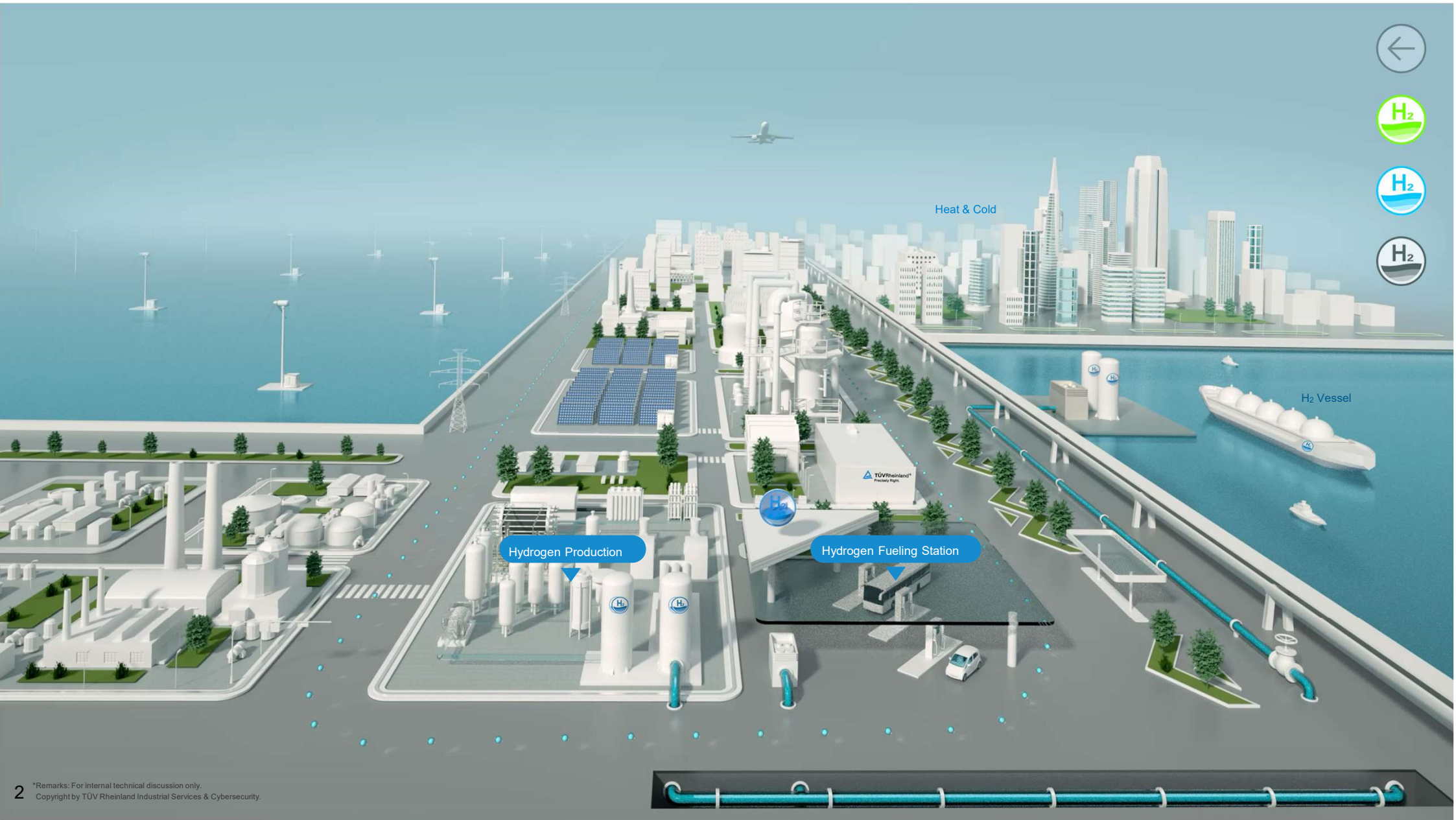


Green hydrogen development strategy and certification in Europe

