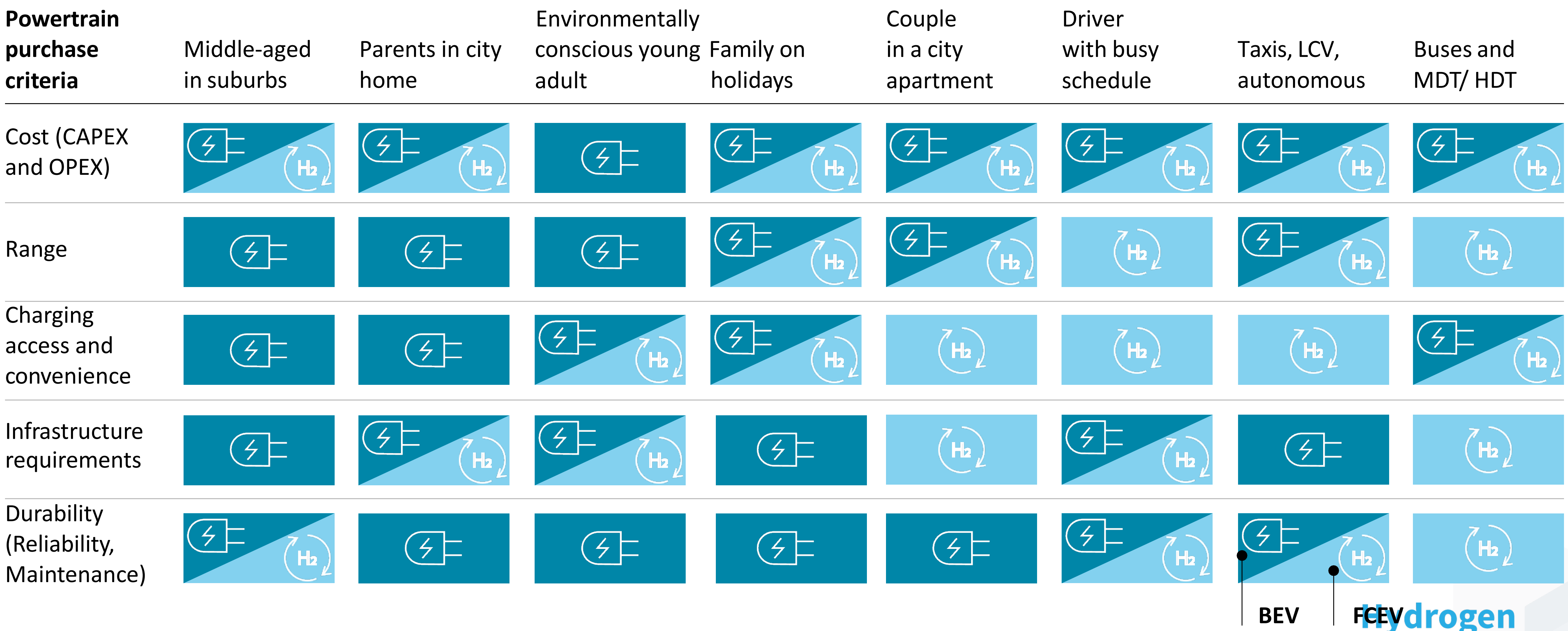



- **Today's grid electricity** (used to charge BEVs) is **not decarbonized** in many countries
- Renewable and low-carbon **Hydrogen as additional decarbonized energy source** independent from grid electricity
- Thus, **every additional FCEV vehicle fueled with renewable or low-carbon hydrogen contributes** to **decarbonization** beyond ongoing shift in the electricity grid

