

# Promoting and accelerating the Hydrogen Industry

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EMN Energy Gases  
Workshop Measurement Solutions for Energy Gases  
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# Hydrogen Europe in numbers

**400+** Members

We represent the whole value chain  
from producers to end users

**44+** Employees

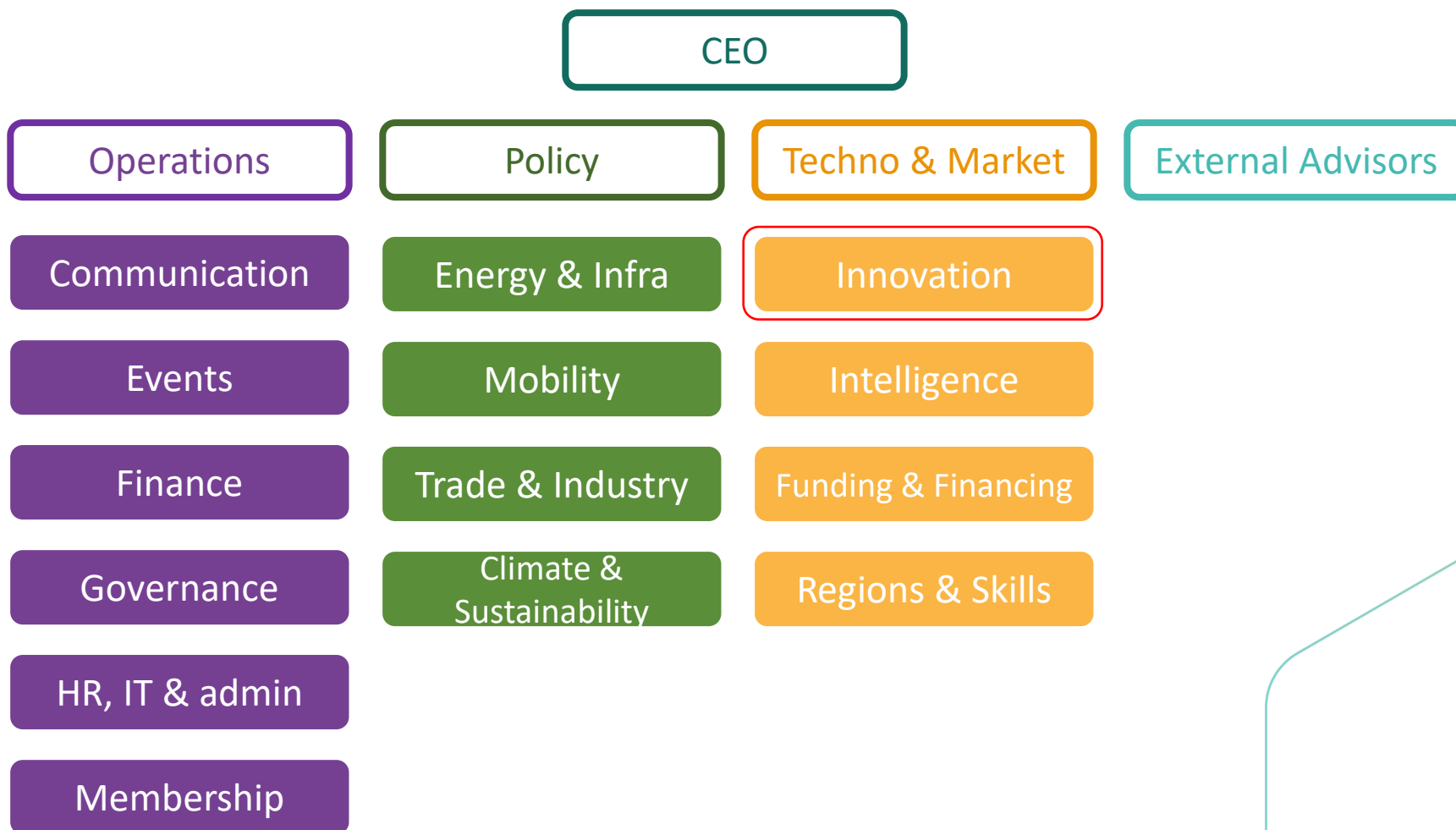
**We are the  
fastest growing  
association in  
Europe**



