

Hydrogen Study: International H₂ Strategies

A study commissioned by and in cooperation with the
World Energy Council – Germany

Dr. Carsten Rolle (WEC)

World Energy Council – Germany (WEC)



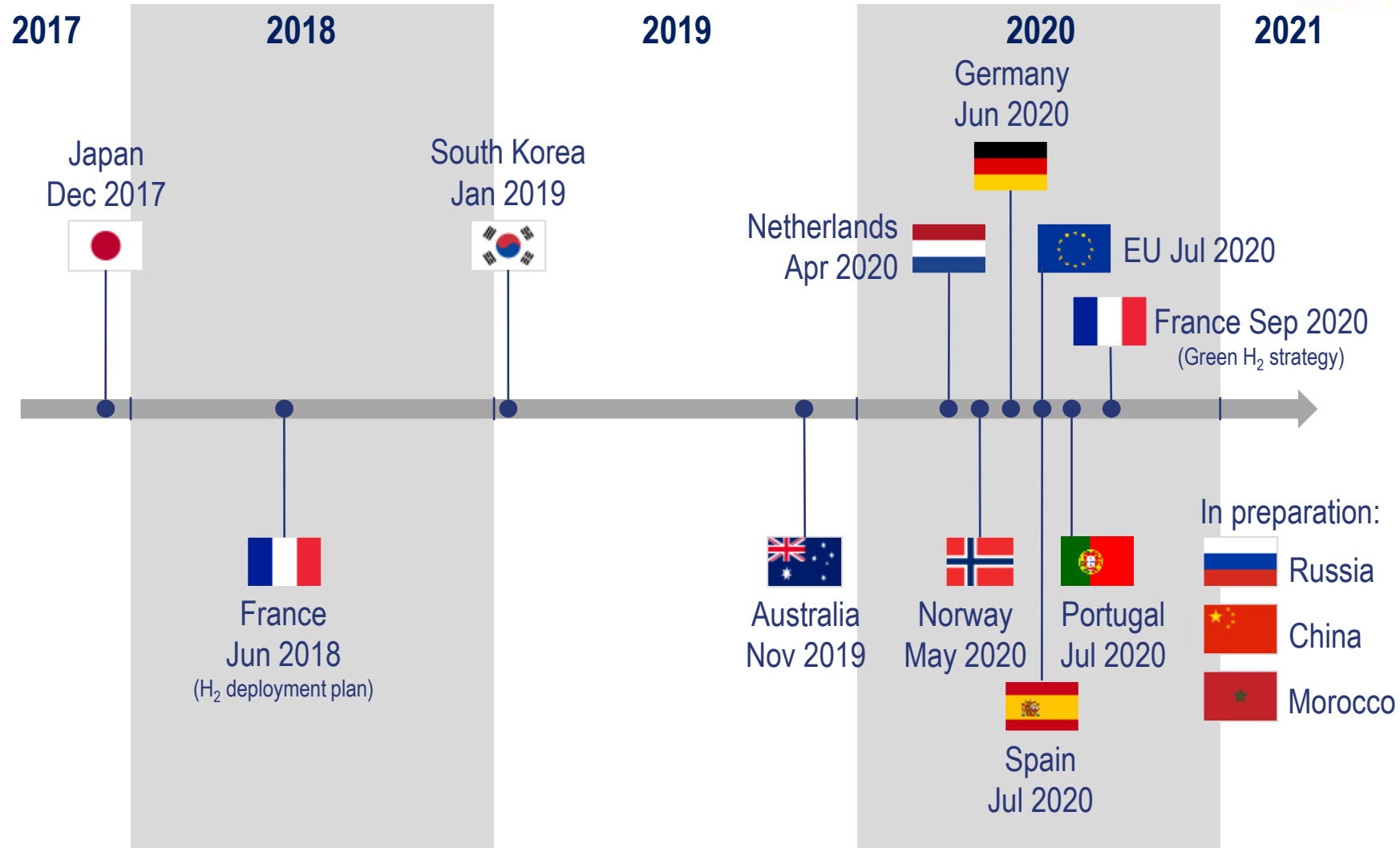
Study objective: analyse and learn from H₂ strategies

What is the national governmental support for H₂ technologies and applications?

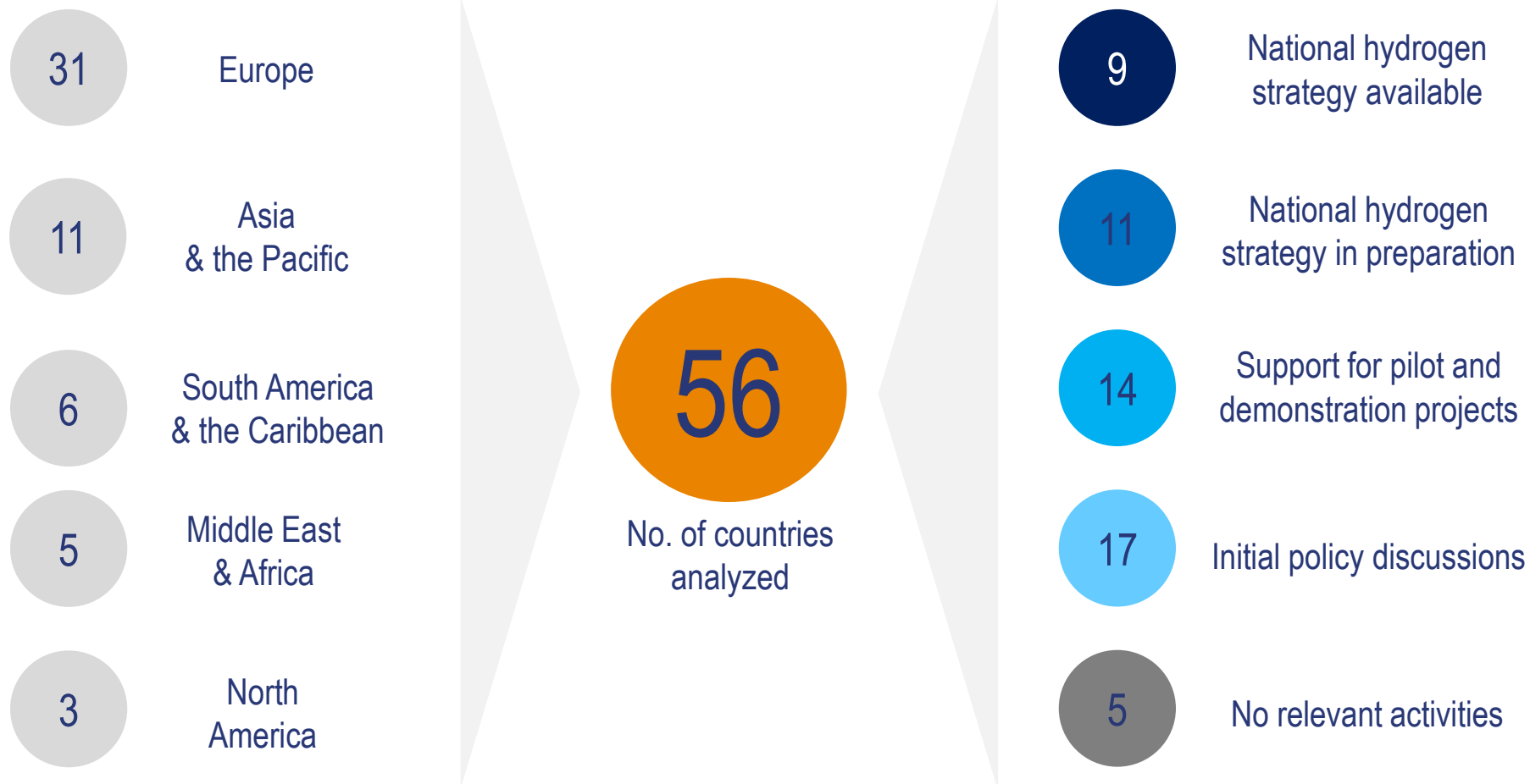
How can current experience benefit discussions of the European and German strategy?