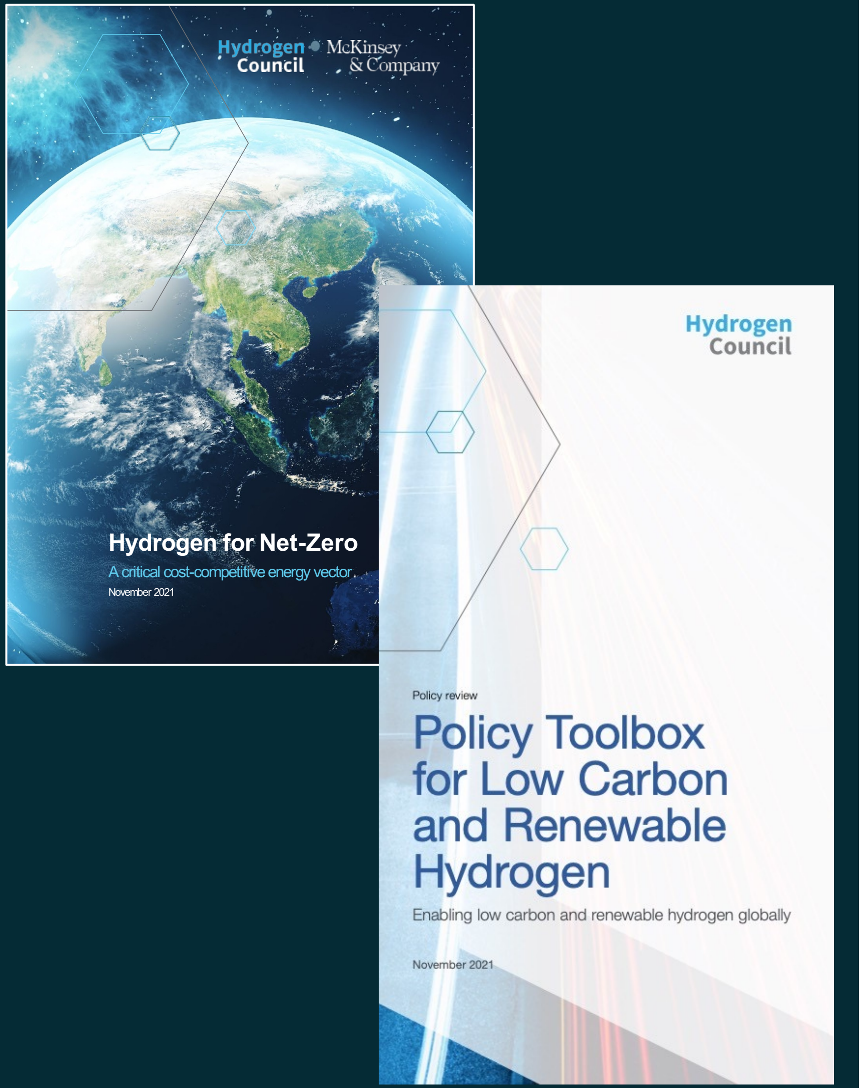
Source: McKinsey EU Power Model January 2020, Eurostat, EEA

# 9 The optimal choice is not black-and-white, it varies according to the location and context of use

**Stereotypical user personas**



## Clean hydrogen can abate 80 GT $CO_2$ by 2050 and 730 MT $CO_2$ by 2030




## …and the Hydrogen Council Policy Toolbox provides a practical guide for policymakers who want to tap into this potential

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### The Policy Toolbox is designed to

- **Capture the evolution of policy design** along different stages of hydrogen market maturity
- **Offer insights into the cross-cutting policies and instruments** that are vital to enable cross border trade in hydrogen, such as hydrogen certification systems
- **Set out policy pathways** through country archetype examples that can be used to inform hydrogen policy and regulation in different national and regional contexts
- **Shed light on the societal value** of hydrogen economy development

# Unlocking the full potential of low carbon and renewable hydrogen investment requires a strong and comprehensive policy roadmap

USD bn[1]