**103k+**

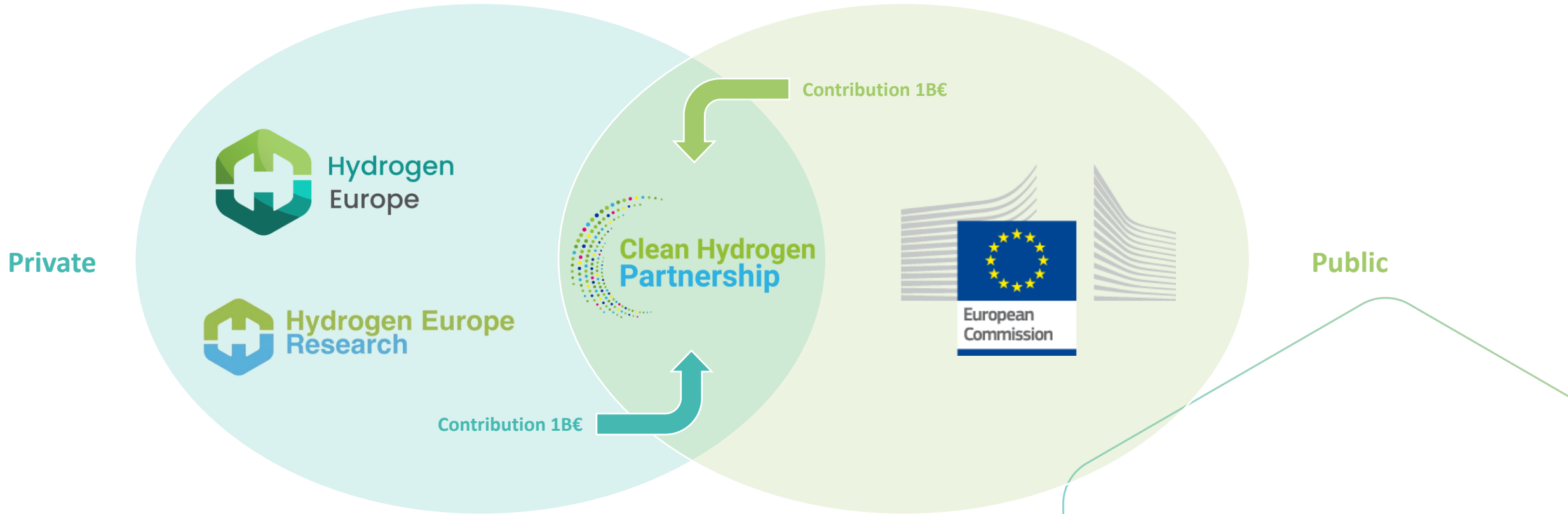
Followers  
on Social Media

# Hydrogen Europe - Organisation



# General structure of the Public Private Partnership

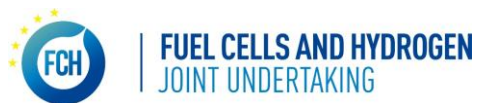
Clean Hydrogen Partnership (or Joint Undertaking)



To facilitate the transition to a greener EU society through the development of hydrogen technologies.



# Legacy: FCH-JU & FCH2-JU



## Energy

Hydrogen production and distribution  
Hydrogen storage for renewable energy integration  
Fuel cells for power & CHP



## Mobility

Road vehicles & Non-road vehicles and machinery  
Maritime rail and aviation applications  
Refuelling infrastructure