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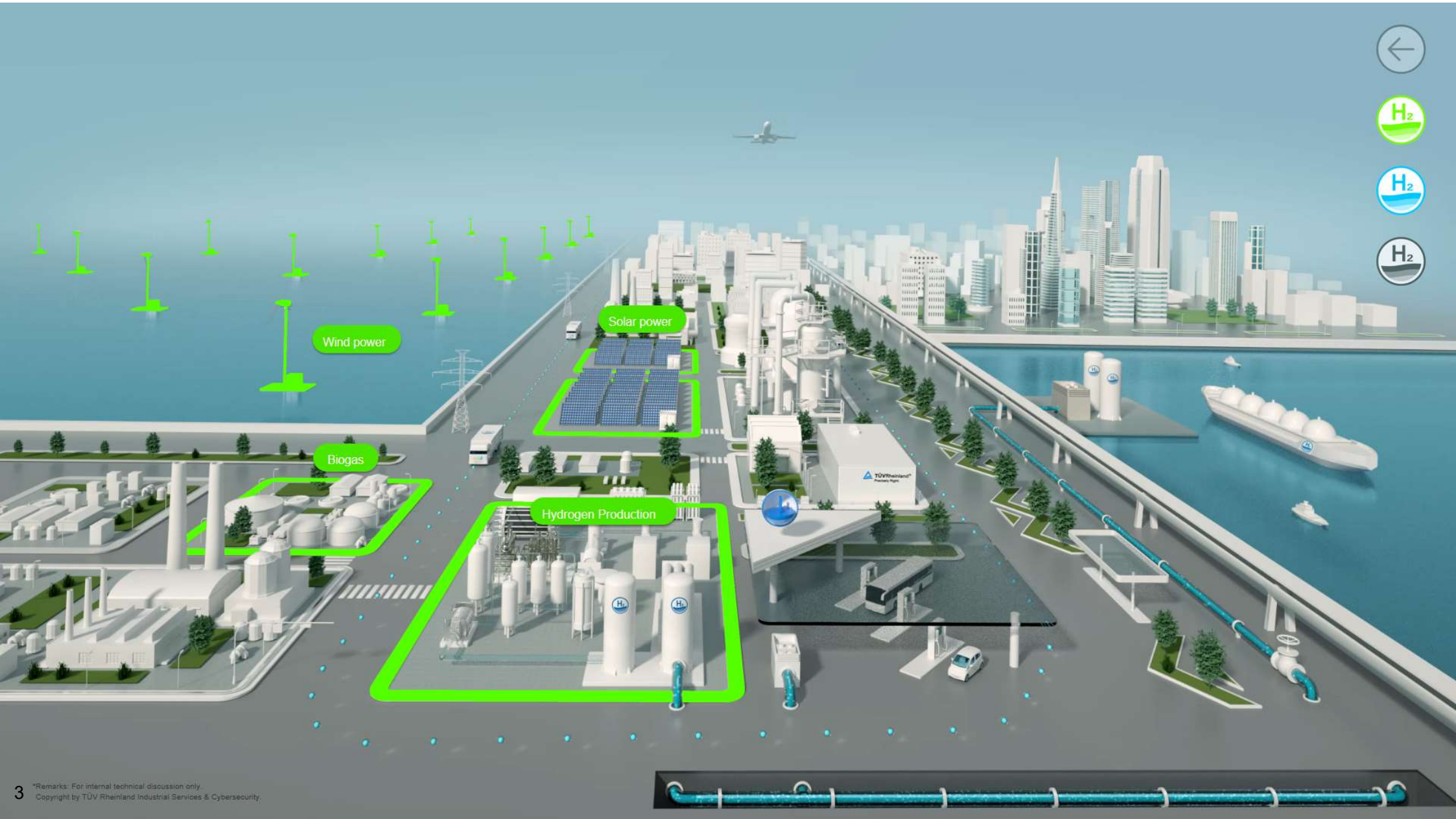
Heat & Cold

