

8 / 10 / 2018

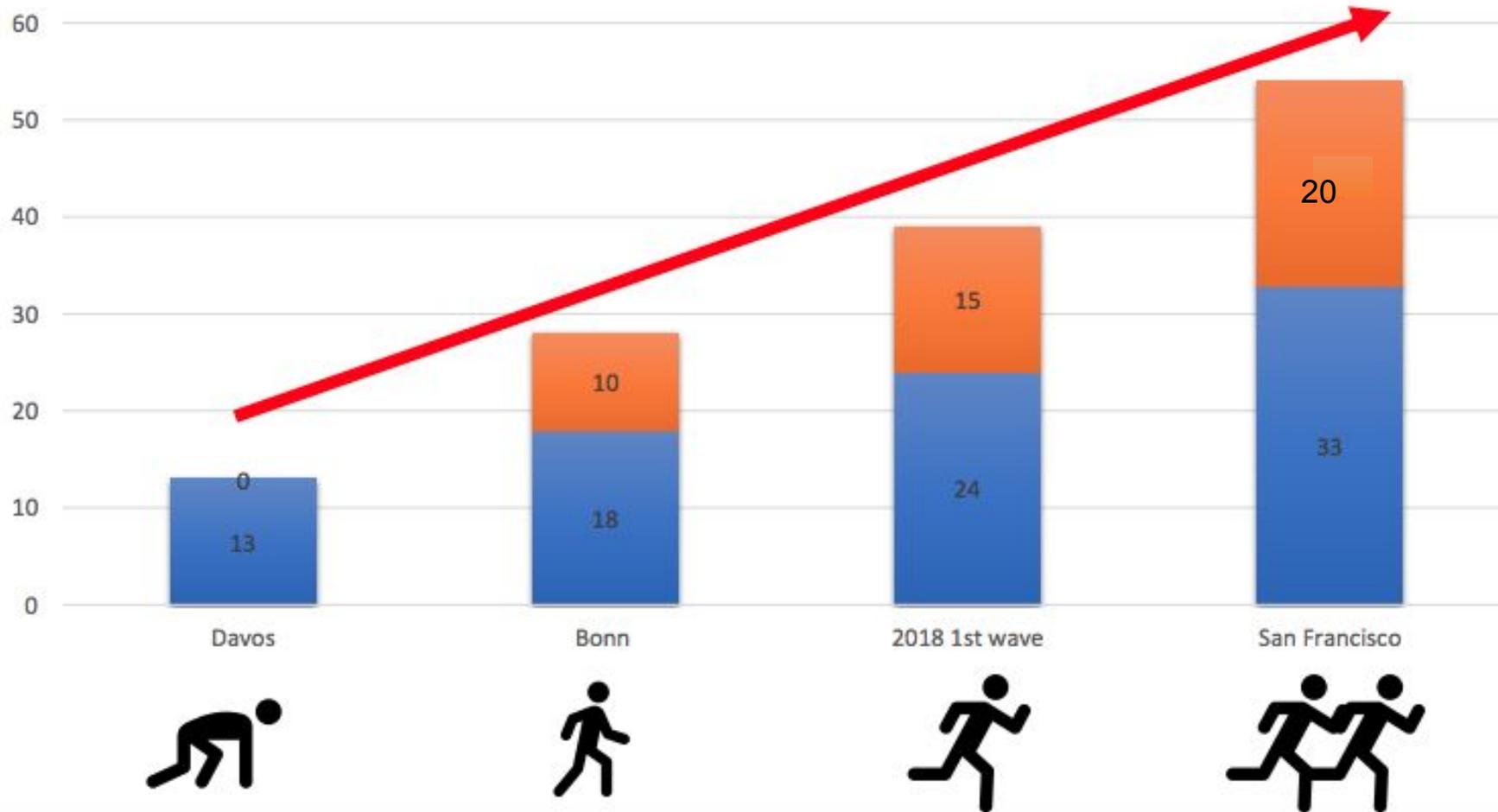
Réunion IDEES - Fondation TUCK

The Hydrogen Council

- A **global CEO-level** initiative, launched at the World Economic Forum 2017, in Davos, January 2017
- With the ambition to:
 - **Accelerate their significant investment** in the development and commercialization of the hydrogen and fuel cell sectors.
 - **Encourage key stakeholders increase their backing** of hydrogen as part of the future energy mix with appropriate policies and supporting schemes.
- Composed of leading energy, transport and industry companies **with a united vision and long-term ambition for hydrogen to foster the energy transition**
- Membership **increased** from 13 steering members to **33 Steering members and 21 supporting members**
- From **11 countries**, covering three main regions : Europe, Asia and North America
- Co-chaired in 2018 by Air Liquide & Hyundai

<http://hydrogencouncil.com/>

QUADRUPLED MEMBERSHIP IN JUST 18 MONTHS





AIRBUS



ALSTOM



BMW GROUP



DAIMLER



Great Wall

HONDA



Iwatani



JXTC Nippon Oil & Energy



TOYOTA

WEICHAI



BALLARD



HYDROGENICS

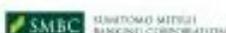
Marubeni



Mitsubishi Corporation



nel*



TOYOTA TSUSHO





AIR LIQUIDE
Creative Oxygen

ALSTOM

AngloAmerican

BMW
GROUP

DAIMLER

ENGIE

HONDA

HYUNDAI

Kawasaki

Shell

THE LINDE GROUP

TOTAL

TOYOTA

Hydrogen Council
January 2017, Davos

World Economic Forum
Davos, January 2017

GCAS side event, SFo, September 2018



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.



Many achievements to promote the role of H2

Launched significant collaborations & partnerships



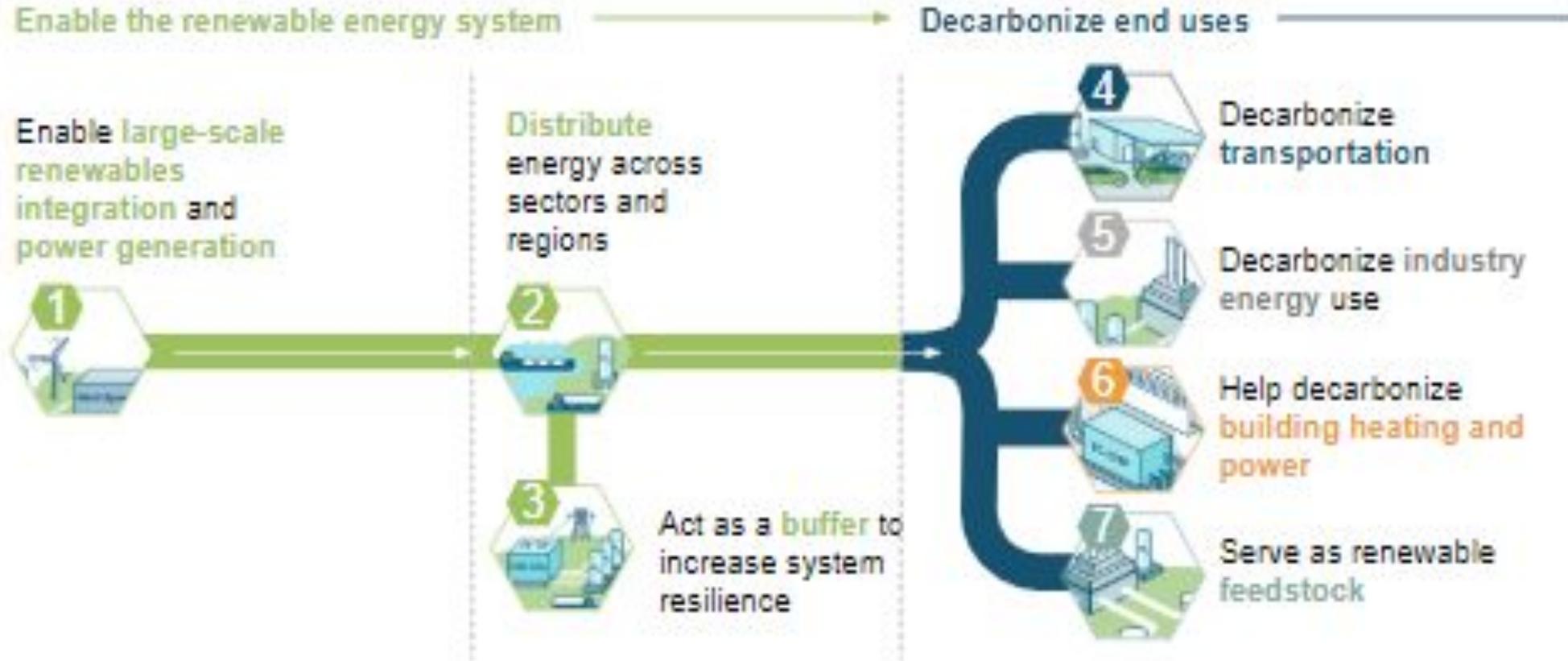
Catalysed "scale up" studies across key markets