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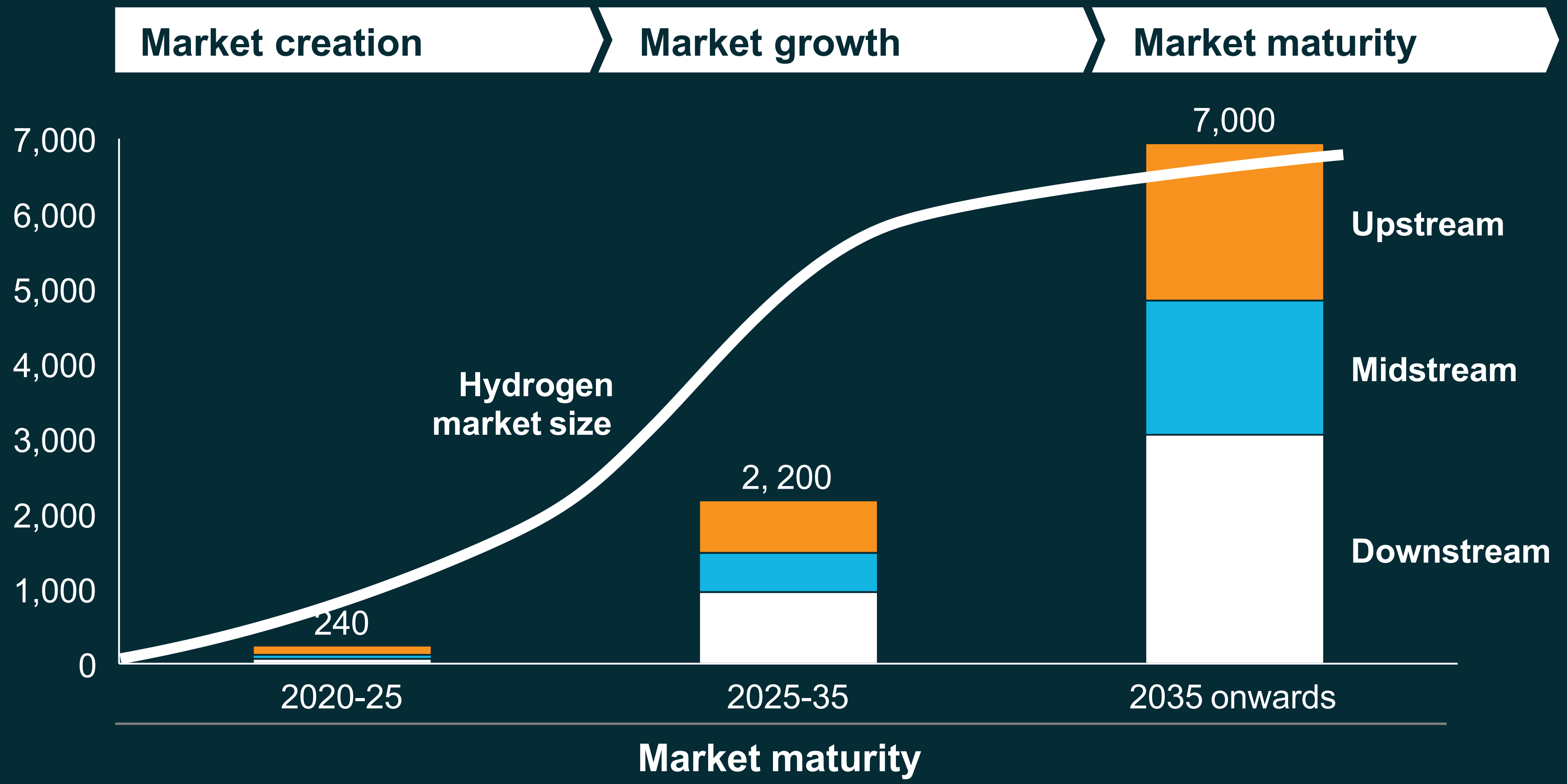


1. Investment in line with the "Hydrogen for Net Zero" scenario; upstream includes hydrogen production (electrolyzers, CCS retrofits for blue H2, new SMR/ATR plants), excludes renewables/gas upstream; midstream includes distribution, transmission (shipping, pipelines, conversion etc.) and storage; downstream investments for end-applications (ammonia plants, fuel cells etc.)