“Hot” strategic hydrogen summer 2020



Overview H₂-strategies and activities (Status: August 2020)



August 2020, World Energy Council, LBST



Overview H₂ strategies and activities (Status: August 2020)



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Overview H₂ strategies and activities (Status: August 2020)

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**National H₂ strategies in place or in preparation
in at least 20 countries**

By 2025 H₂ strategies are expected to cover > 80% of global GDP

National hydrogen strategy available

National hydrogen strategy in preparation

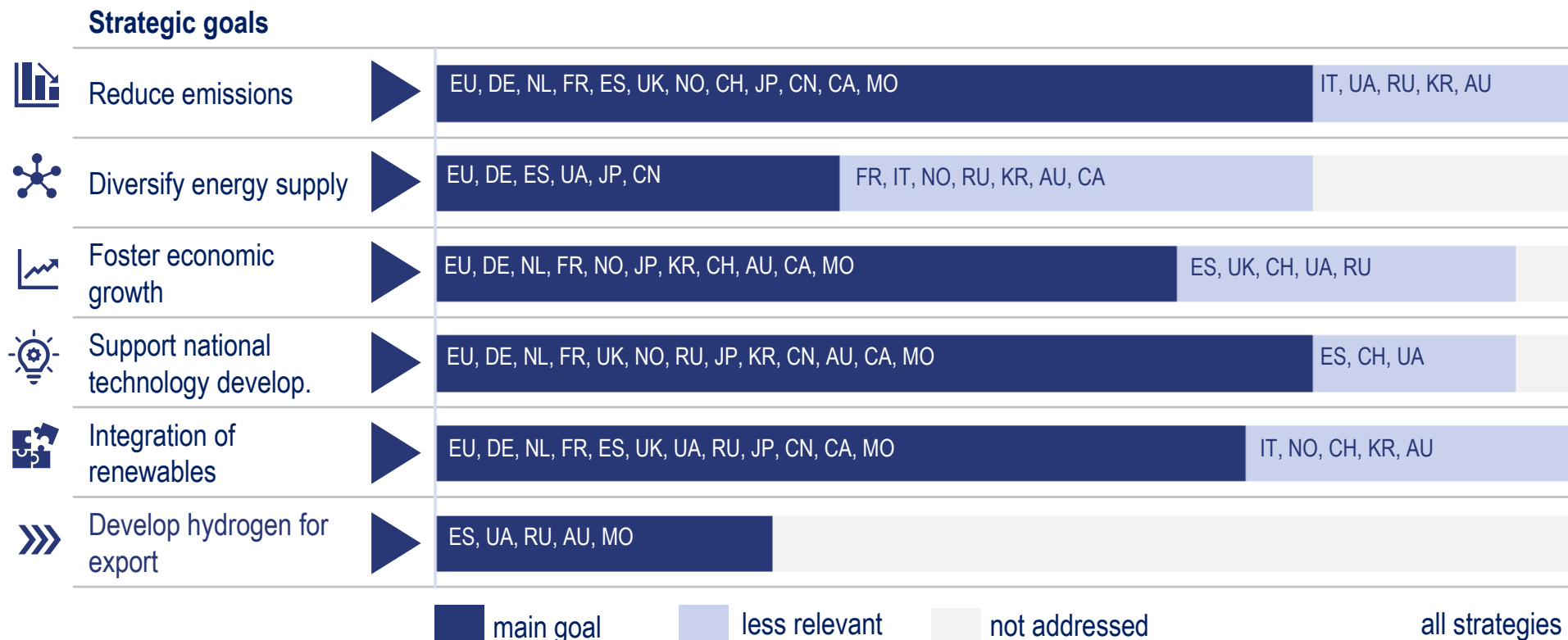
Support for pilot and demonstration projects

Initial policy discussions

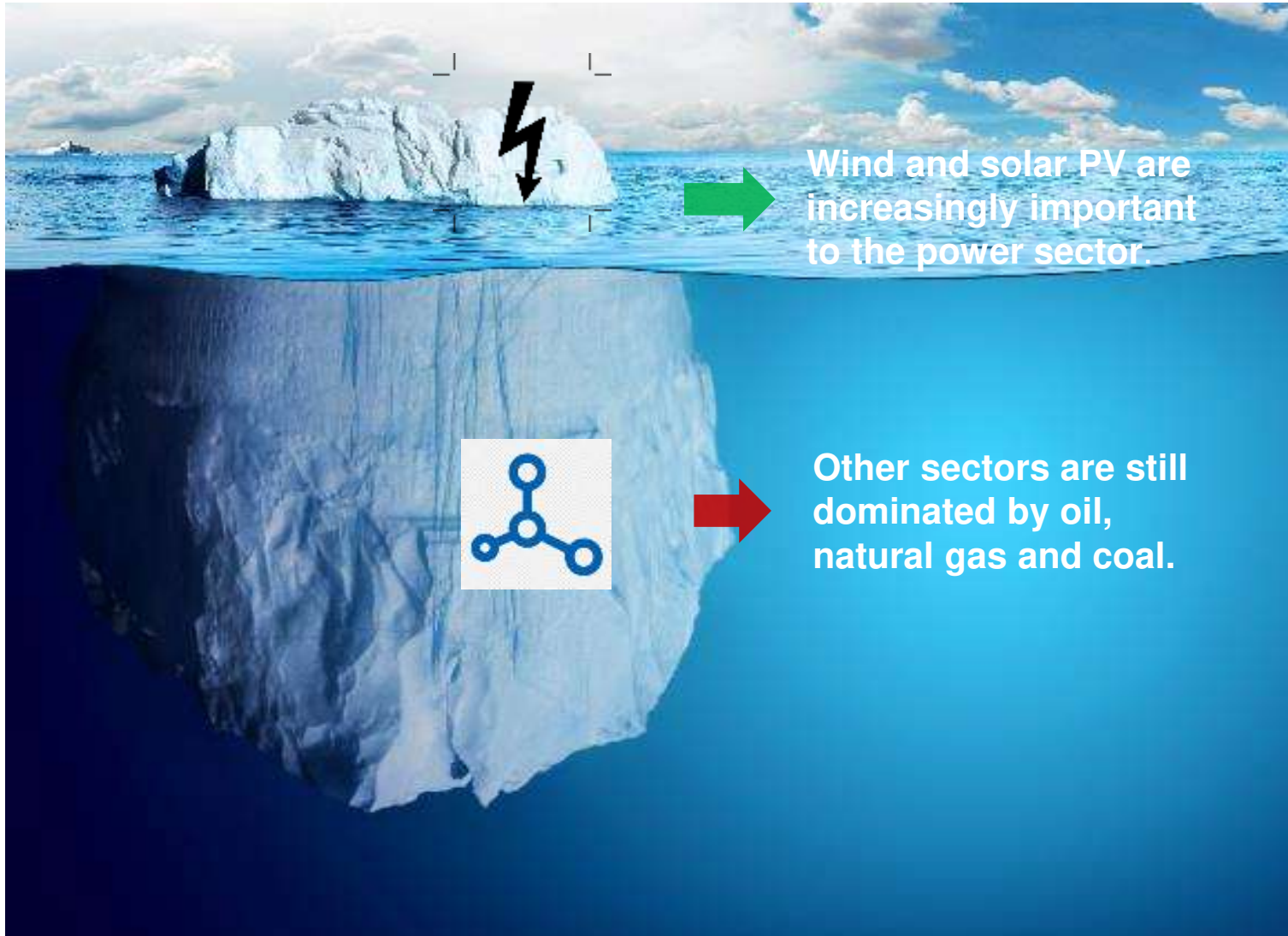
No relevant activities

Not assessed

Main goals of current H₂ strategies per country



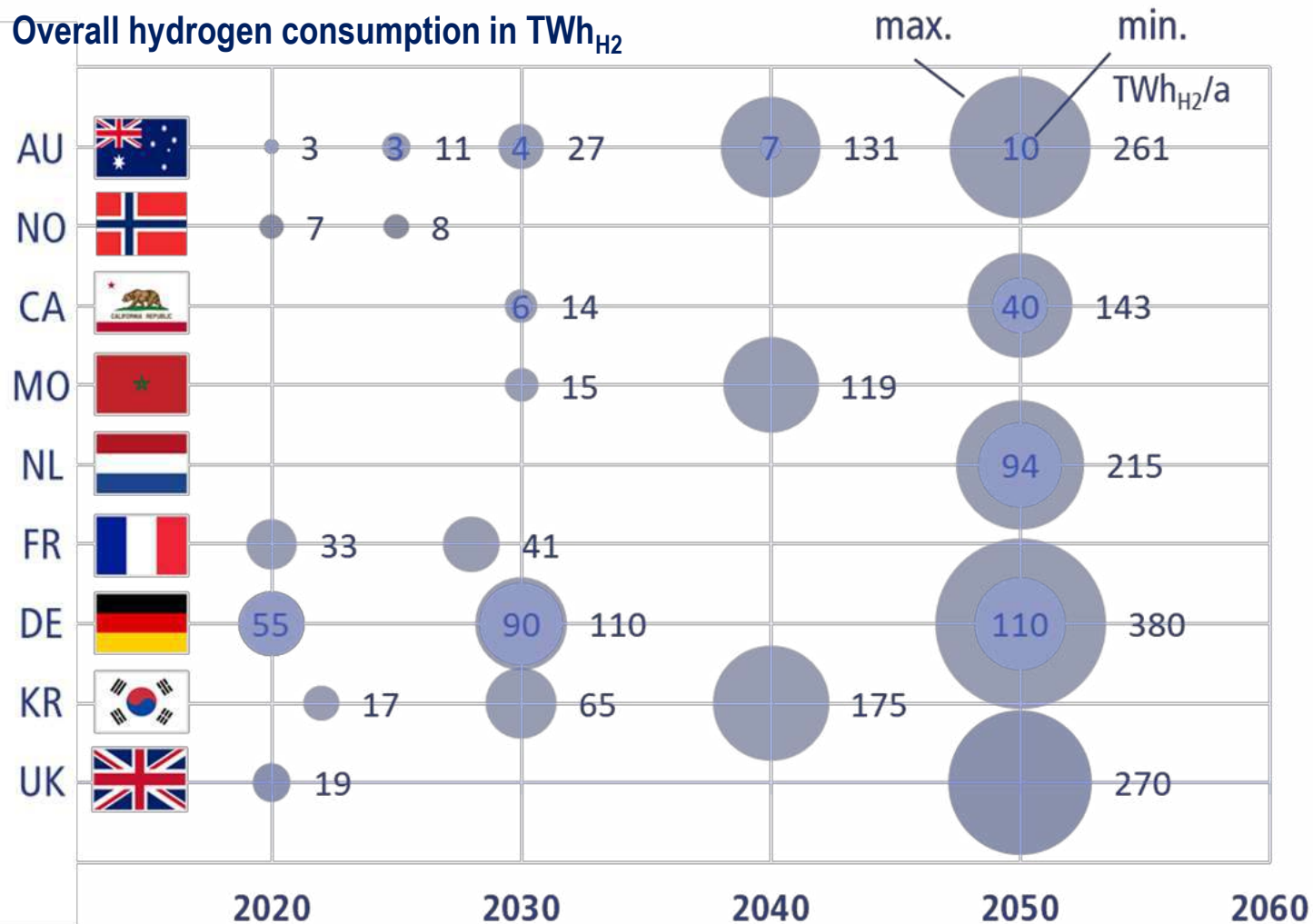
Climate-neutrality is only achievable with green molecules