H2 Vessel

Hydrogen Production

Hydrogen Fueling Station

TÜV Rheinland
Energy Audit





Fossil Fuels

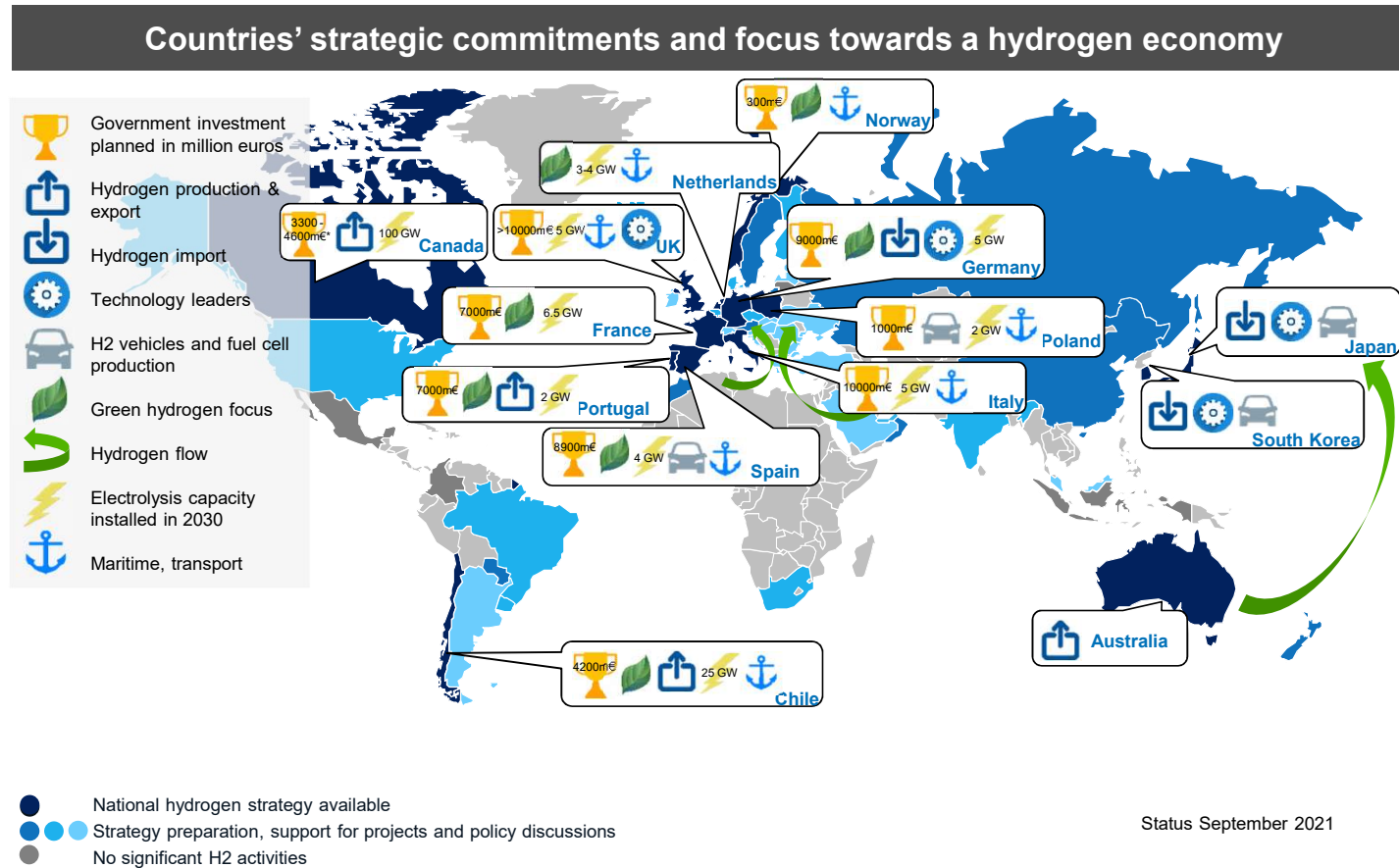
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TÜV Rheinland
Process Safety