Shared joint vision in key fora & high level events



H2: Seven Key Roles in Energy Transition



How hydrogen empowers the energy transition



Hydrogen Council January 2017



Hydrogen scaling up

A sustainable pathway for the global energy transition

Hydrogen Council November 2017



Hydrogen scaling up

A sustainable pathway for the global energy transition

HYDROGEN COUNCIL | COP 23 | 13 NOVEMBER 2017

We estimated the potential of hydrogen in a two degree scenario

Step 1
Bottom-up model
of energy system

Segmented the energy system into sectors

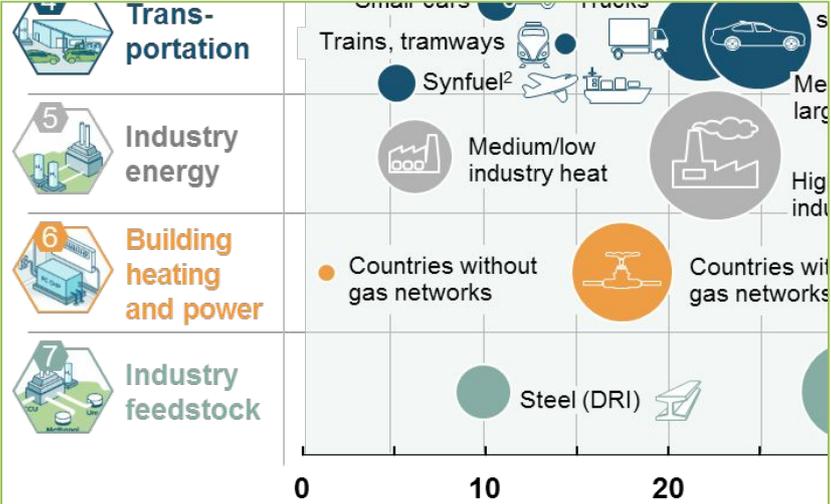
Defined sub-segments by sector, such as fleet turnover and efficiency development

| Segment | Subsegment | Energy use, EJ | Fleet million | Lifetime years | |
|--------------------------|--------------|----------------|---------------|----------------|-------|
| Passenger road transport | 2/3-wheelers | 4 | 1,448 | 16-18 | |
| | Cars | A/B | 8 | 593 | 10-15 |
| | | C/D | 17 | 1,059 | |
| | | E+ | 2 | 108 | 6-8 |
| | | Taxis | 5 | 36 | |
| Freight road transport | Vans/LCV | 6 | 201 | ~10 | |
| | Buses | Coaches | 1 | 4 | ~15 |
| | | City Buses | 1 | 2 | |
| Small buses | | 5 | 13 | | |

Step 2
Definition of the 2050 vision
of hydrogen potential

Estimated **adoption potential and sales share** per subsegment by each company

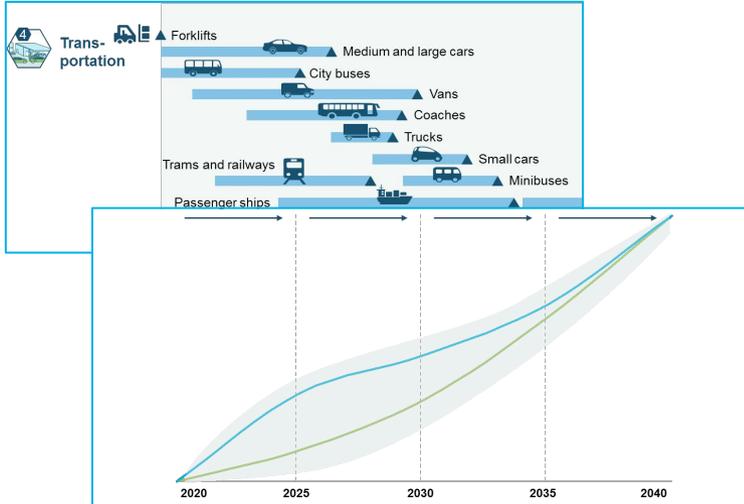
Consolidated a **joint view**, modeled fleet, consumption and hydrogen demand, and pressure-tested results