- Until recently global climate policy efforts have been focused on decarbonizing the **power sector**.
- According to IEA the **electricity** makes up **only 19 %** of global final energy consumption.
- Hydrogen is the key to addressing the **remaining 81 %** and bringing renewable electricity into industrial processes, transport, heating and cooling.

Expected hydrogen consumption

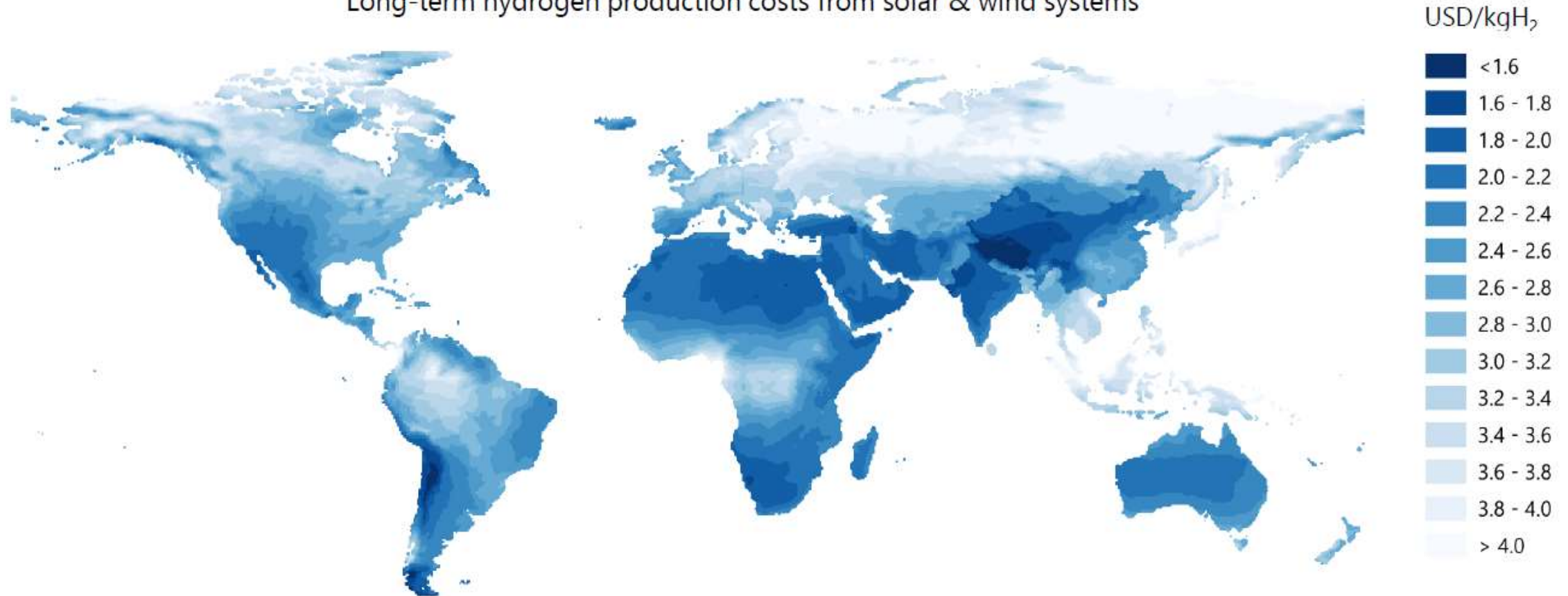
Overall hydrogen consumption in TWh_{H₂}



Scaling upper H₂ demand expected for 2050 in national strategies to global level indicates a potential of up to 9000 TWh
 (an amount almost as large as half the primary energy consumption of the EU-28)

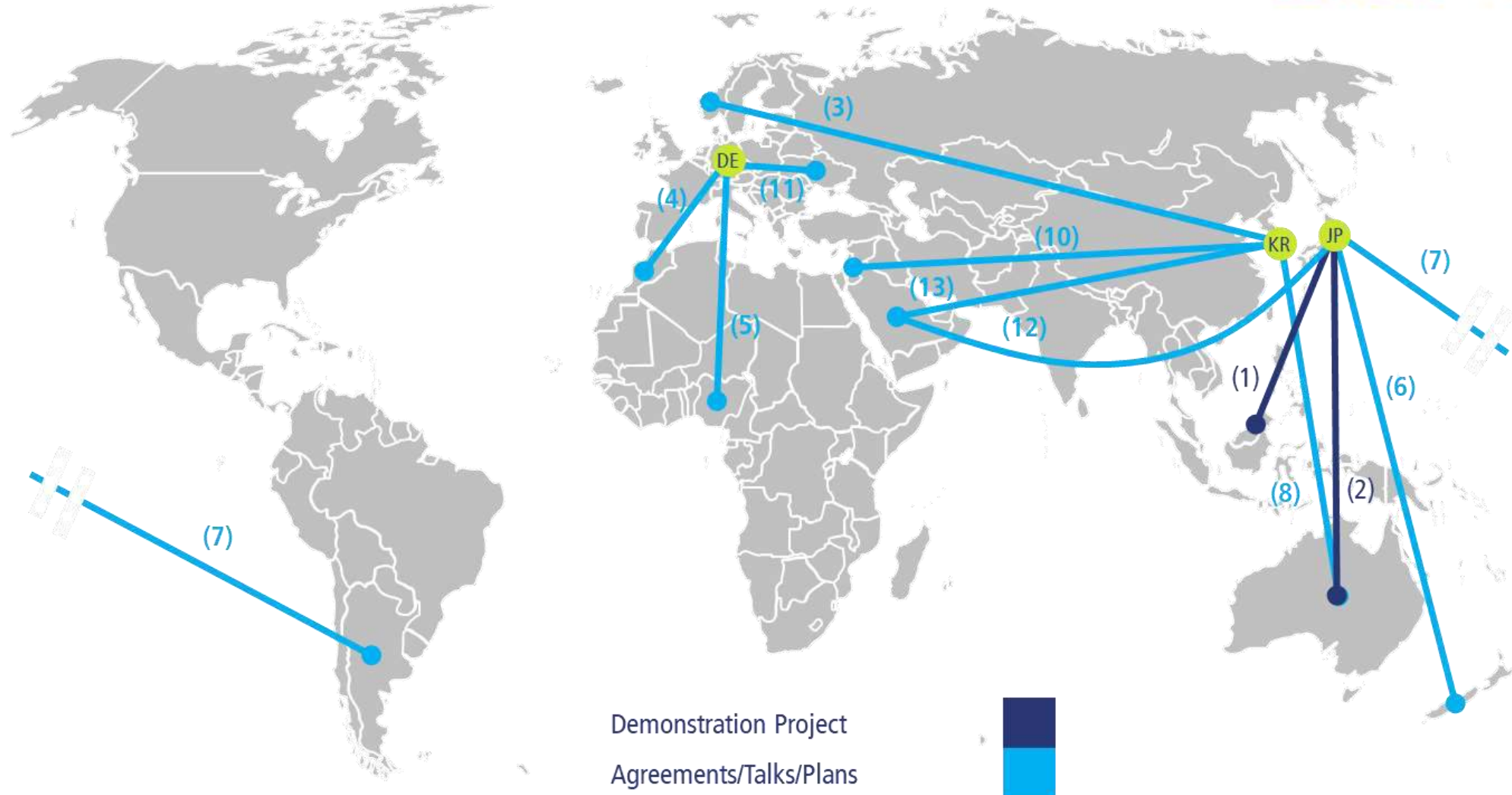
International trade could help harnessing world's best production locations...