Content

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2	Green hydrogen development strategy in Europe (#6)
3	Hydrogen colour scheme (#1)
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5	Hydrogen value chain technologies & TÜV Rheinland solutions (#1)

Global overview of national hydrogen strategies until 2030

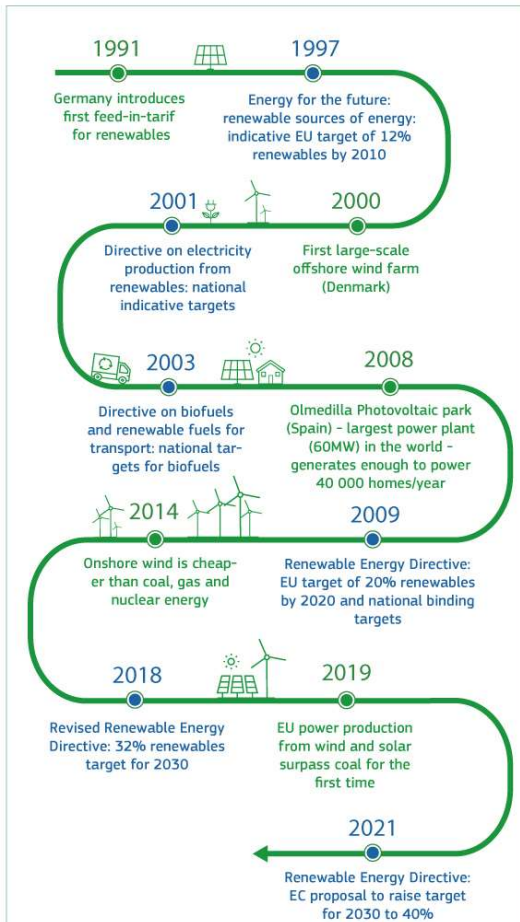


- ## Key insights
- In 2030, the EU aims to produce 10 million tonnes of hydrogen with a combined electrolyser capacity of 40 GW. Power-to-X technologies are expected to create a market volume of 140 billion € and 140,000 jobs.
 - UK Hydrogen Strategy implies a focus on upskilling workers, creating 'Hydrogen Ready' products and focuses on captive fleets until 2030.
 - The US has revealed investments in H2, but not a national strategy yet.
 - China set a national low carbon target for 2030 in which the development of the hydrogen industry plays a crucial role making China a promising market.
 - Japan and South Korea are early starters, technologically ahead, with a focus on tech leadership and fuel cell & car production.
 - Middle East and North Africa to provide large-scale renewable electricity and H2 for export.
 - India announced a "hydrogen mission" for CO2 foot print reduction of 200 m€.

Created by TÜV Rheinland, information based on public available data.

Strategy for green hydrogen development in Europe

□ European Green Deal, RED II and European Hydrogen Strategy



https://ec.europa.eu/energy/topics/renewable-energy/directive-targets-and-rules/renewable-energy-directive_de

7

- 1. European Green Deal** aims to have commercially viable key technologies such as clean hydrogen and fuel cells until 2030. Decarbonization of steel, chemical and cement industry. (P.8, 10)
- 2. The Renewable Energy Directive (RED II)** aims to “the objective of a low-carbon economy by the year 2050”, P.3, Clause (19). It also aims to allow **guarantees of origins** for gases from renewable sources, like hydrogen, Clause (59).
- 3. European Hydrogen Strategy** wants to reach large scale hydrogen production and its decarbonisation. Hydrogen will be used in integrated energy systems and in circular use of resources. Cumulative investments in renewable hydrogen in Europe could be up to EUR 180-470 billion by 2050. (P. 2-3).

Note:
the page/clause numbers refer to the content of the 3 corresponding documents

Strategy for green hydrogen development in Europe

❑ The EU hydrogen strategic roadmap to 2050 covers 3 phases

- ❑ To install at least **6 GW of renewable hydrogen electrolysers** in the EU and the production of up to **1 million tonnes of renewable hydrogen**.
- ❑ Build up a robust pipeline of investments.