# 6 pillars of efficient policy design for low carbon and renewable hydrogen

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### 1. Make use of local strengths & benefit from cross-border cooperation

Leveraging local strengths is an important starting point in policy design, which should be complemented by cross-border cooperation and trade to unlock efficiency gains.

### 2. Create certainty through targets and commitment

To drive down cost and attract investment, governments can reduce policy-risks and market uncertainty through legislation

### 3. Provide hydrogen-specific support across the supply chain

To catalyze and grow new markets, hydrogen-specific support is required across production, midstream infrastructure and end use sectors (focusing on industry and transport as a matter of priority).

### 4. Support robust carbon pricing

Robust regional carbon pricing mechanisms should be built up from existing schemes and work together with hydrogen-specific support to drive efficient and effective uptake in the longer term.

### 5. Adopt harmonized standards & certification systems

International standards and robust certification systems play a crucial role in the development of the hydrogen economy, enabling cross-border trade in hydrogen.

### 6. Factor in societal value and values

Societal value and values should be factored into policy decisions. Well-designed hydrogen policies can have a positive contribution to several UN Sustainability Development Goals

# 2022 Work Plan

Materials Sustainability Study

Hydrogen Trade  Flow Study

Hydrogen in the Energy System Study

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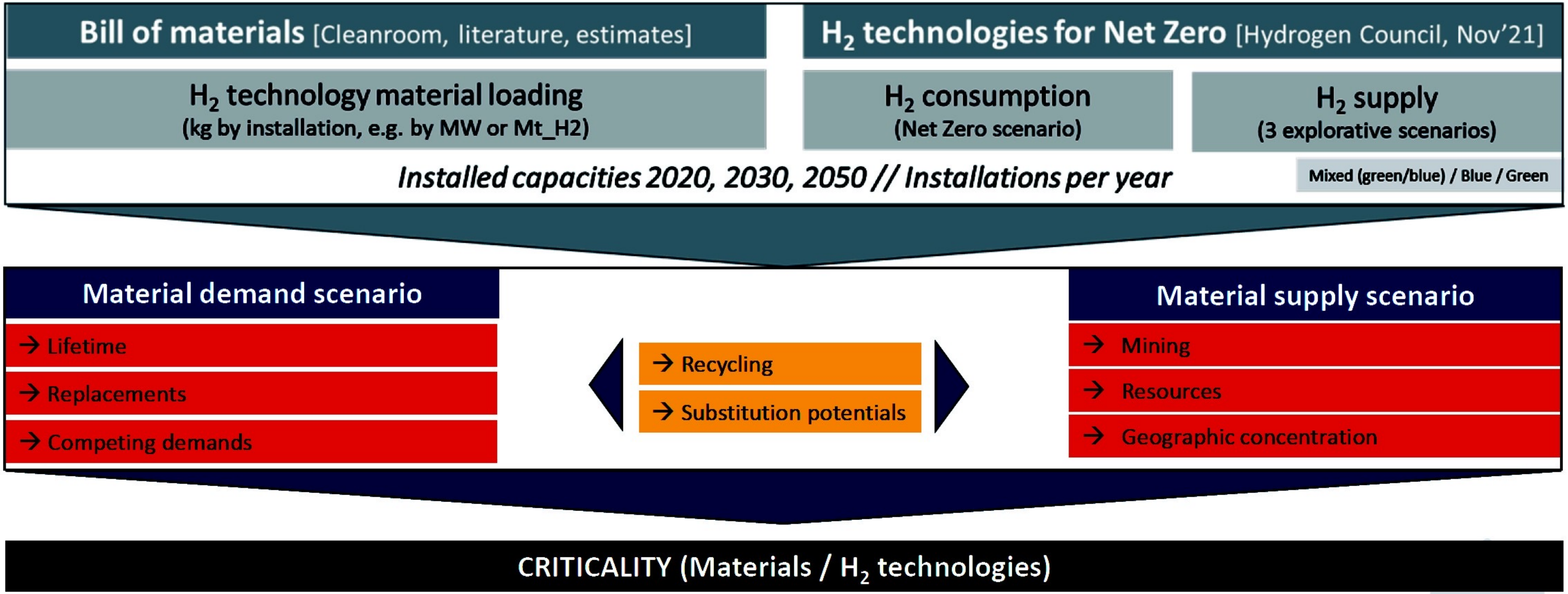
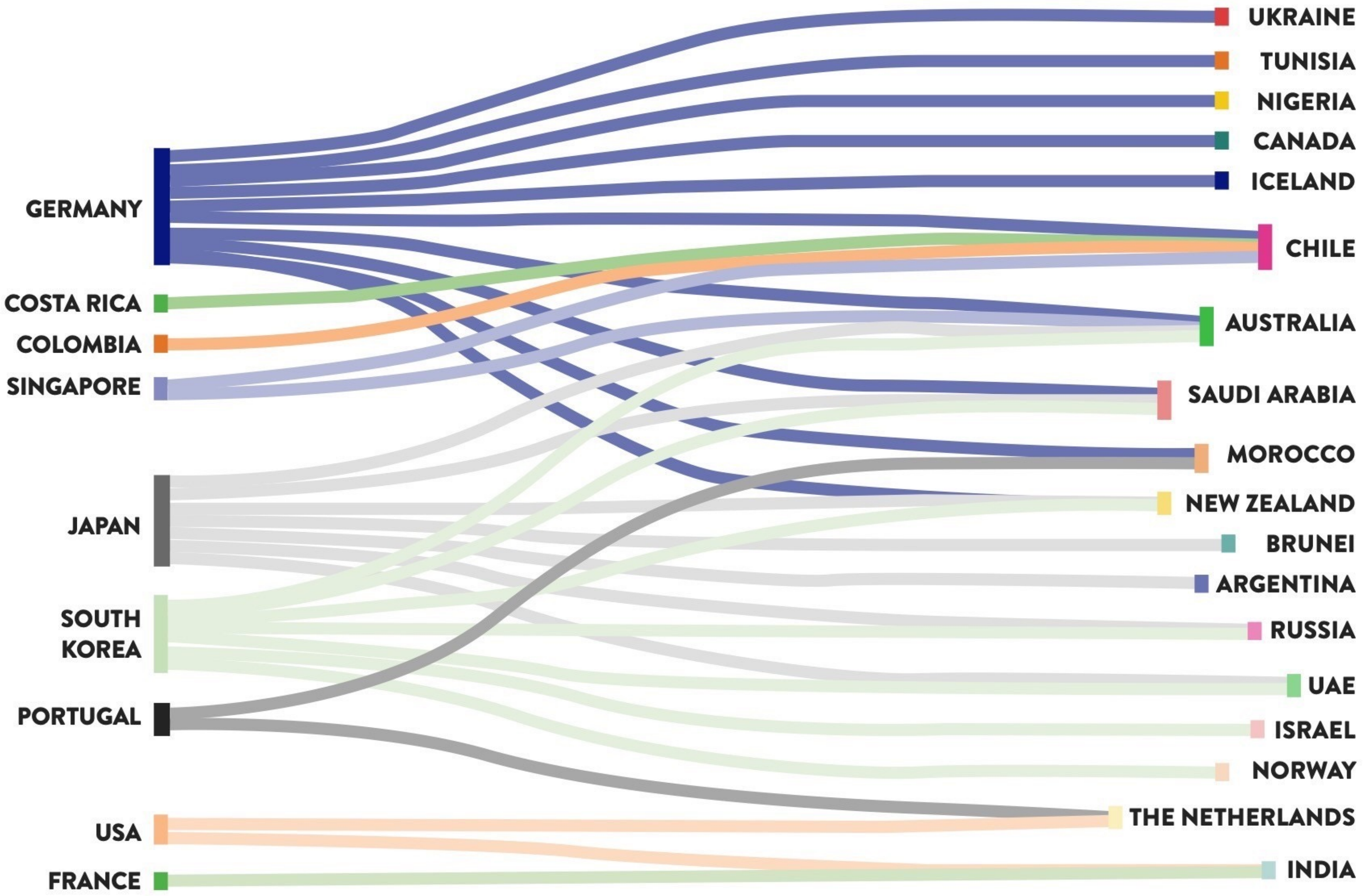
# Materials Sustainability Investigation – July 2022