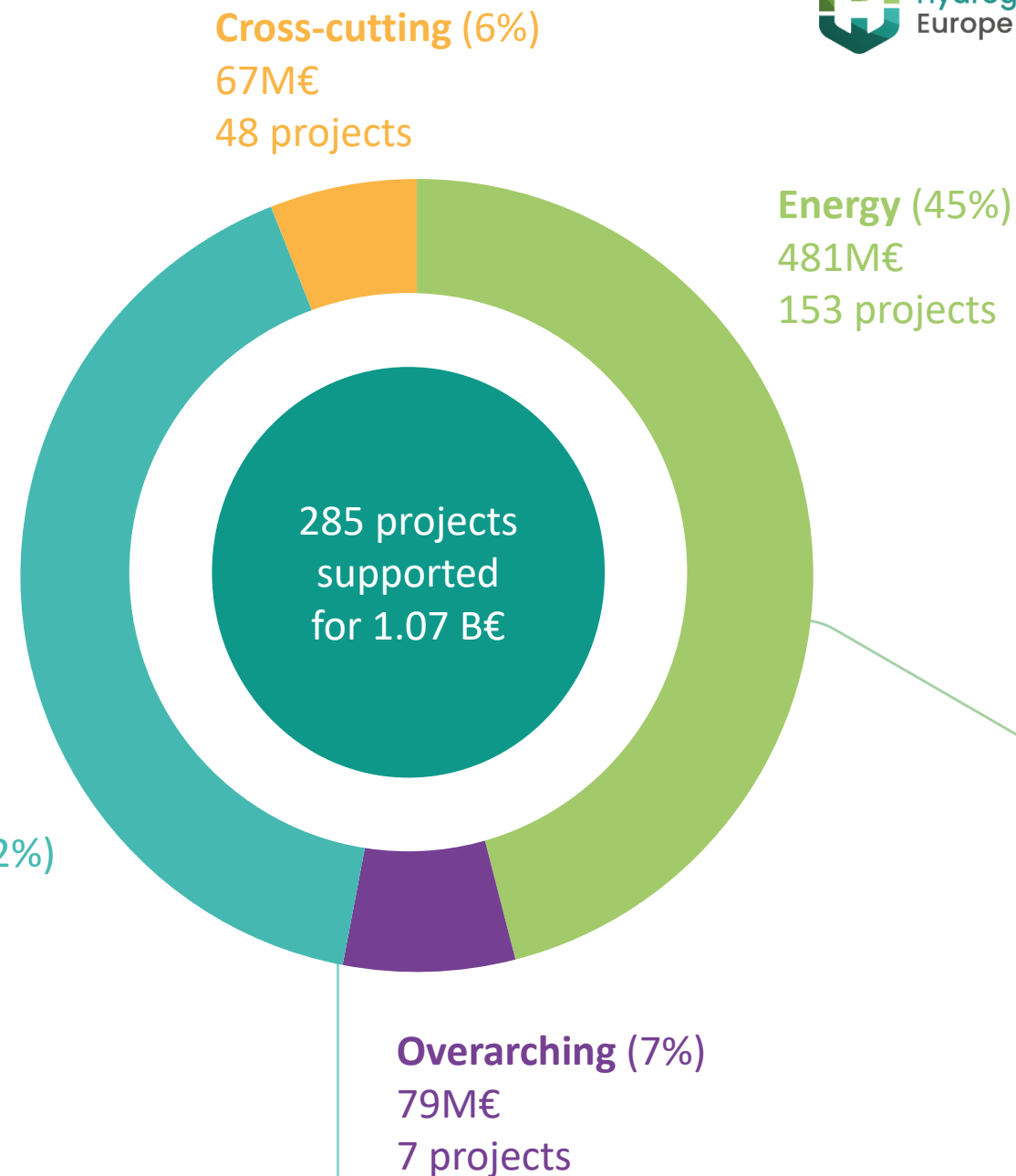
## Cross-cutting

Standards, safety  
Education, Public awareness



## Overarching

Hydrogen ecosystems  
Valleys



# Objectives for Clean Hydrogen Partnership

## General Objectives



Support the implementation of the Commission's Hydrogen Strategy



Stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications



Strengthen the competitiveness of the EU clean hydrogen value chain



Contribute to the EU ambitious 2030 and 2050 climate ambition

## Specific Objectives



Improve the cost-effectiveness, efficiency, reliability, quantity and quality of clean hydrogen solutions across entire value chain



Strengthen the knowledge/capacity of scientific and industrial actors along the Union's hydrogen value chain while supporting the uptake of skills



Demonstrations of clean hydrogen solutions with a view to local, regional and Union-wide deployment, aiming to involve stakeholders in all Member States and across entire value chain



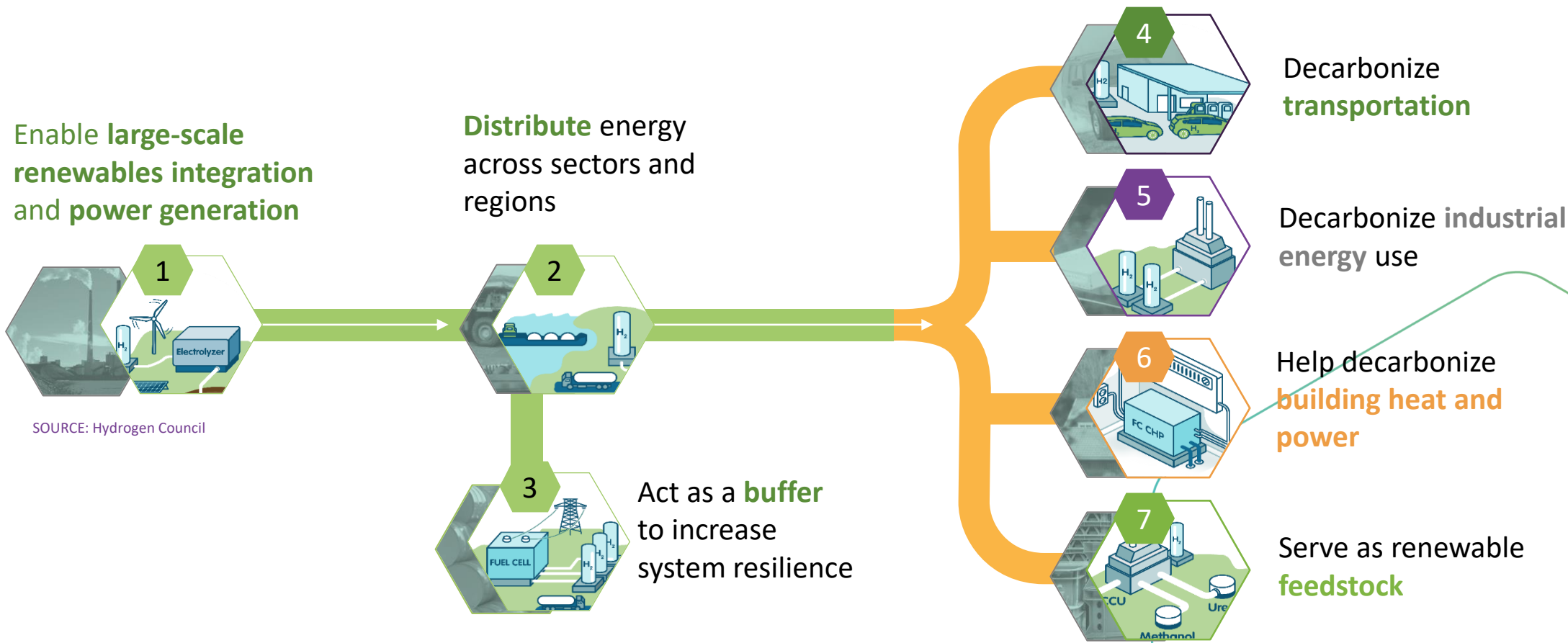
Increase public and private awareness, acceptance and uptake of clean hydrogen solutions