- ❑ **Renewable hydrogen technologies** should reach **maturity** and be deployed at **large scale** to reach **all hard-to-decarbonize sectors** where other alternatives might not be feasible or have higher costs.
- ❑ **Renewable electricity production** needs to **massively increase** as about **a quarter of renewable electricity** might be used for **renewable hydrogen production**.

2020-2024

2025-2030

2031-2050



- ❑ To install at least **40 GW of renewable hydrogen electrolysers** and the production of up to **10 million tonnes of renewable hydrogen**.
- ❑ Aim at completing an **open and competitive EU hydrogen market**, with **unhindered cross-border trade** and **efficient allocation of hydrogen supply among sectors**.



Source: A hydrogen strategy for a climate-neutral Europe
<https://www.axpo.com/lu/en/about-us/magazine.detail.html/magazine/renewable-energy/eu-hydrogen-strategy.html>

Strategy for green hydrogen development in Europe

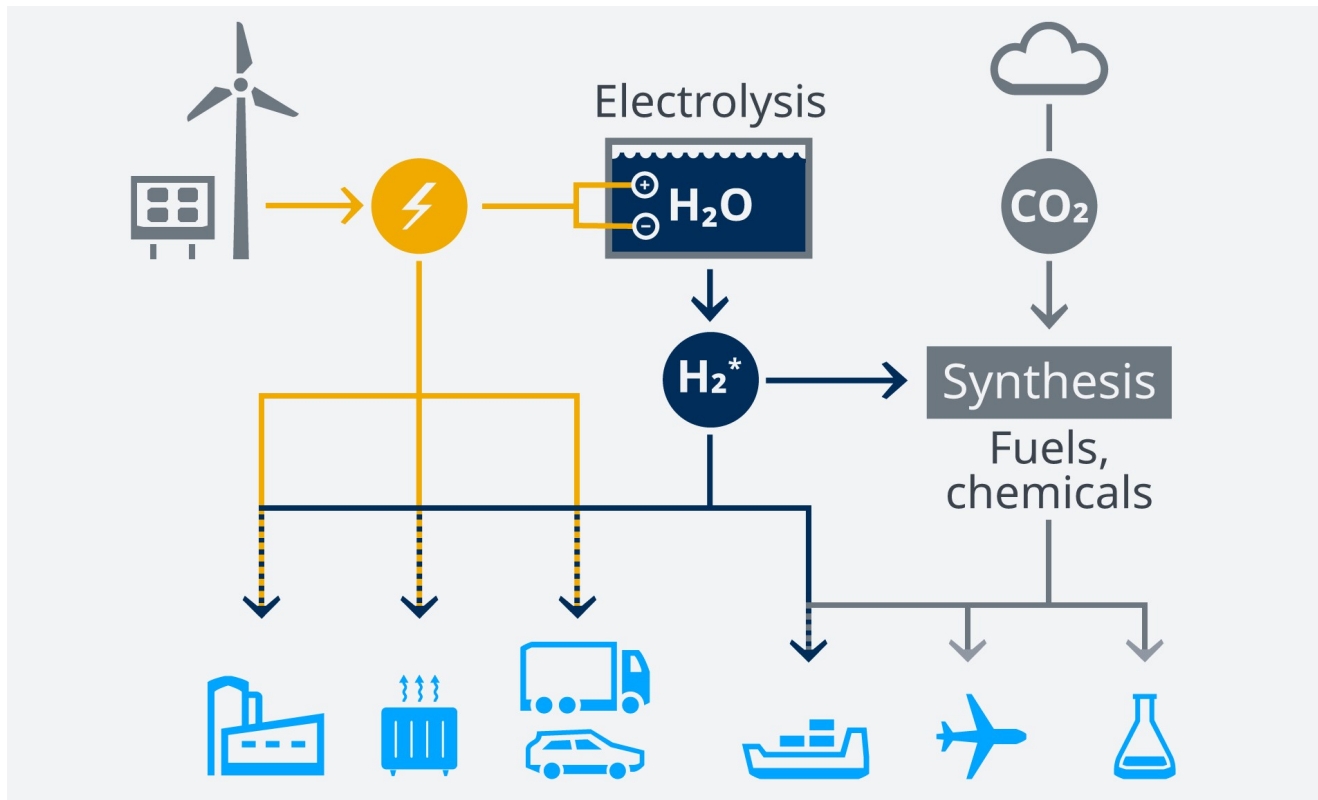
□ Hydrogen Europe's Top 10 recommendations