Long-term hydrogen production costs from solar & wind systems



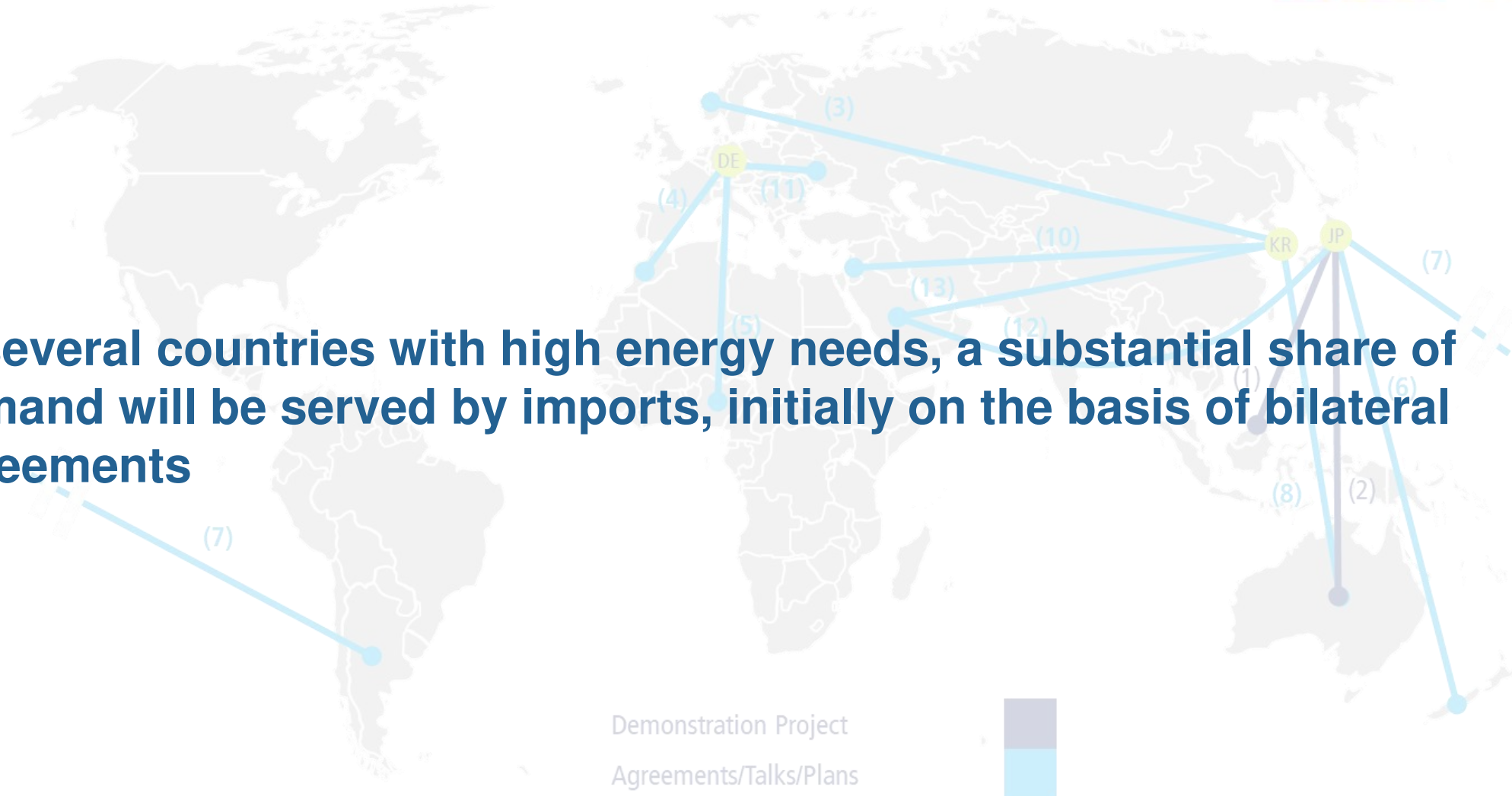
The declining costs of solar PV and wind could make them a low-cost source for hydrogen production in regions with favourable resource conditions.

Hydrogen as an energy vector: International cooperation



Hydrogen as an energy vector: International cooperation

In several countries with high energy needs, a substantial share of demand will be served by imports, initially on the basis of bilateral agreements



Main target sectors of current H₂ strategies per country

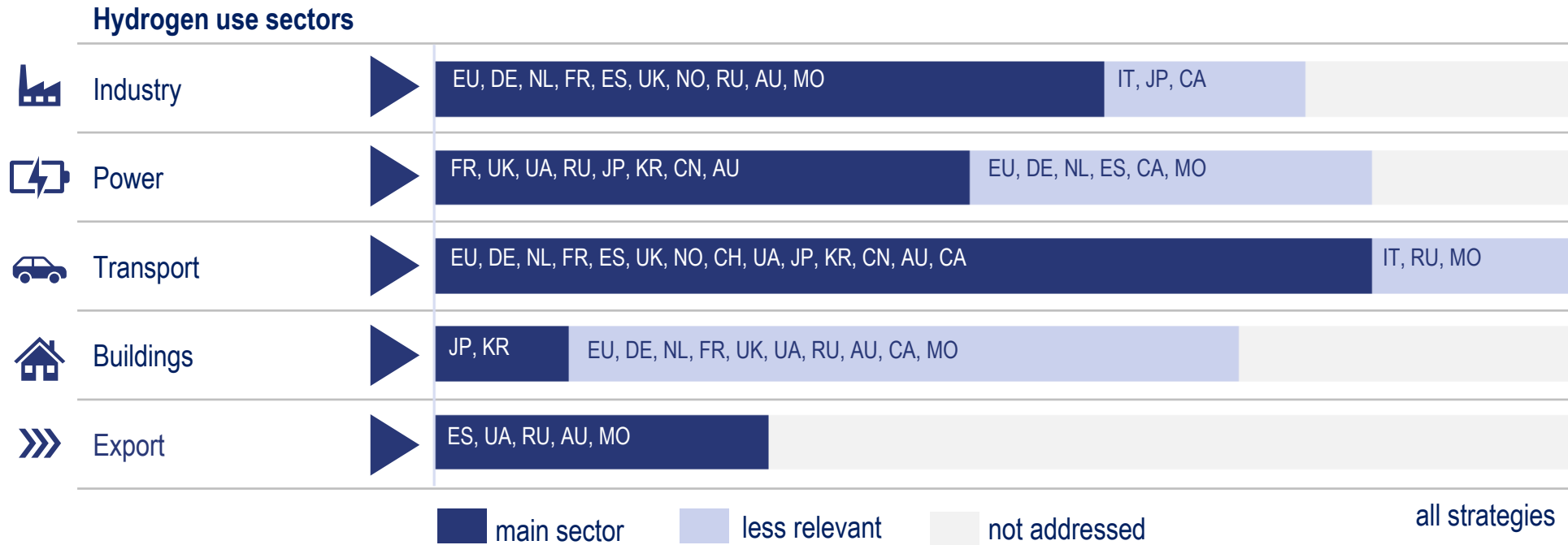
Hydrogen use sectors		EU	DE	NL	FR	ES	IT	UK	NO	CH	UA	RU	JP	KR	CN	AU	CA	MO
 Industry		✓	✓	✓	✓	✓	(✓)	✓	✓	✗	✗	✓	(✓)	✗	✗	✓	(✓)	✓
 Power		(✓)	(✓)	(✓)	✓	(✓)	✗	✓	✗	✗	✓	✓	✓	✓	✓	✓	(✓)	(✓)
 Transport		✓	✓	✓	✓	✓	(✓)	✓	✓	✓	✓	(✓)	✓	✓	✓	✓	✓	(✓)
 Buildings		(✓)	(✓)	(✓)	(✓)	✗	✗	(✓)	✗	✗	(✓)	(✓)	✓	✓	✗	(✓)	(✓)	(✓)
 Export		✗	✗	✗ ¹⁾	✗	✓	✗	✗	✗ ²⁾	✗	✓	✓	✗	✗	✗	✓	✗	✓

✓ main sector (✓) less relevant ✗ not addressed

1) Hydrogen imports transit to other counties (e.g. Germany) considered.

2) For Norway, hydrogen is not targeted for direct export, but indirectly through the export of NG with local CCS.