Step 3
Development of the
roadmap and 2030 view

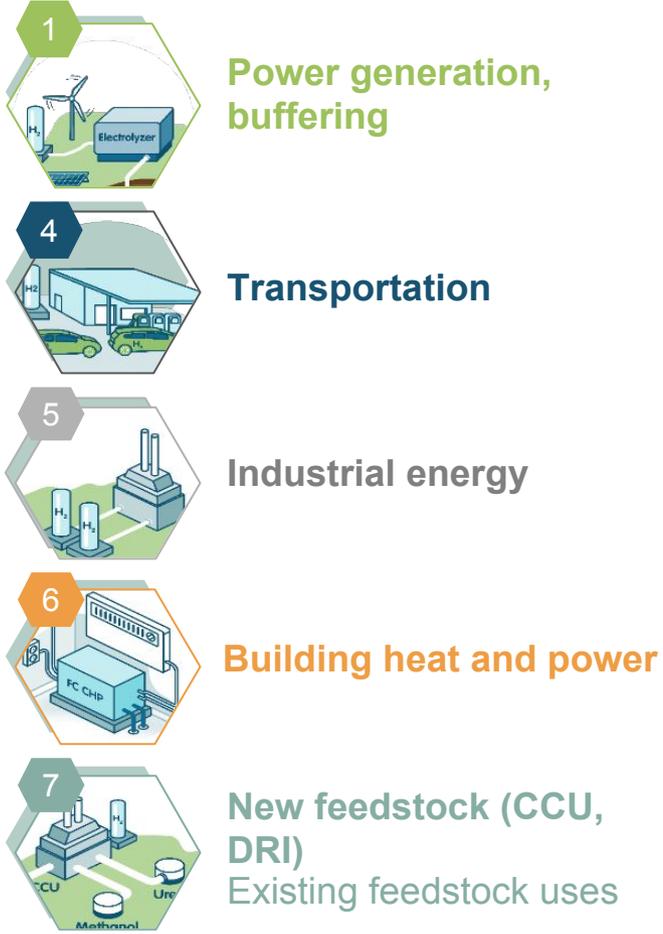
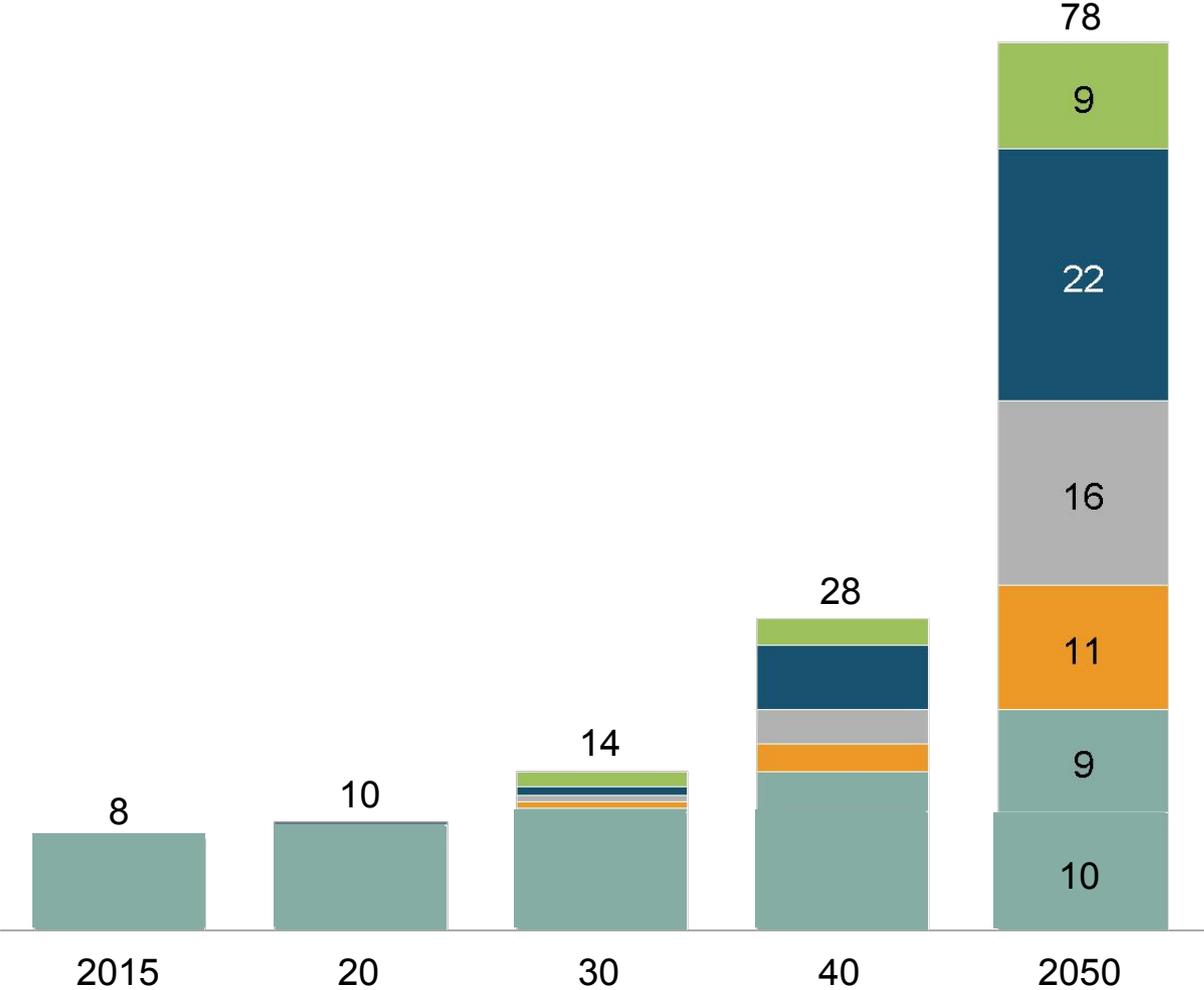
Calculated **potential scale-up paths** based on technology readiness

Derived **implied investments** in scale-up and quantified **benefits** – in growth, jobs and emissions