# Hydrogen within the energy transition

## The 7 roles of hydrogen

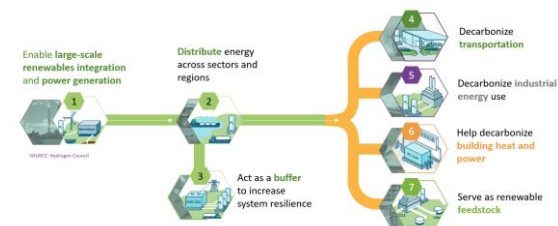
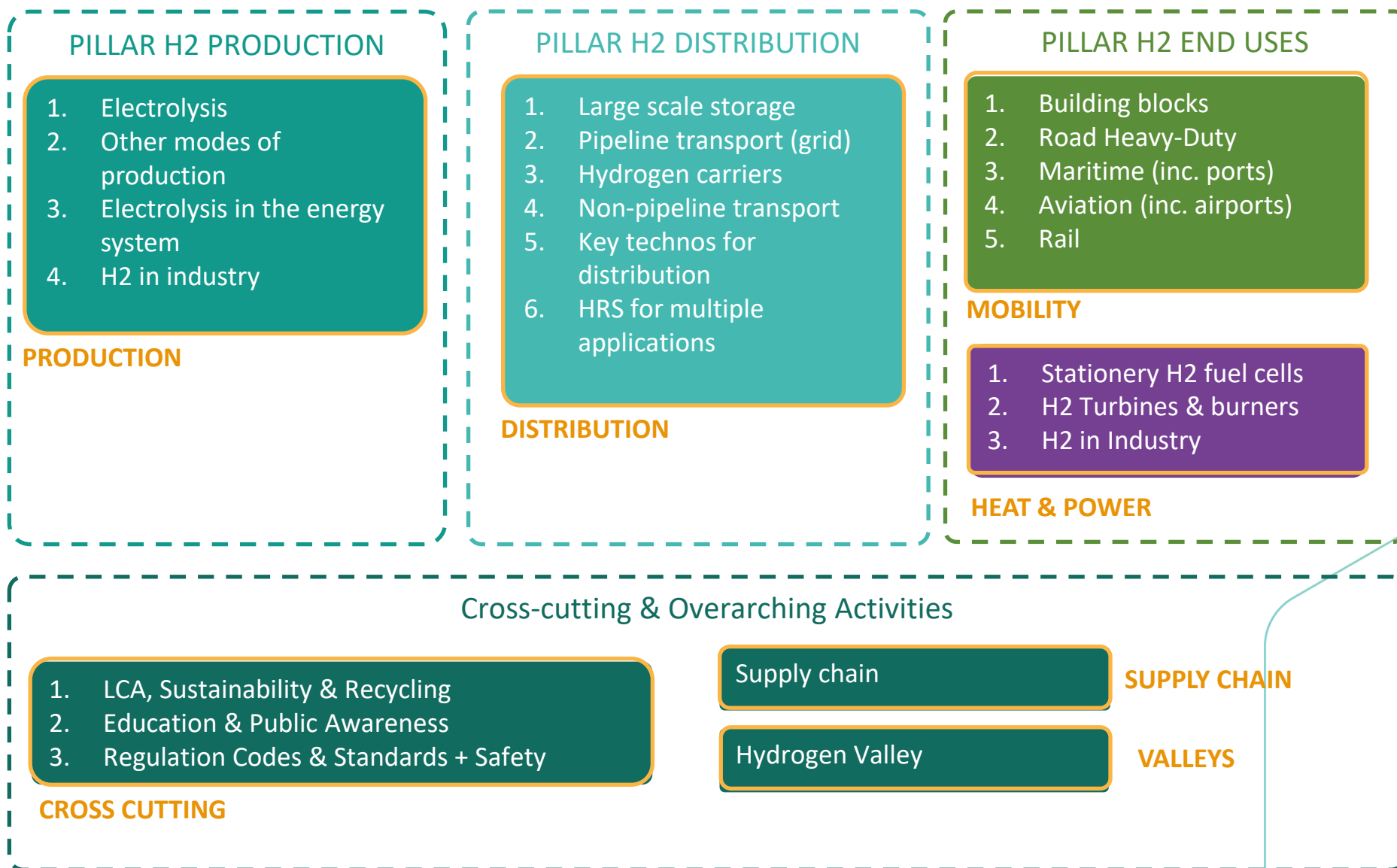
Enable the renewable energy system