Main target sectors of current H₂ strategies per country



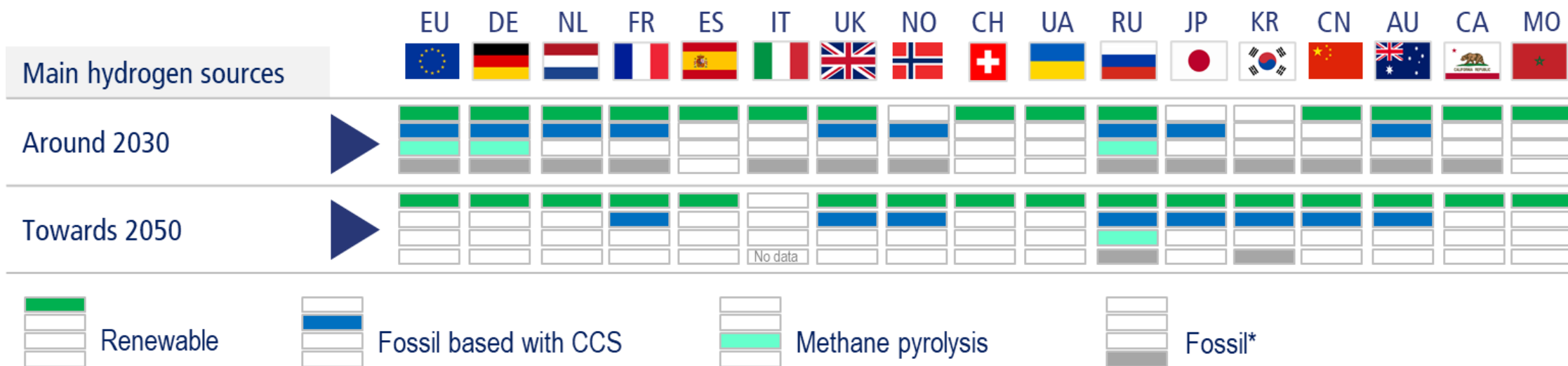
H₂-related requirements: the color of hydrogen

Around 2030

- Renewable and fossil-based hydrogen (with and without CCS) are generally considered viable medium-term sources.
- Methane pyrolysis for hydrogen production is mainly discussed as option in the German and Russian strategies.

Towards 2050

- Renewable hydrogen is the most favorable hydrogen quality in the long-term. Various countries considering it the only viable long-term option.
- Fossil based hydrogen with CCS is regarded a feasible hydrogen source in the long-term in a range of countries.



* In Russia in 2050 mainly based on nuclear power

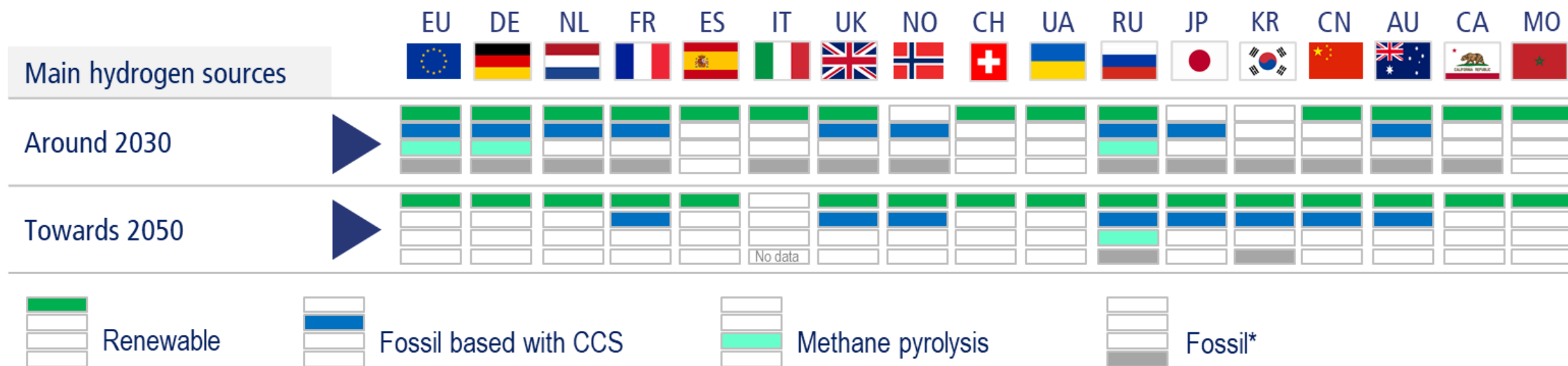
H₂-related requirements: the color of hydrogen

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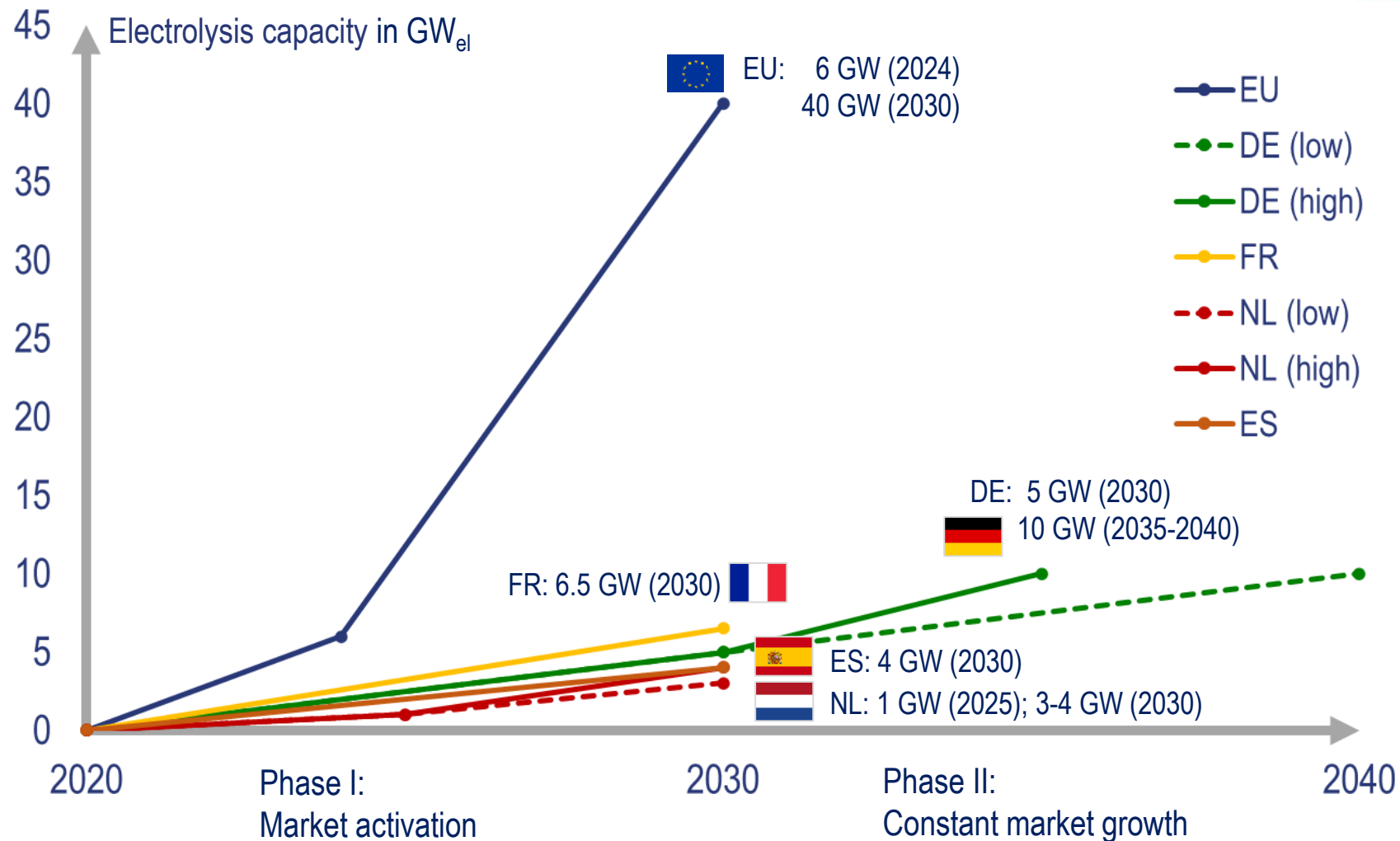
**Green H₂ is central to all strategies;
blue H₂ mainly plays a role in a transition period before 2050**

- Various countries considering it the only viable long-term option.
- Fossil based hydrogen with CCS is regarded a feasible hydrogen source in the long-term in a range of countries.