- 1** Define an **EU wide terminology for renewable and low carbon hydrogen** together with a methodology to calculate life cycle greenhouse gas emissions **in order to enable a functioning clean hydrogen economy**
- 2** Establish the principle of CO₂ as the new **"currency"** of the energy system
- 3** Promote and support hydrogen market **stimulation programs** including quotas/targets, dedicated programs and support schemes
- 4** Enable a **competitive hydrogen economy** by clarifying the market design and supporting **sectoral integration**
- 5** Revise the **Trans-European Networks for Energy (TEN-E) Regulation** to support the development and roll out of hydrogen networks
- 6** Revise the directive for the Deployment of Alternative Fuels Infrastructure (DAFI) to **boost the use of hydrogen in the mobility sector**
- 7** Support for a **strong, effective and all encompassing** Clean Hydrogen for Europe Partnership
- 8** **Remove undue barriers** to hydrogen production and hydrogen infrastructure
- 9** **Unlock hydrogen's potential** by leveraging innovative financial instruments
- 10** Launch the Clean Hydrogen Alliance and **establish hydrogen as a key element in global EU climate diplomacy** and neighborhood policy

Source: The EU Hydrogen Strategy - Hydrogen Europe's Top 10 Key Recommendations

Strategy for green hydrogen development in Europe

□ Power-to-X in Germany



Source: Deutsche Welle (Germany)

- In 2016, Federal Ministry of Education and Research (BMBF) supported “Power-To-X project”, which focuses on the storage of excess power into other energy carriers.
- Power-To-X identifies technologies that transform power from renewable resources into material energy storage, energy carriers, and energy-intensive chemical products.

Strategy for green hydrogen development in Europe

□ 3 funded hydrogen R&D projects in Germany, as example

H2Giga:

- Involves **112 partners, including key electrolyser makers** thyssenkrupp AG, Siemens Energy AG and SunFire GmbH
- **500 Mio. EUR** subsidies
- Research in **mass production of electrolyzers**

H2Giga

TransHyDe:

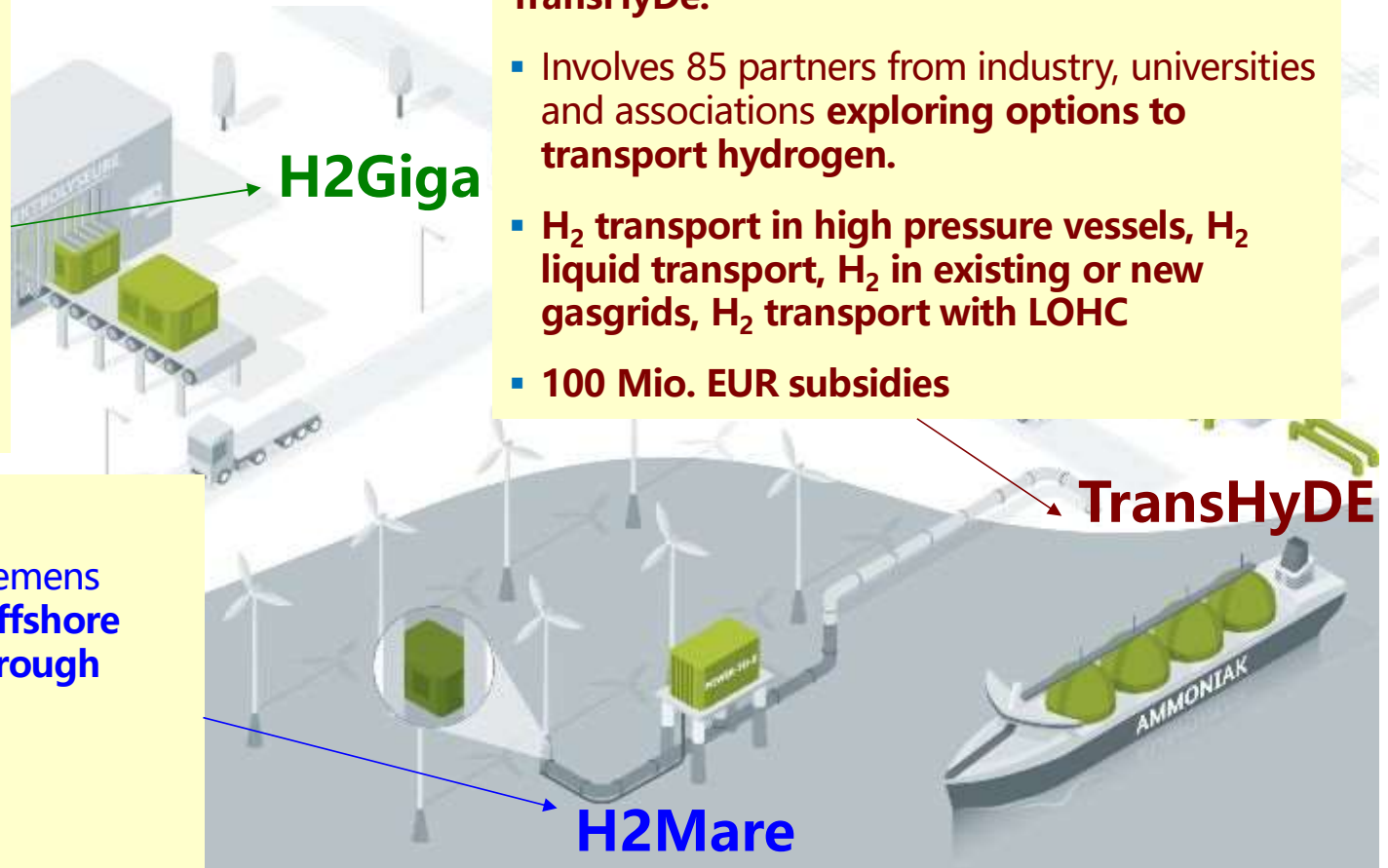
- Involves 85 partners from industry, universities and associations **exploring options to transport hydrogen.**
- **H₂ transport in high pressure vessels, H₂ liquid transport, H₂ in existing or new gasgrids, H₂ transport with LOHC**
- **100 Mio. EUR** subsidies

TransHyDE

H2Mare:

- Involves i.a. Siemens Energy and Siemens Gamesa to **explore and develop offshore production of green hydrogen through wind turbines.**
- **100 Mio. EUR** subsidies

H2Mare



Source: German Ministry for Education and Research

Strategy for green hydrogen development in Europe

□ Statements from German industry on relevance of hydrogen

“ThyssenKrupp and RWE join forces to enable zero emission steelmaking” - June 2020

“H2 is a core part of our strategic roadmap. We’ll have an H2 department from October 1st on.”

- RWE Innovation & New Tech.
Lisa Willnauer

“Long-term regulatory reliability and an investment-friendly legal framework are required”

- E.ON Board Member
Dr. Thomas König

“Shell consortium to develop NorthH2, renewable H2 project in Netherlands producing 3-4GW of wind energy”

- February 2020

“We need financing concepts to initiate rapid scaling”

- Siemens-Energy CEO
Christian Bruch

“Siemens Energy launches its first megawatt green hydrogen production project in China” - August 2020

BASF and RWE plan a 2GW offshore wind farm for green electricity and green hydrogen for chemical industry - May 2021



Consortium of 40+ companies working to establish Germany-wide **H2 infrastructure to enable the energy transition** incl. Evonik, bp, Alstom, RWE, Engie, Rosen, BASF, Uniper, Siemens

Sources: NS Energy, Handelsblatt 8th July 2020 No. 129, Get-H2, personal interview RWE August, 2020, Siemens Energy, Steel Times International, background image from Shell (Status August 2020)

Hydrogen colour scheme

Green H₂

Green Hydrogen is produced by electrolysis of water. Needed electricity has to be generated from renewables.