Decarbonize end uses



# Set of 20 roadmaps to achieve our objectives

3+1 pillars





# Our Strategic Research & Innovation Agenda

## Hydrogen Production

### Electrolysis

- Technology development are covered for all type of electrolysis, provided the main input is water/steam and main output is hydrogen.
- It also includes demonstration of integration of renewables via electrolysis and H2 in Industry. Demonstration can evolve towards Flaships.

### Other modes of production

- Several types of technologies can be covered, provided the input is renewable-based:
  - Hydrogen from raw biogas
  - Biological production
  - Solar thermal
  - Hydrogen from waste/biomass gasification

### Key KPIs

Electrolysis	2020	2030
<b>CAPEX (€/kW)</b>		
Alk	600	400
PEM	900	500
SO	2130	520
<b>OPEX (€/(kg/d)/y)</b>		
Alk	50	35
PEM	41	21
SO	410	45
<b>Use of CRM (mg/W)</b>		
Alk	0,6	0,0
PEM	2,5	0,25
SO	-	-

*Note: Tables of KPIs available at the end of the SRIA*

# Our Strategic Research & Innovation Agenda

## Hydrogen Distribution (1/2)

### Bulk storage

- Both underground (salt caverns, aquifers) and aboveground are covered.

### Gas grid

- Both blending and pure H2 grids are covered. It is referred to natural gas grid (not dedicated H2 pipelines).

### H2 carriers

- Strong focus on LH2 and LOHC. Ammonia also covered, stopping at Haber-Bosch process.
- Methanol and other carbonated molecules out of scope. Limited room for solid carriers.

### Key KPIs

Storage	2020	2030
<b>CAPEX (€/kg)</b>		
Depleted gas fields	n/a	5
Salt caverns	35	30
Aboveground	750	600

H2 carriers	2020	2030
Liquefaction (kWh/kg)	10-12	6-8
Liquefaction cost (€/kg)	1,5	<1
Hydrogen carrier specific energy consumption (kWh input/ kg H2 recovered)	20	12

*Note: Tables of KPIs available at the end of the SRIA*

# Our Strategic Research & Innovation Agenda

## Hydrogen Distribution (2/2)

### Other modes of transport

- Coverage of Transport via new-built pure hydrogen pipelines, road transport of CGH2 & LH2, road transportation of LH2, Shipping of bulk LH2.

### Key technologies

- Coverage of compression, purification and metering solutions

### Hydrogen Refueling Stations (HRS)

- Development of HRS with focus on Heavy-Duty applications and multi-modal aspects. Ports/Airports could be considered here.

### Key KPIs

Transport of H2	2020	2030
Pipeline Total capital investment (M€/km)	1,1	0,9
Tube trailer CGH2 CAPEX (€/kW)	650	350
Tank trailer LH2 CAPEX (€/kW)	>200	100
Compression	2020	2030
CAPEX for pipelines (€/kW)	1300	650
CAPEX for HRS (€/kW)	7700	3500
Tank trailer LH2 CAPEX (€/kW)	>200	100
HRS	2020	2030
CAPEX 350bar (k€/(kg/day))	0,8-3,5	0,5-2
CAPEX 700bar (k€/(kg/day))	2-6	1-3
CAPEX LH2 (k€/(kg/day))	2-6	1-3

*Note: Tables of KPIs available at the end of the SRIA*

# Our Strategic Research & Innovation Agenda

## Hydrogen End-uses – Mobility (1/2)

### Building blocks

- Development of technology bricks i.e. Power conversion (fuel cell) and energy storage (H2 tanks), serving all applications below
- Very specific building blocks (e.g. very large FC) are developed under their specific application roadmap

### HDV

- Covers both on-road and off-road vehicles, focus clearly on HDVs (i.e. vans are excluded) with attention to spill-overs

### Key KPIs

Building blocks / HDVs	2020	2030
CAPEX FC module (€/kW)	1500	<100
FC stack durability (h)	15000	30000
FC PGM loading (g/kW)	0,4	<0,3
CGH2 tank CAPEX (€/kg)	800	300
LH2 tank CAPEX (€/kg)	n/a	245

*Note: Tables of KPIs available at the end of the SRIA*

# Our Strategic Research & Innovation Agenda

## Hydrogen End-uses – Mobility (2/2)

### Waterborne

- Focus on inland shipping and short-sea shipping and Ports. Hydrogen and Ammonia are addressed. Focus on Fuel Cells.