In a 2-degree-world, hydrogen could contribute ~18% of demand

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



18%
of final energy demand

Hydrogen: a central pillar of the required energy transition

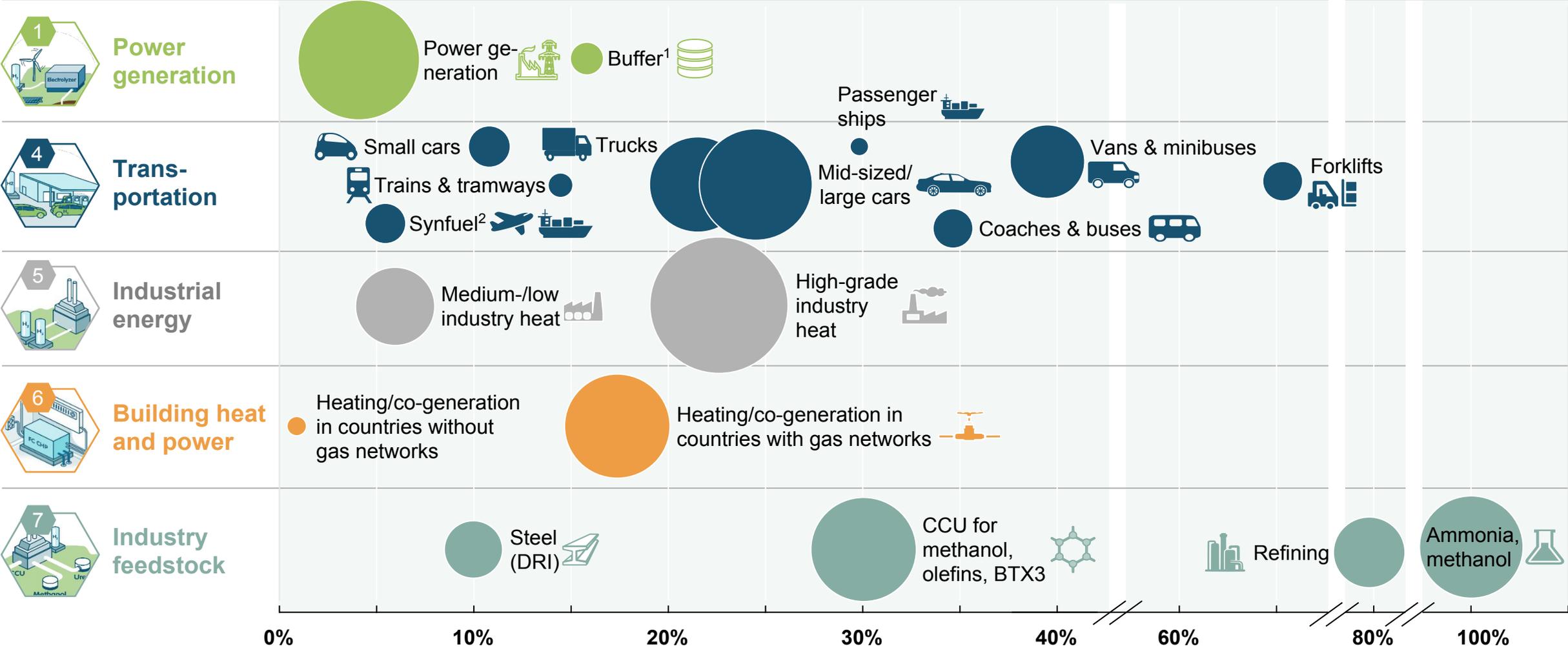
Estimated impact in 2050



¹ Value add of fuel cells

Hydrogen has significant potential across all applications

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



Relative importance by 2050 Market share potential in segment

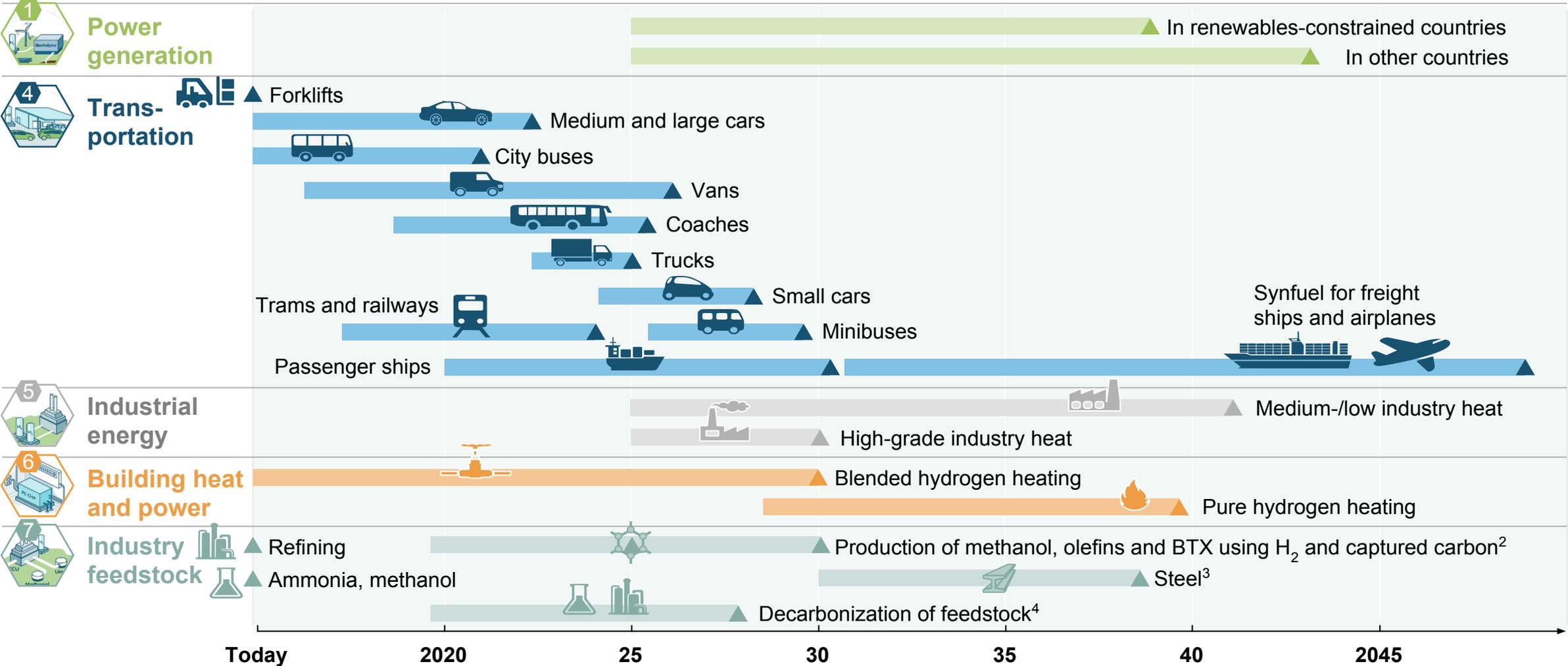
¹ Percent of total annual growth in hydrogen and variable renewable power demand

² For aviation and freight ships

³ Percent of total methanol, olefin, BTX production using olefins and captured carbon

The technologies exist and are ready to be deployed

Start of commercialization: Mass market acceptability¹:



¹ Mass market acceptability defined as sales >1% within segment in priority markets ² Market share refers to the amount of production that uses hydrogen and captured carbon to replace feedstock
³ DRI with green H₂, iron reduction in blast furnaces and other low-carbon steel making processes using H₂ ⁴ Market share refers to the amount of feedstock that is produced from low-carbon sources
 SOURCE: Hydrogen Council