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Expected electrolysis capacity: 40 GW in EU by 2030



A dynamically growing market for hydrogen



**National
H₂ strategies in place
or in preparation in
at least 20 countries**

By 2025 H₂ strategies
are expected in countries
representing > 80% of
global GDP

- Scaling upper H₂ demand expected for 2050 in national strategies to global level indicates a **potential of up to 9000 TWh**
- In several countries with high energy needs, a **substantial share of this demand will be served by imports**, initially on the basis of **bilateral agreements**
- **Initial applications focus on the transport and industry sectors**
- **Green H₂ central to all strategies**;
blue H₂ mainly plays a role in a transition period before 2050
- **Market ramp-up in 3 phases**:
activation (<2030) ⇒ growth (>2030) ⇒ established (2050)

Emerging opportunities for commercial actors



Large H₂ production capacities required

A > 40 B€ market
alone in the EU
until 2030

- Large **industrial partnerships** will be formed for production and export/import
- **Refineries and chemical industry** to become the first important large-scale green H₂ markets in the mid-term
- **Road transport market** (vehicles and trucks) currently stronger in Asia than in Europe
- **Green synthetic liquid e-fuels (PtL)** can grow into an interesting opportunity with large potential quantities particularly in the aviation and/or maritime sector

New policies needed to achieve strategic aims



**Most strategies focus
on targets rather than
measures**

Policy development
is lagging behind
strategic aims

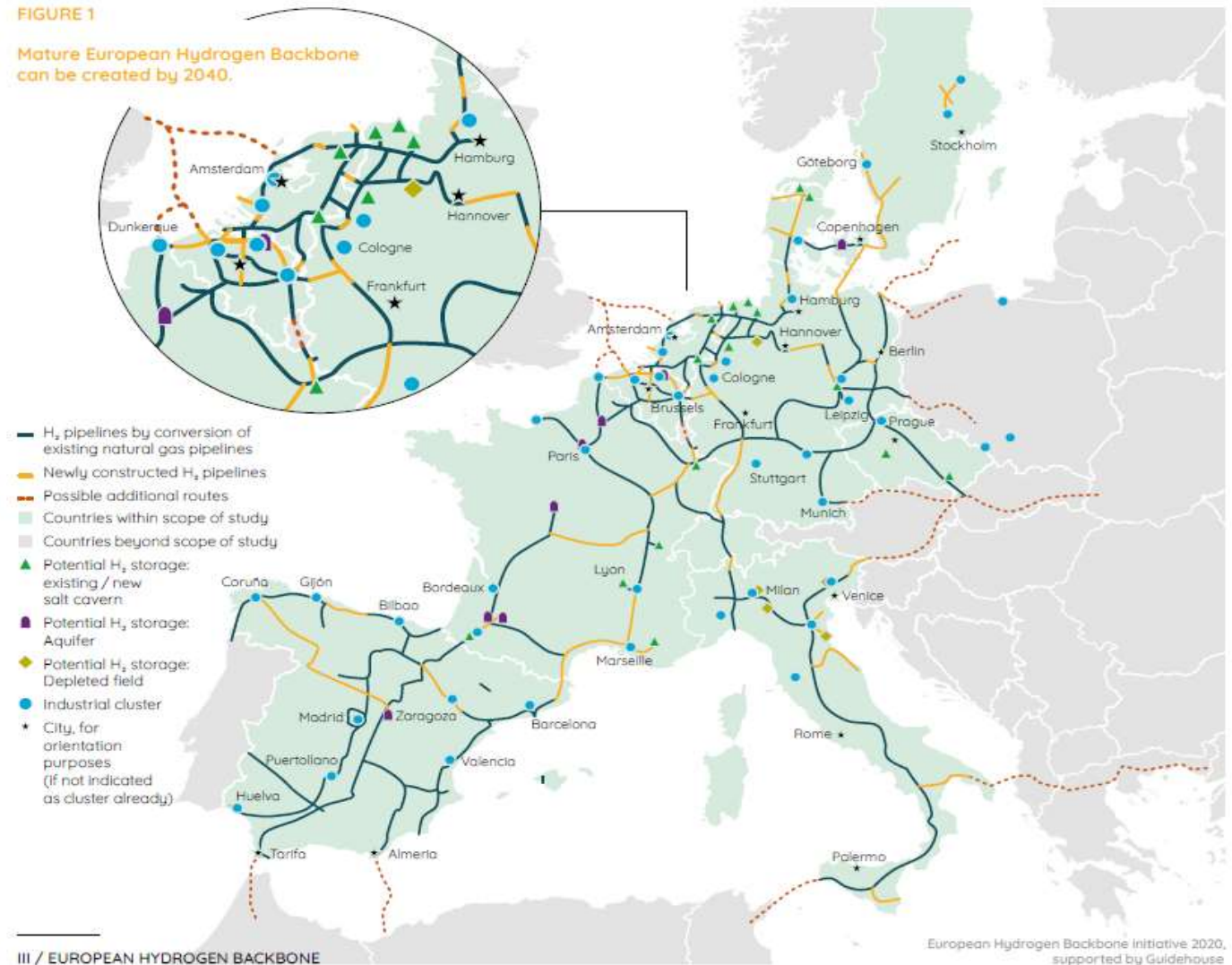
Current measures
insufficient to catalyse
envisaged strong
growth

- Building on earlier successes, policies should focus on commercialisation:
 - **Sectoral quota** stimulate large scale demand
 - Targeted support for **establishing comprehensive value chains**, providing nuclei for sustainable business
 - Move from CAPEX to **OPEX support**
 - Globally **high CO₂ prices** help further reduce cost gap
 - Provide **long-term perspective and security of investment**
- A broadly agreed **green or low carbon hydrogen certification** mechanism is crucial
- **Infrastructure development** requires public financing and central coordination for planning and harmonisation
- Complement all activities with measures supporting **public acceptance**

The vision for a European Hydrogen backbone

- First vision endorsed by the European gas transmission operators
- Presented by 11 TSOs from 9 member states

The companies foresee a network gradually emerging from the mid-2020s onwards to an initial 6,800 km pipeline network by 2030, connecting 'hydrogen valleys'. By 2040, a hydrogen network of 23,000 km is foreseen, 75% of which will consist of converted natural gas pipelines, connected by new pipeline stretches (25%).



The creation of an internal hydrogen market requires a European joint approach



Europe-wide harmonization and standardization of definitions and classification of renewable gases & hydrogen (also required for establishment of **European certification scheme** for hydrogen and accountability of green hydrogen towards EE- and CO2 emission reduction targets of end-consumers, e.g. RED II)



Interoperability of a European-wide hydrogen infrastructure and harmonization of the market design in place (e.g. regulation and financing of infrastructure)



Foster European research and innovation programs (H2020, regulatory sandboxes) as well as support mechanisms (IPCEI)



Revision of State Aid Rules to enable active funding of hydrogen projects (OPEX support)



The creation of a European internal market for hydrogen provides a chance to establish new value chains within Europe that foster the European Union, create new labor market and could improve energy security. -> EU COM proposes Euro denomination of hydrogen transactions

Grazie mille!
Danke!
Thank you!



ludwig bölkow
systemtechnik

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Backup

PtX plants ramping up fast

		EU	DE	NL	FR	ES	IT	UK	NO	CH	UA	RU	JP	KR	CN	AU	CA	MO
																		
 PtX plants in operation	▶	64	34	2	8	1	4	4	1	5	0	0	15	0	1	3	1	0
 PtX MW in operation	▶	57	29	1	1	<1	1	3,5	1	1	0	0	11	<1	<1	6	<1	0
 PtX plants in preparation*	▶	160	77	14	19	8	4	16	13	2	0	0	2	1	7	10	3	1
 PtX MW in preparation*	▶	9500	750	3800	1.600	161	2000	308	288	40	0	0	0	~10	5200	20	3	100

*announced, studied, under construction; incl. plants without detail on size (as of July 2020)

Main targets in subsector transport per country









































Transport subsectors	EU	DE	NL	FR	ES	IT	UK	NO	CH	UA	RU	JP	KR	CN	AU	CA	MO
Passenger cars	✗	(✓)	✓	✗	(✓)	(✓)	(✓)	(✓)	✗	✓	✗	✓	✓	✓	(✓)	✓	✗
Buses	✓	✓	✓	✓	(✓)	(✓)	✓	(✓)	✗	✓	✗	✓	✓	✓	✓	✓	(✓)
Trucks	✓	✓	✓	✓	(✓)	(✓)	✓	✓	✓	(✓)	✗	✓	✓	✓	✓	✓	(✓)
Rail	✓	✓	✗	✓	(✓)	(✓)	✓	(✓)	✗	(✓)	(✓)	(✓)	(✓)	✓	✗	(✓)	✗
Ships	✓	✓	(✓)	✓	(✓)	(✓)	✓	✓	✗	(✓)	✗	✓	(✓)	(✓)	✓	✓	✗
Aviation	✓	✓	(✓)	(✓)	(✓)	✗	✗	✗	✗	✗	✗	✗	✗	(✓)	✗	✗	✗
Other*	✓	✓	✗	✓	✗	✗	✗	✗	✗	✗	✗	✓	(✓)	(✓)	✗	✓	✗

✓ main subsector
 (✓) less relevant
 ✗ not addressed

* Material handling, light utility vehicles, special purpose vehicles (e.g. construction machinery, towing tractors) and drones