### Aviation

- Coverage of FC & turbines, used as propulsive and non-propulsive application. Focus on LH2. Airports are also considered here.

### Rail

- Coverage of all types of trains, focus on FC and H2. Train stations/depot can also be considered

### Key KPIs

Waterborne	2020	2030
CAPEX FC system PEM (€/kW)	2000	1000
FC power rating (MW)	0,5	10
FC lifetime (h)	20000	80000

Aviation	2020	2030
FC module lifetime	15000	30000
FC system gravimetric index (kW/kg)	0,75	2
Tank gravimetric efficiency (%weight)	12	35

Rail	2020	2030
FC stack cost (€/kW)	n/a	<50
FC stack durability (h)	15000	30000
PGM loading (g/kW)	0,4	<0,3

*Note: Tables of KPIs available at the end of the SRIA*



# Our Strategic Research & Innovation Agenda

## Hydrogen End-uses – Heat & Power

### Stationery FC

- Coverage of FC for CHP, prime and back-up powers, focusing on H2 driven FCs and up to 10MWe.

### Turbines, boilers and burners

- Focus preferably on 50+Mwe, in complementarity to FCs
- Aim to have 100% hydrogen ready European gas turbines & burners by 2030, fulfilling emissions standards, for dispatchable power and high temperature heat.

### Key KPIs

Stationery FC	2020	2030
CAPEX SOFC (€/kW)	10000	2000-3500
CAPEX PEMFC (€/kW)	1900-6000	900-4000
OPEX SOFC (€/kWh)	10-12	1,5-2,5
OPEX PEMFC (€/kWh)	5-10	2-4
Non-recoverable CRM as catalyst (mg/Wel)	0,1	0,01

Turbines & burners	2020	2030
H2 range in gas turbine fuel (%mass & %vol)	0-5 & 0-30	0-100
NOx emissions (NOx mg/MJ fuel)	31	24

*Note: Tables of KPIs available at the end of the SRIA*

# Our Strategic Research & Innovation Agenda

## Overarching activities

### H2 Valleys

- Aim to develop and demonstration ecosystems whereby technology system operate together
- Usually « big ticket » items

### Supply chain

- Focus on troubleshooting supply chain bottlenecks and manufacturing capacities
- Most complex issue of overarching nature where the JU may not be the most appropriate tool –while supply chain may be issue number 1!

### Key KPIs

Recycling	2020	2030
Due to the nature of these roadmaps, no technological KPIs have been defined.		