Investments of \$280bn until 2030 build \$140bn+ annual market

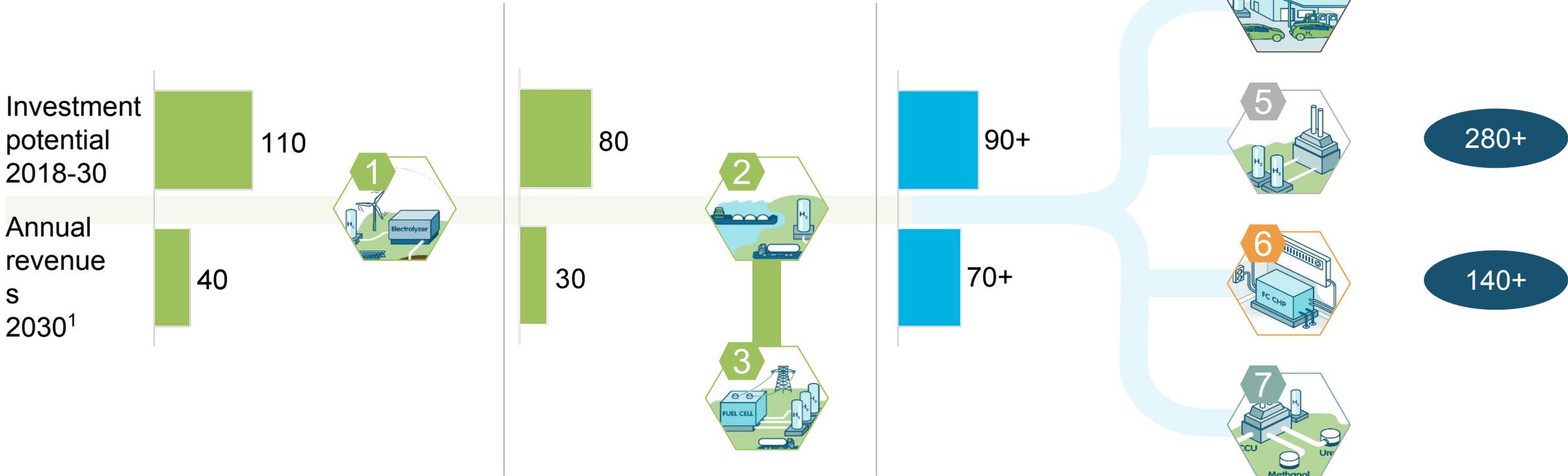
\$ billion¹

Enable the renewable energy system → Decarbonize end uses — Total

Hydrogen production

Storage, transport, and distribution

End-uses in transportation, industry energy, buildings and feedstock



¹ Excluding existing feedstock uses, Considering only hydrogen value-added



Building the French Hydrogen Economy

February 2018

A prospective study

About this prospective study

Participants



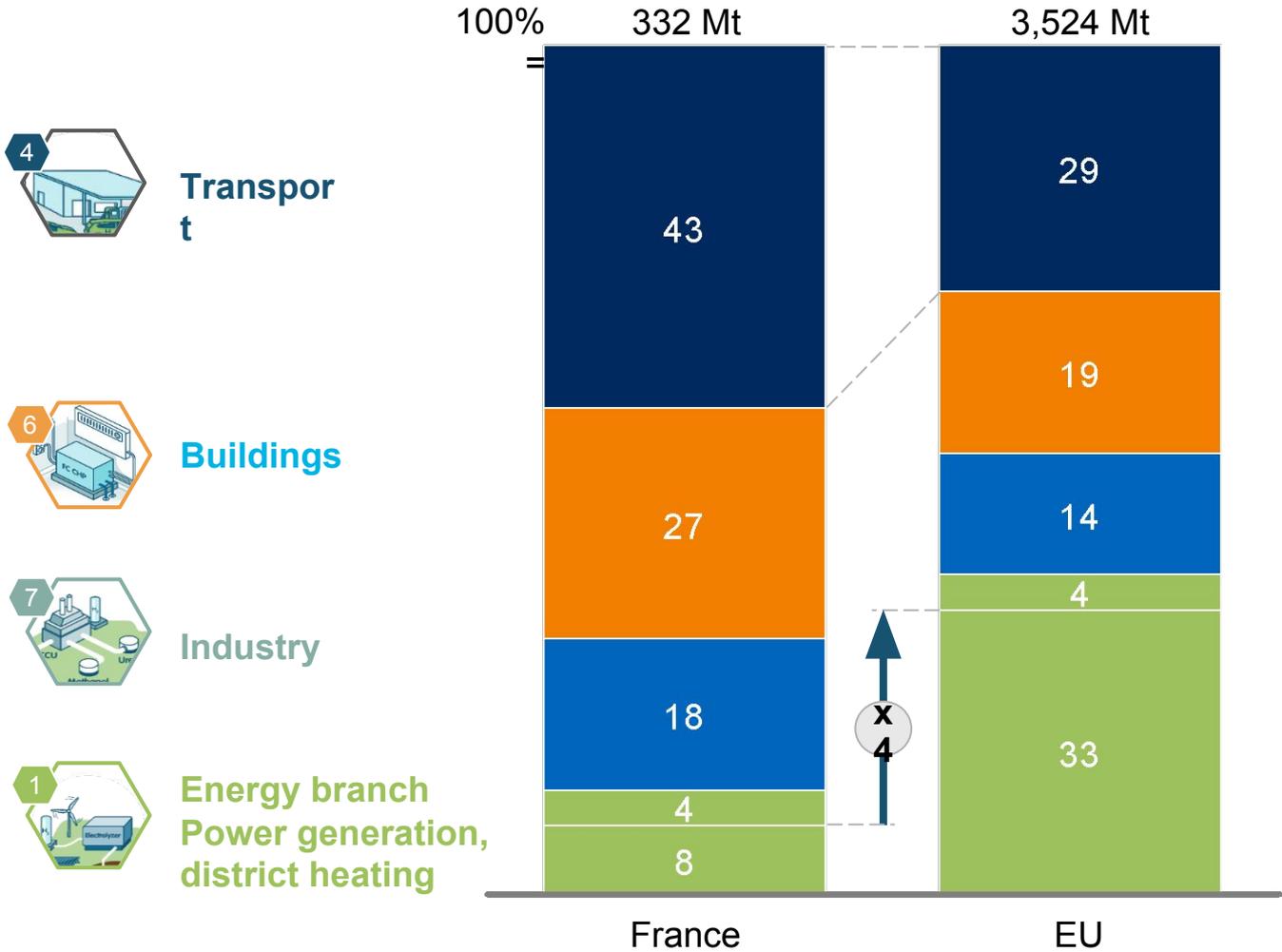
Objectives

- **Comprehensive quantified vision and milestones** for the deployment of hydrogen in France
 - Based on the Report by the Hydrogen Council: “Hydrogen – Scaling Up”
 - Adapted to French Energy landscape
- Not a forecast, but an **ambitious yet realistic** scenario
- Answers the question “How could hydrogen contribute to **achieving the French climate goals?**”

With a low-carbon power mix, the focus for hydrogen in France is on decarbonization of end-use sectors

Energy related CO₂ emissions 2015

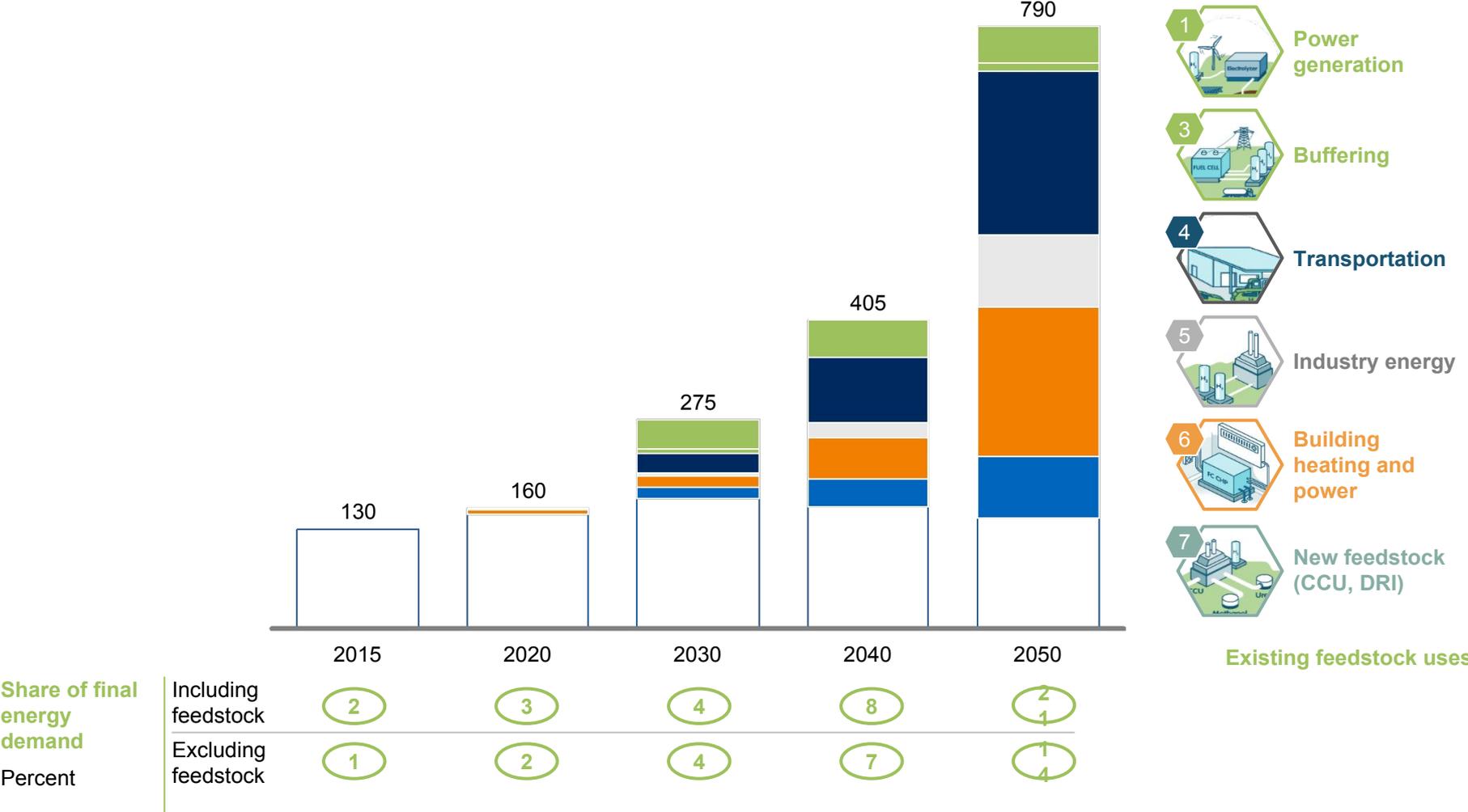
Percent



SOURCE: EU RTS 2016

Demand side: Annual hydrogen demand could increase to ~790 PJ by 2050 – primarily driven by transport and building heat and power uses