# New trade paths have be activated by hydrogen Standardization and Certification need Focus now




*Source: WEC, 2021*

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# Hydrogen History is Made January 2022

Left Kobe for Australia on December 24th, 2021

Return to Kobe in March, 2022

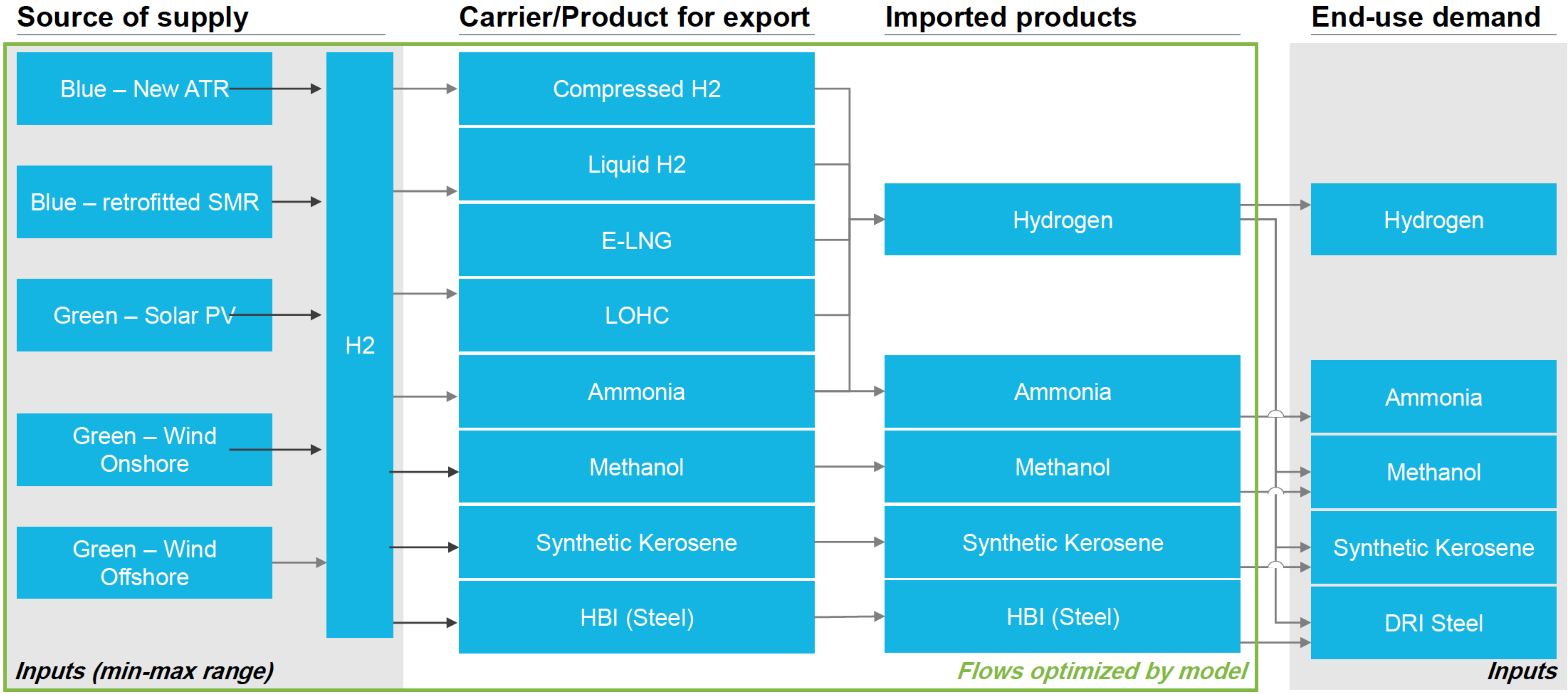
Maiden Voyage Ceremony at Port of Hastings on January 21st, 2022