*Note: Tables of KPIs available at the end of the SRIA*

# Our Strategic Research & Innovation Agenda

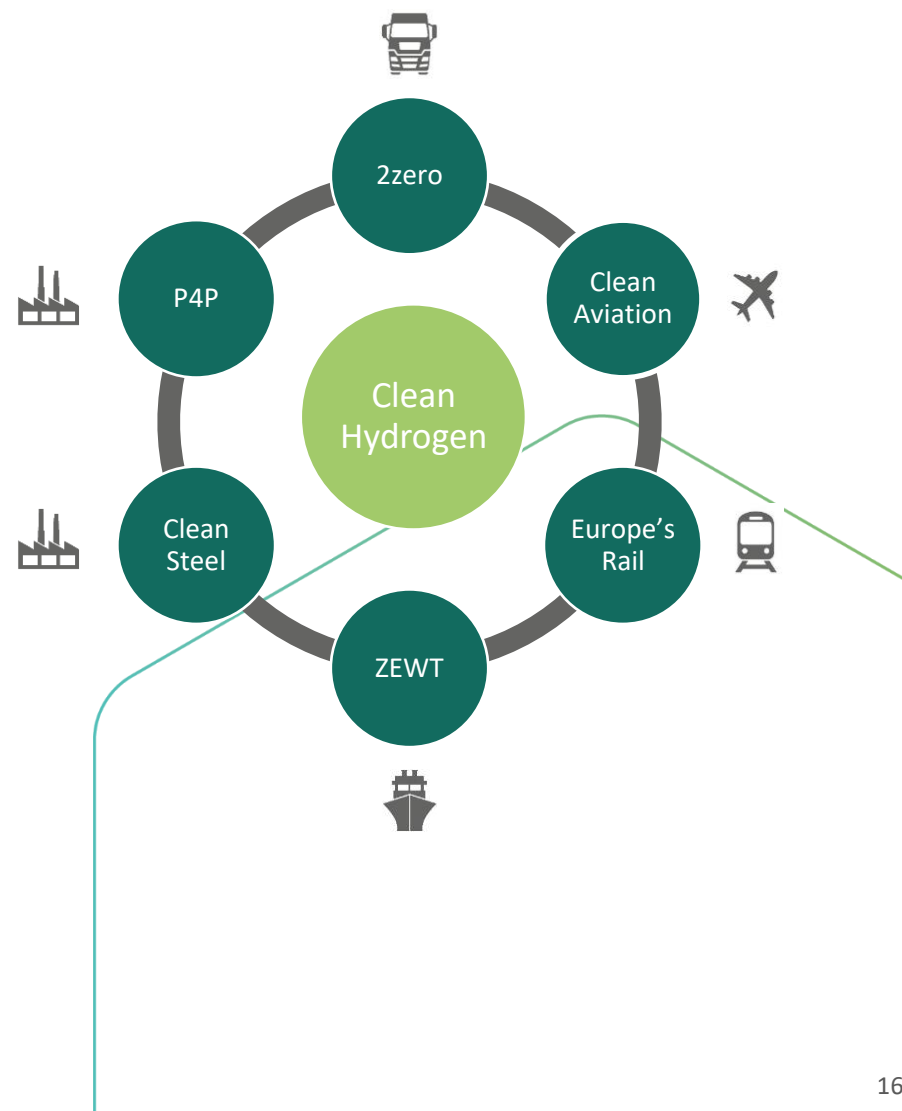
## Additional activities - Synergies

### Interaction with other programmes

- Mission Innovation - IC8
- Connecting Europe Facility
- Any other relevant funding stream, EU and/or National level

### Interaction with others PPPs

- Common roadmaps
- Stakeholder Group (part of our Governing Board)
- MoUs between Private Parties



# Our Strategic Research & Innovation Agenda

## Additional activities - Synergies

### Signature of a MoU last week

- EURAMET
- Hydrogen Europe
- Hydrogen Europe Research

### The forms of cooperation include:

- Exchange of knowledge about capabilities and needs in the field of metrology for hydrogen
- Exchange of information on research in the field of hydrogen performed under each partnership and create synergies that enhance the efficiency and impact of both research programmes under the partnerships.
- Joint exchange of information on further funded research programmes dealing with energy gases, energy transition and/or climate topics.