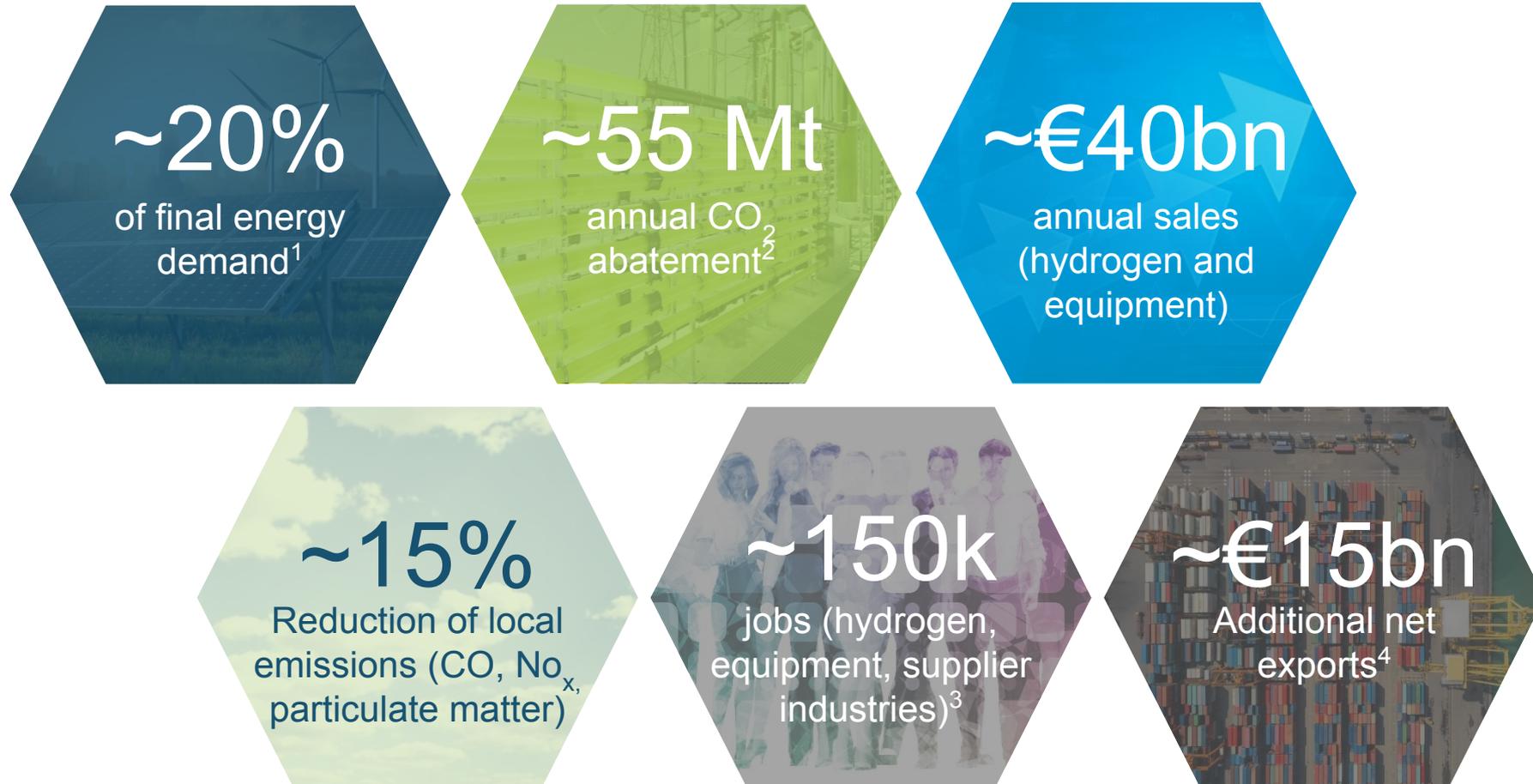
French energy demand supplied with hydrogen, PJ



SOURCE: Hydrogen France Study team

Summary: Hydrogen could benefit the French energy system, environment, and economy

2050 hydrogen vision (annual figures)