1869 Oil (153y)
1959 LNG (63 yrs)
2022 Hydrogen

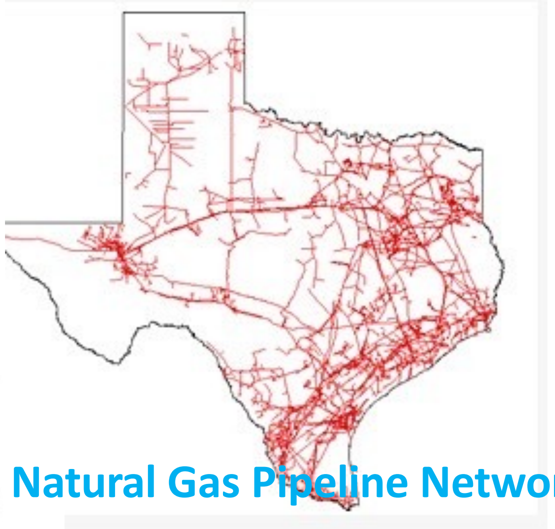
Hydrogen Council

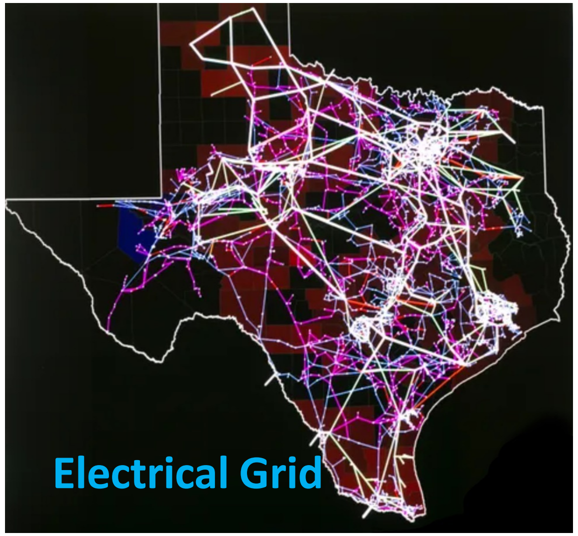
Kawasaki
Powering your potential

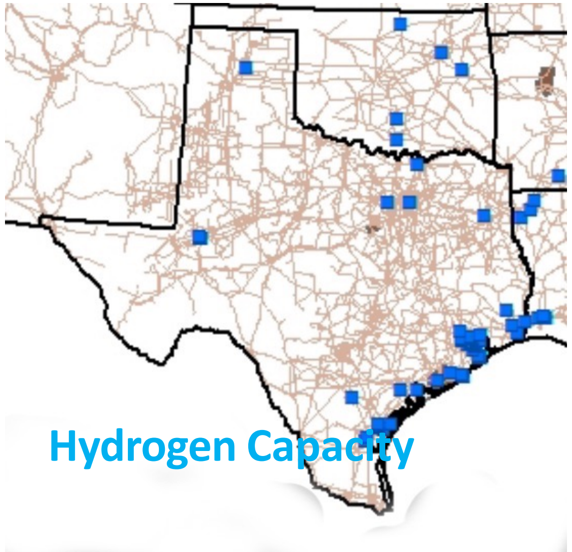
# The Hydrogen Trade Model will identify the cost-minimizing flows between sources of hydrogen supply and end-use products