Definition e-fuels

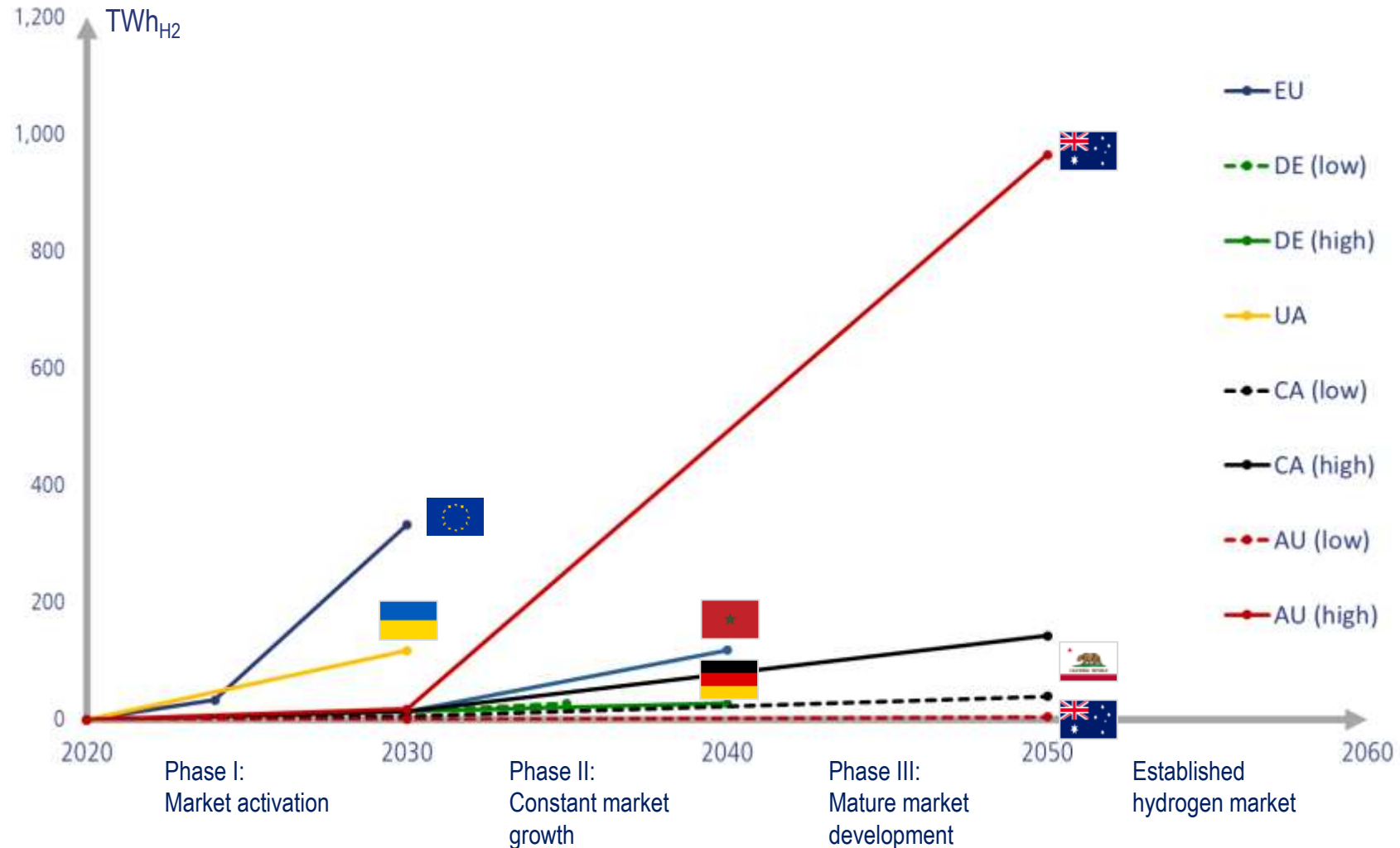
- Synthetic fuels with renewable hydrogen as intermediate product of the Power-to-Fuel process
- In broader sense: Power-to-Liquids (PtL), Power-to-Methane (PtCH₄), ammonia, and methanol as fuels

Power-to-Liquids	Power-to-Methane	Ammonia	Methanol
<p> NL: Blending obligation for aviation (14% in 2030; 100% in 2050)</p> <p> DE: 2% in aviation in 2030 to be considered</p> <p> ES: Support PtL production and use in aviation</p> <p> EU (Long-term) option for ships and planes</p> <p> AU: ships and planes</p> <p> NO: Mentioned for aviation</p>	<p> IT: Mentioned in NECP as one of multiple renewable gases</p> <p> DE: Option for heating in buildings</p> <p> JP: Potential relevant option to import energy</p>	<p>Potential carrier for energy exports/imports: EU, DE, NO, ES, MO, AU, JP, KR</p> <p>       </p> <p>Green feedstock for industry: EU, DE, NL, ES, NO, AU</p> <p>     </p> <p>Potential fuel for ships: EU, NO, UK, AU, KR, AU</p> <p>    </p>	<p>Potential carrier for energy exports/imports: DE, ES, MO, JP</p> <p>   </p> <p>Green feedstock for industry: EU, DE, ES, NO, AU</p> <p>    </p> <p>Potential fuel for ships: EU, KR</p> <p> </p> <p>Potential fuel for aviation: EU</p> <p></p>

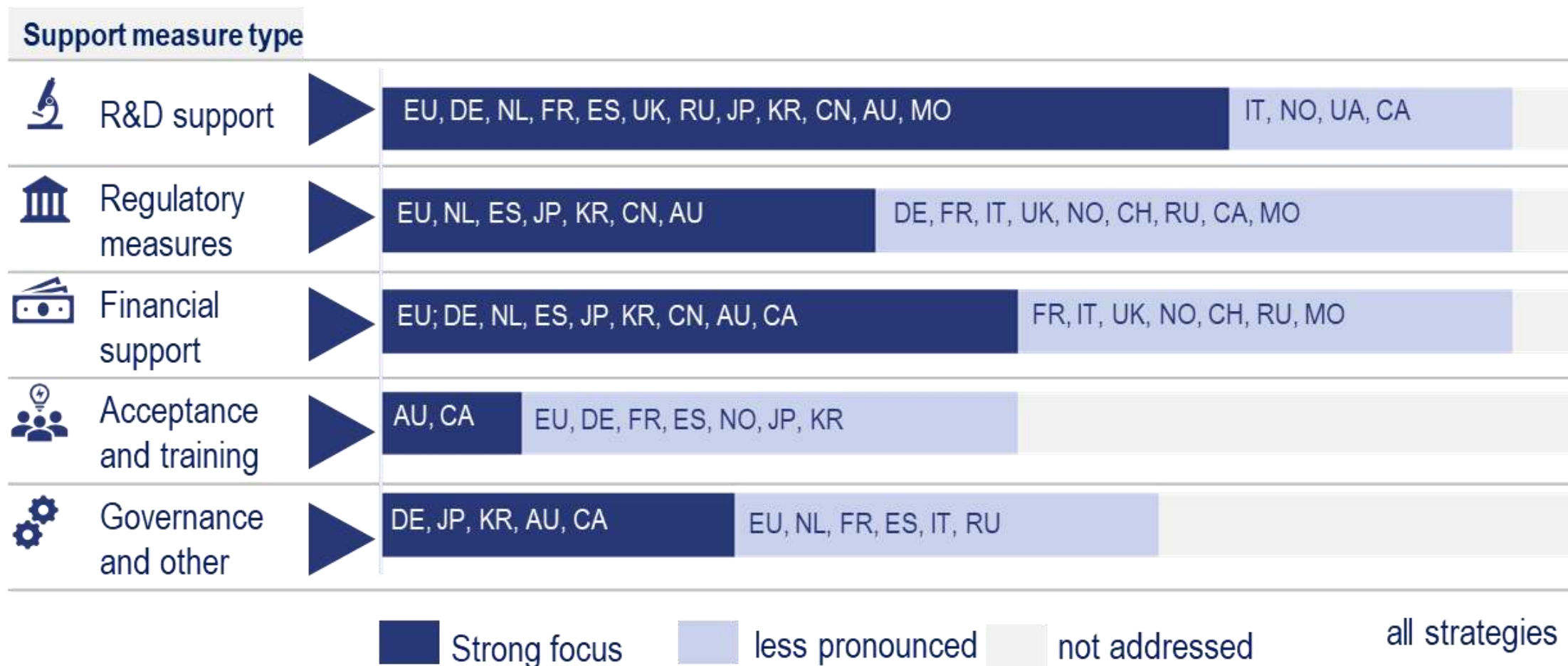
Conclusion

- E-fuels mentioned only in some strategies mainly without quantitative figures (except e.g. PtL for aviation in NL and DE)
- PtL mainly for aviation and maritime sectors; PtCH₄ in gas sector or as carrier for energy import/export; ammonia & methanol as ship fuel or carrier for energy import/export
- Advantages and disadvantages of e-fuels should be evaluated if not taken into account in a strategy