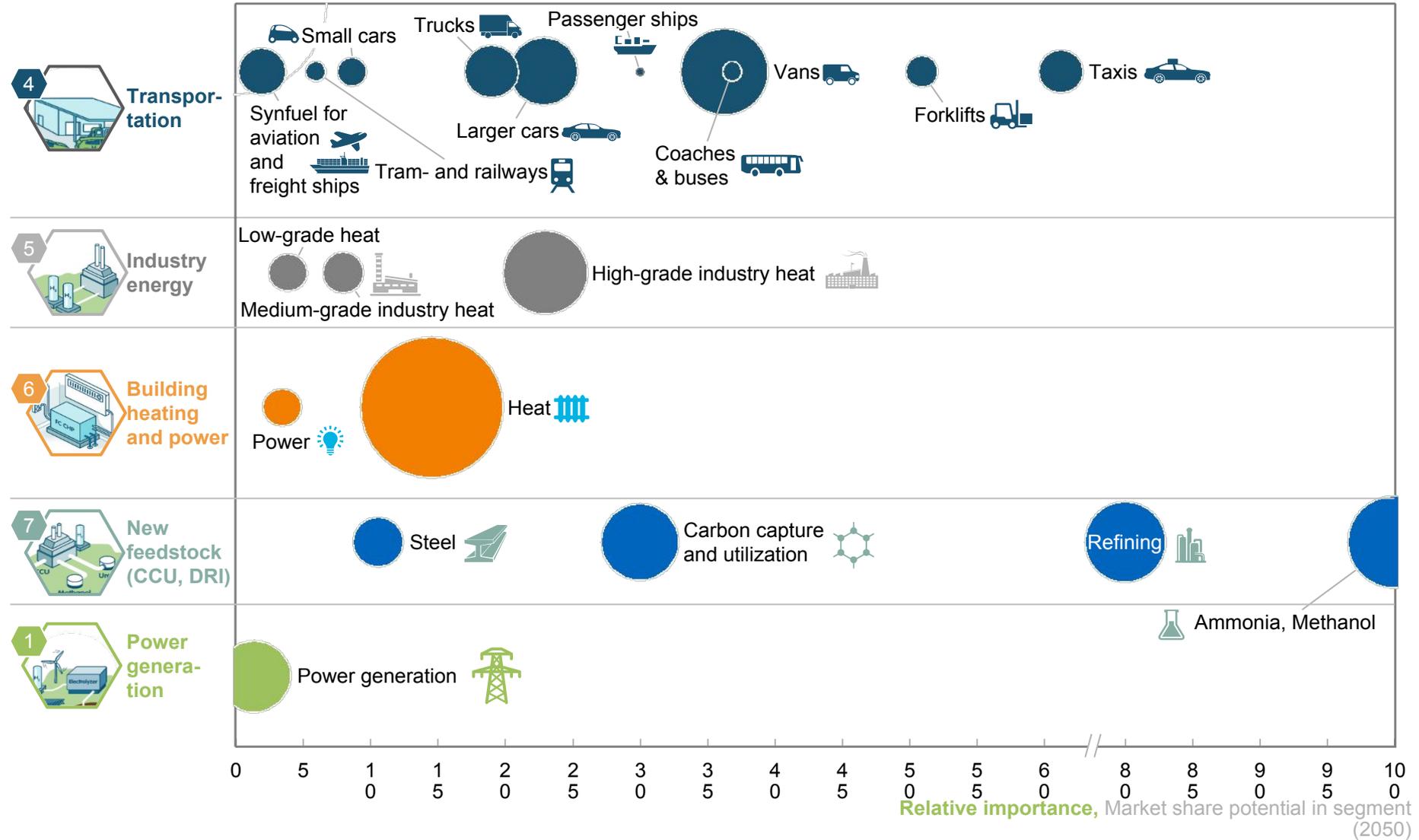


1 Including feedstock; 2 Compared to the reference scenario; 3 Excluding indirect effects; 4 Through hydrogen/equipment exports and reduced oil imports

SOURCE: Hydrogen Council; IEA ETP Hydrogen and Fuel Cells CBS; National Energy Outlook 2016