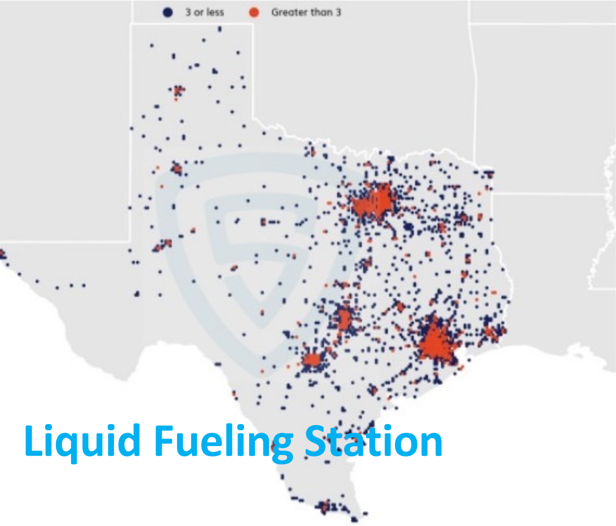


# Over 100 years & Billions of Infrastructure
# How will it work in time and space in 2050?

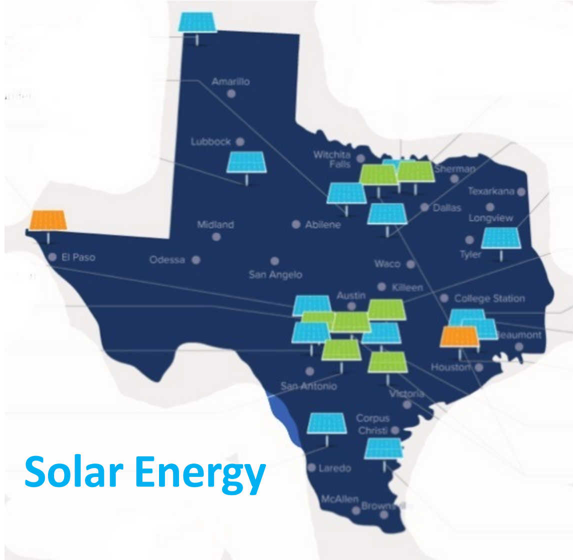

Natural Gas Pipeline Network


Electrical Grid

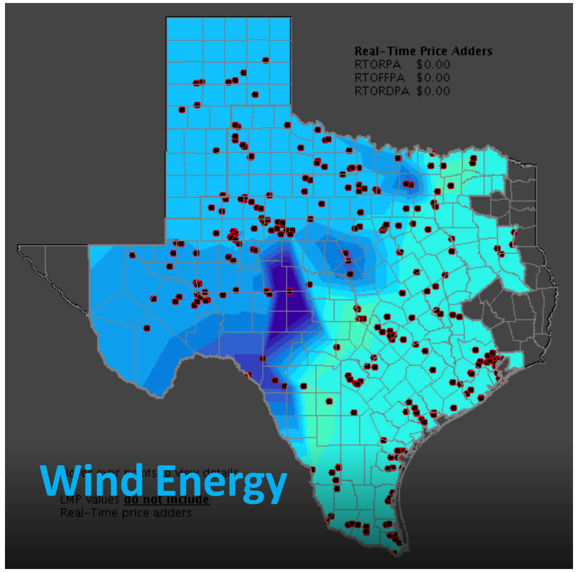

Hydrogen Capacity



Liquid Fueling Station



Solar Energy



Wind Energy

# Some Suggestions on CCS

1. Recognize the need to engage in public dialogue
2. Recognize social license is starting in a deficit position currently
3. Participate in the global standards process for a singular hydrogen certification process and standard
4. Advocate and practice transparency on industry status and progress
5. Make your contribution to mitigation of carbon release:
   - the safest possible
   - biggest possible
   - in the best places possible

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For any questions or comments:

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