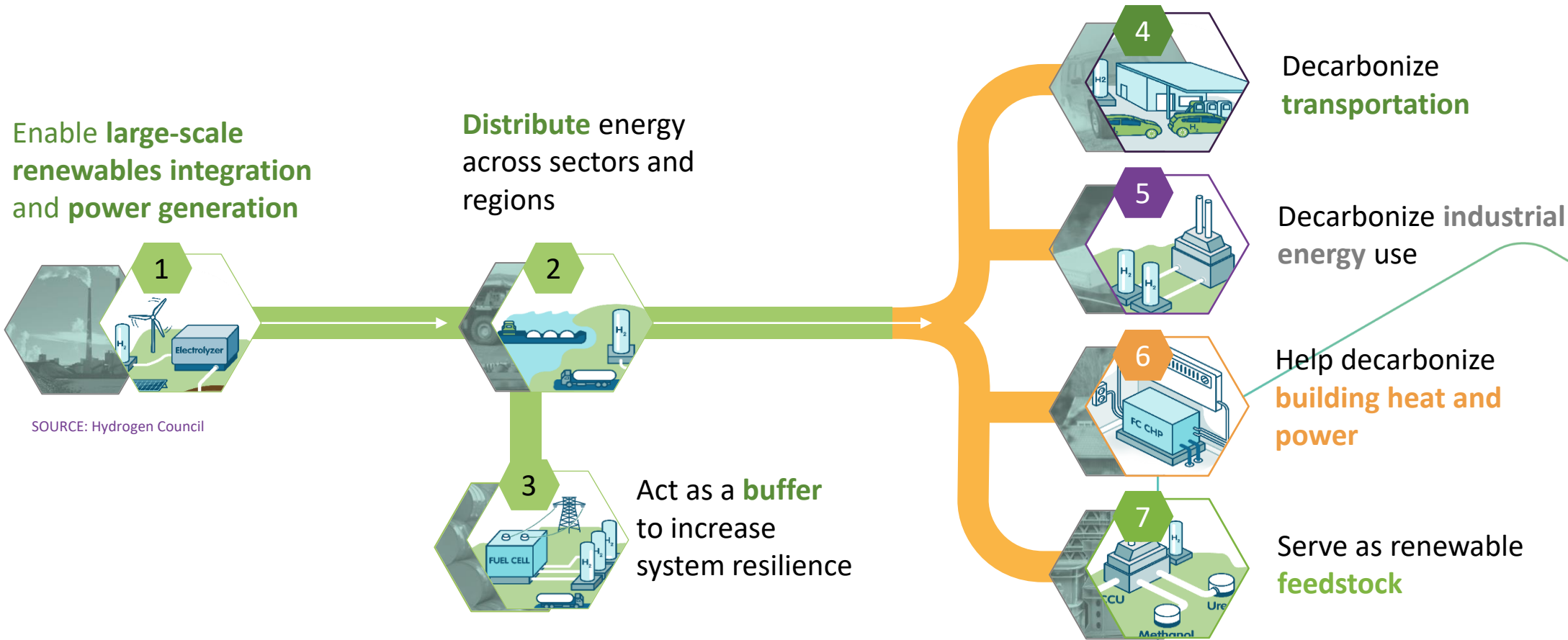


# Metrology/measurements for hydrogen

What is your opinion?

Enable the renewable energy system

Decarbonize end uses



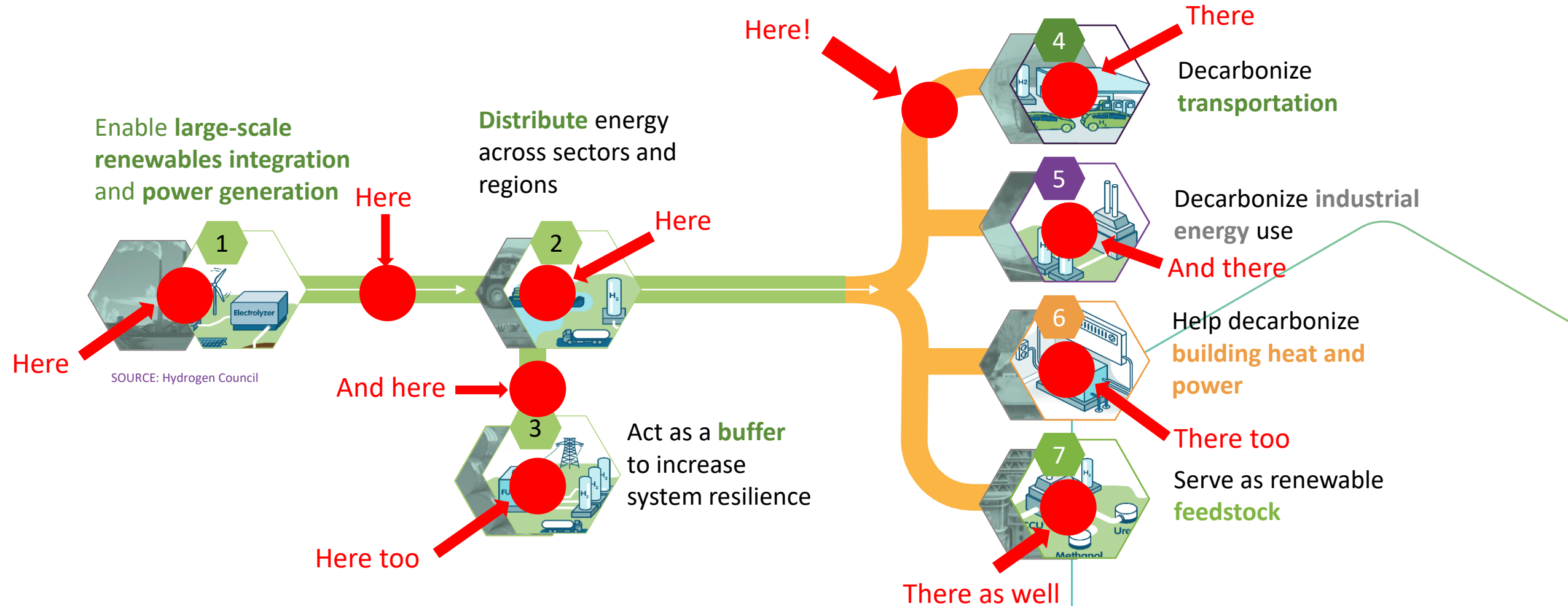


# Metrology/measurements for hydrogen

Answer: Everywhere.

Enable the renewable energy system

Decarbonize end uses



# Metrology/measurements for hydrogen

## Example: Needs for Mobility applications

- PEM fuel cells require high purity
- Accuracy for billing
- Need for scaling-up the measured quantities
- Need for measurements protocols
- Safety measures

**Several EU projects already addressed needs, yet R&D needs for Metrology applied to Hydrogen remains significant to allow for smooth market deployment.**

**This is an example only and needs are across supply chains:**

**No Metrology solutions = No deployment.**



# Thank You



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