Hydrogen adoption rates and total potential in 2050 differ by sector and segment

○ Bubble size indicates hydrogen potential in 2050 in EJ

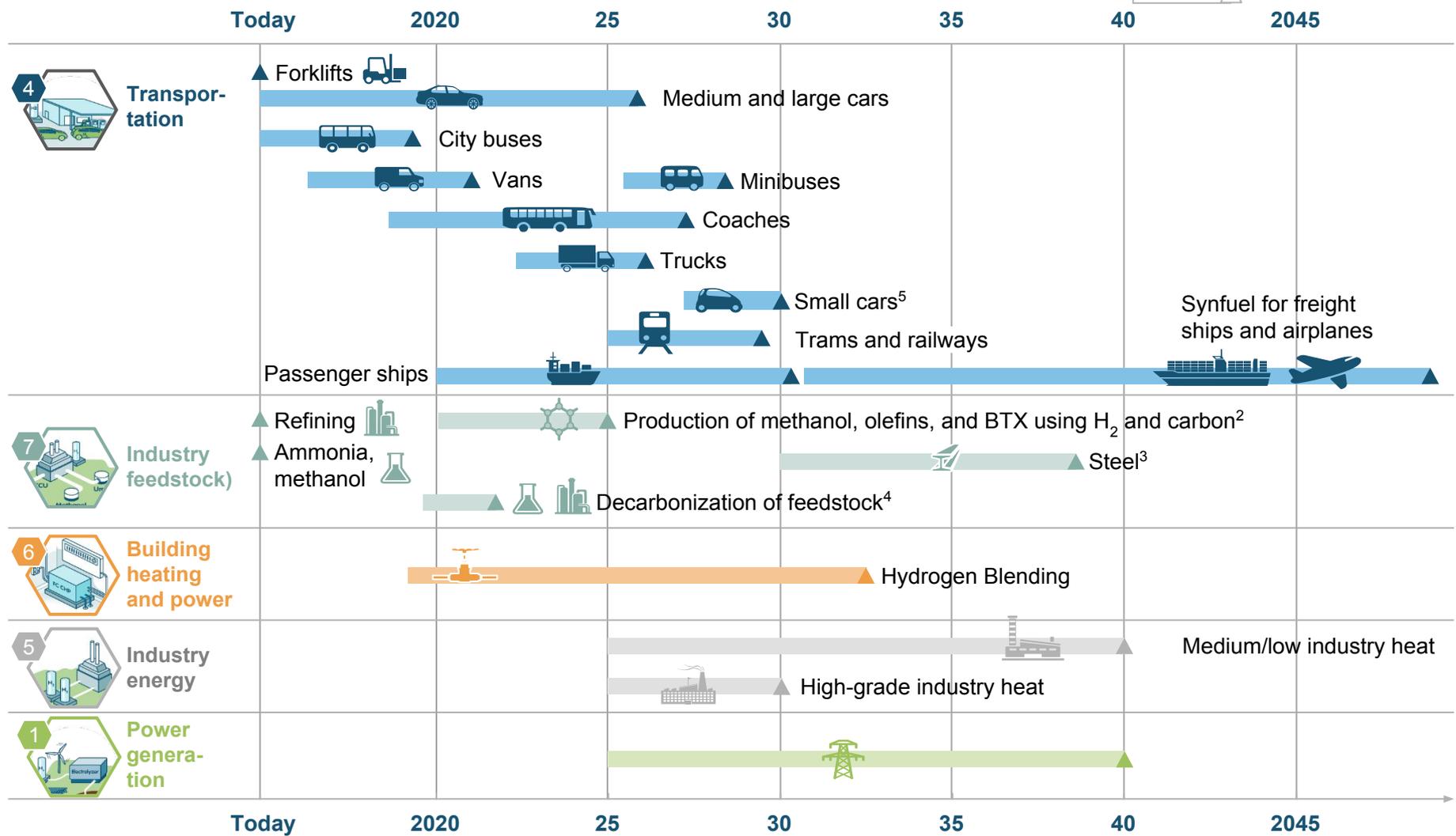


1 Percent of total methanol, olefin, BTX production

SOURCE: Hydrogen France Study team

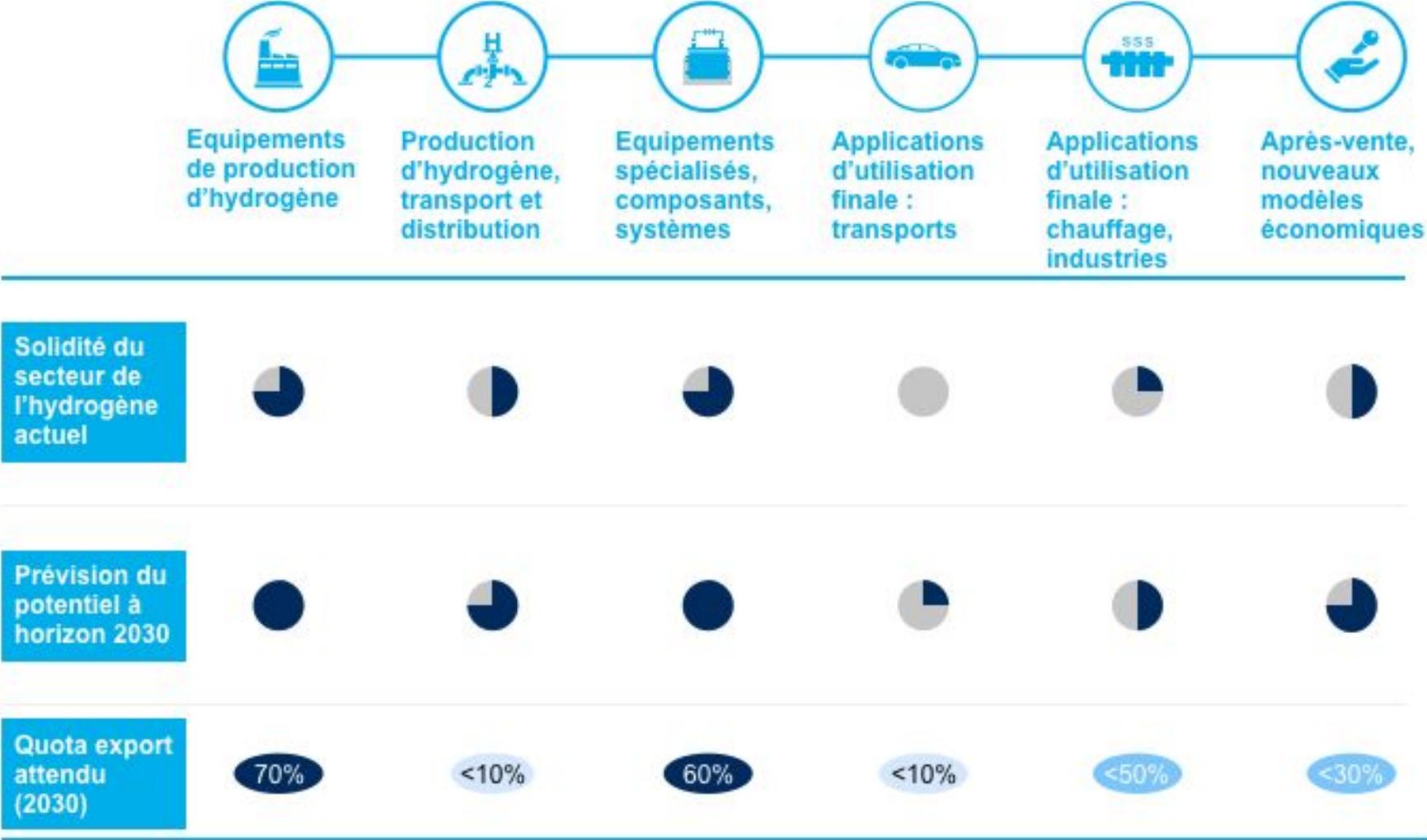
Many hydrogen technologies are getting ready for deployment at scale

Start of commercialization Mass market acceptability¹



1 Defined as sales >1% within segment
 2 Market share refers to the amount of production that uses hydrogen and captured carbon to replace feedstock
 3 DRI with green H₂, iron reduction in blast furnaces, and other low-carbon steel making processes using H₂
 4 Market share refers to the amount of feedstock that is produced from low-carbon sources
 5 Commercialization date for France adjusted from global roadmap in accordance with ramp-up date

French industry: well positioned, esp. equipments and components

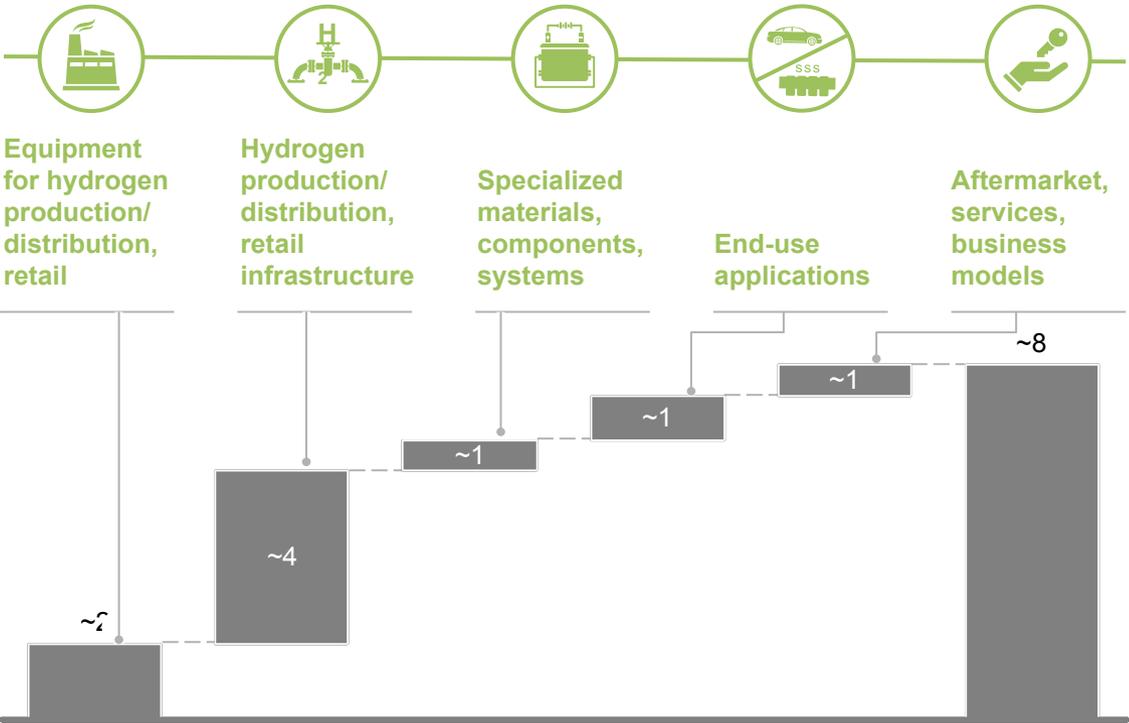


SOURCE : Réponses à l'enquête effectuée auprès de 25 entreprises / membres de l'AFHYPA

Under favorable policies, industry players indicate readiness to scale up investments to required levels

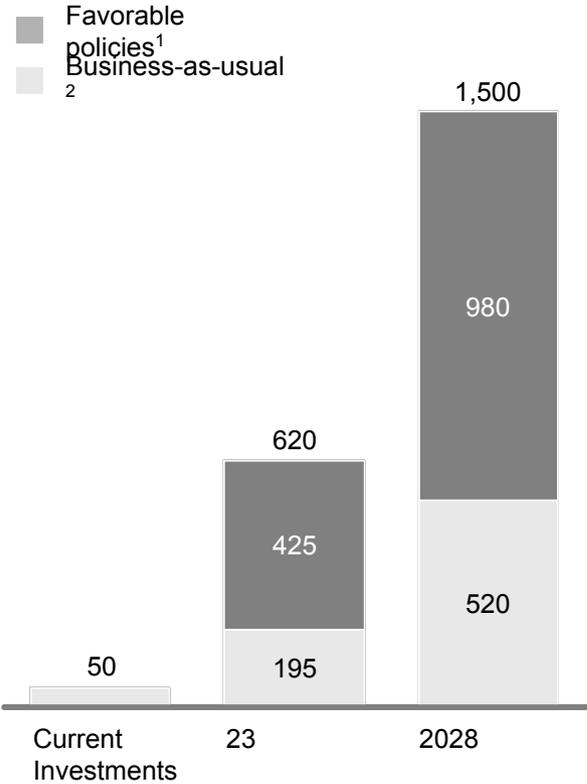
Total investment need (estimated)

Cumulative, 2018-2030. EUR billions



Investment readiness of key players (survey among 25 companies)

Annual. EUR millions



¹ Hydrogen Scenario: The French government takes additional efforts to combat climate change and support hydrogen solutions in order to achieve a two-degree-scenario in line with the Paris Agreement, which includes for instance the full implementation of H2Mobility; ² Business-as-usual (BAU): The government does not increase its efforts to combat climate change and does not take additional measures to support the introduction of hydrogen technology. Concrete and binding measures such as law and current subsidies will be implemented