Expected green hydrogen production



Major support measures per country



Main goals of current H₂ strategies per country

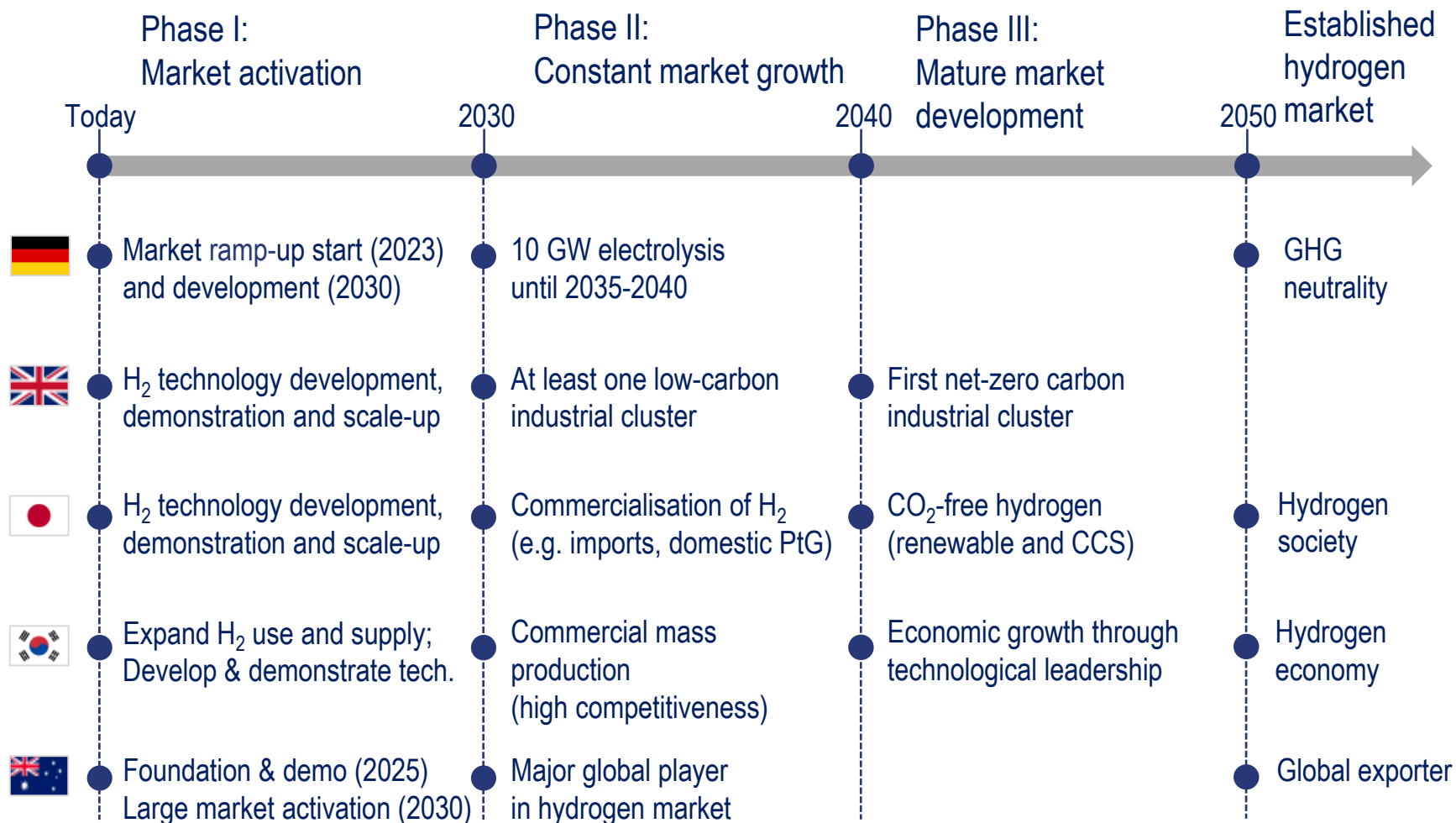
Strategic goals		EU	DE	NL	FR	ES	IT	UK	NO	CH	UA	RU	JP	KR	CN	AU	CA	MO
	Reduce emissions	✓	✓	✓	✓	✓	(✓)	✓	✓	✓	(✓)	(✓)	✓	(✓)	✓	(✓)	✓	✓
	Diversify energy supply	✓	✓	✗	(✓)	✓	(✓)	✗	(✓)	✗	✓	(✓)	✓	(✓)	✓	(✓)	(✓)	✗
	Foster economic growth	✓	✓	✓	✓	(✓)	✗	(✓)	✓	(✓)	(✓)	(✓)	✓	✓	✓	✓	✓	✓
	Support national technology develop.	✓	✓	✓	✓	(✓)	✗	✓	✓	(✓)	(✓)	✓	✓	✓	✓	✓	✓	✓
	Integration of renewables	✓	✓	✓	✓	✓	(✓)	✓	(✓)	(✓)	✓	✓	✓	(✓)	✓	(✓)	✓	✓
	Develop hydrogen for export	✗	✗	✗ ¹⁾	✗	✓	✗	✗	✗ ²⁾	✗	✓	✓	✗	✗	✗	✓	✗	✓

✓ main goal (✓) less relevant ✗ not addressed

1) Hydrogen imports transit to other counties (e.g. Germany) considered.

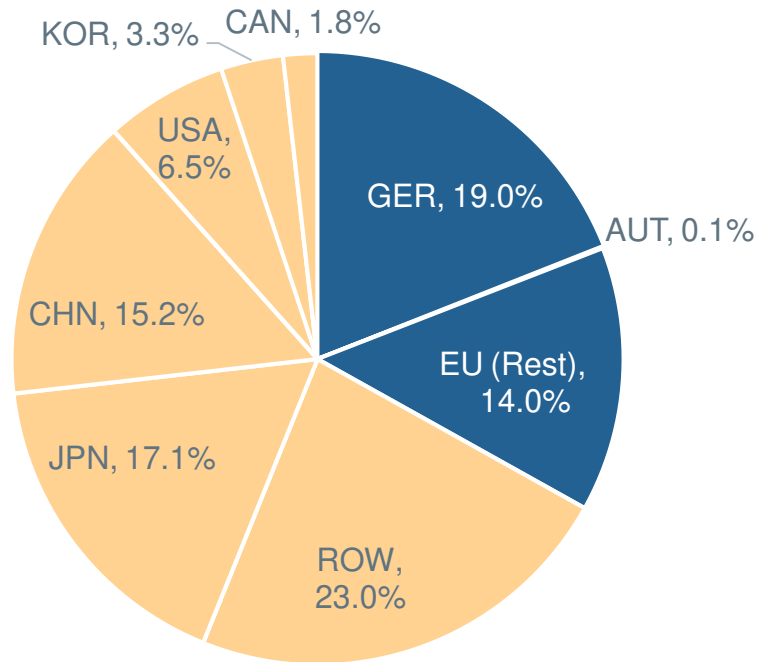
2) For Norway, hydrogen is not targeted for direct export, but indirectly through the export of NG with local CCS.

H₂ market development in 3 major phases (examples from selected countries)



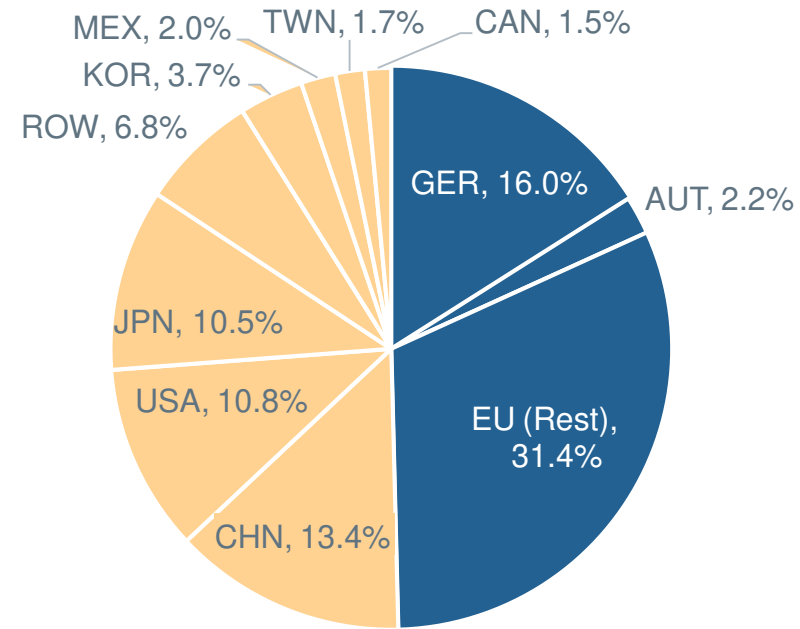
Potential market shares of the European and German manufacturers

Expected annual production of electrolysers for PtX production



The EU accounts for about **33.1%** of the world's expected annual production of electrolysers for PtX production

Expected production of other PtX production capacities by 2020



The EU accounts for about **49.4%** of the expected production of other PtX production equipment in 2020

Various countries demonstrate strong potential for PtX production/exports ...



Source: Weltenergieerat | Frontier Economics