Grey H₂

Grey Hydrogen is produced from fossil fuels. Usually natural gas is heated to gain CO₂ and H₂ (Steam reforming)

Colour scheme

Turquoise H₂

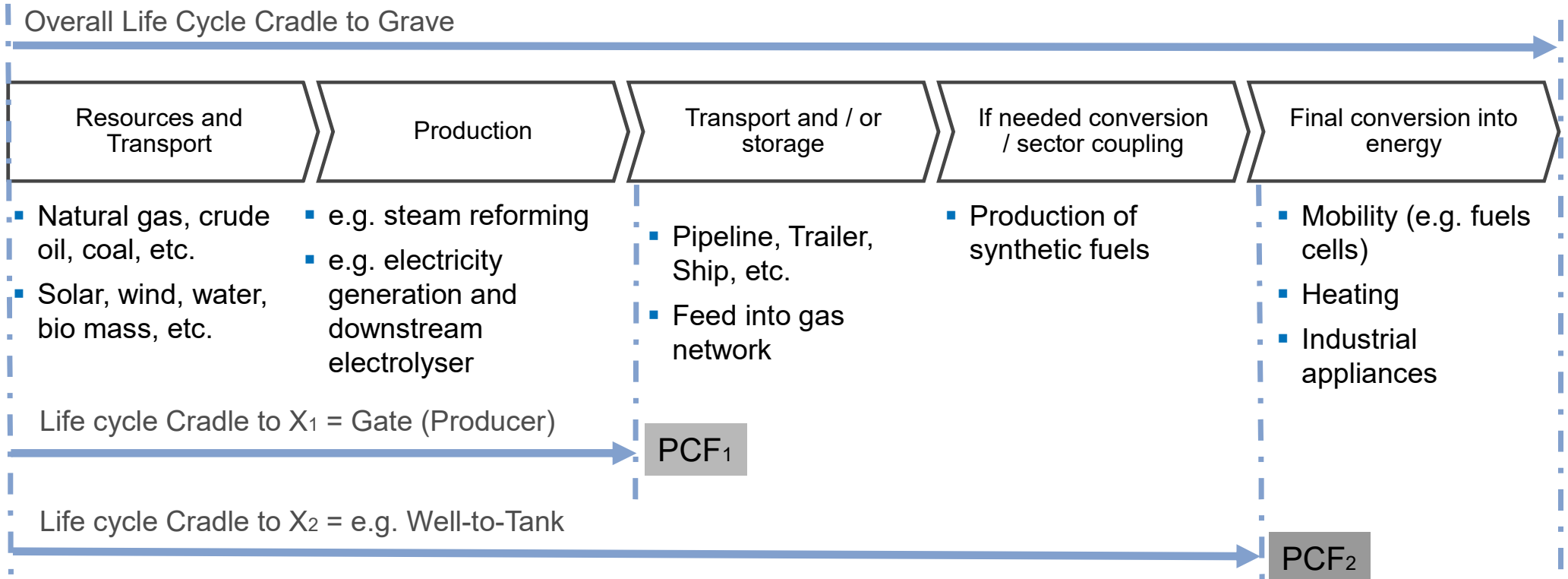
Turquoise Hydrogen is produced by thermal splitting (Pyrolysis of natural gas). As a side product elemental carbon is formed instead of CO₂.

Blue H₂

Blue Hydrogen is Grey Hydrogen which CO₂ is captured and stored underground (CCS)

TÜV Rheinland green hydrogen certification

□ TÜV Rheinland Standard H2.21 - Life cycle and product carbon footprint (PCF)



TÜV Rheinland green hydrogen certification

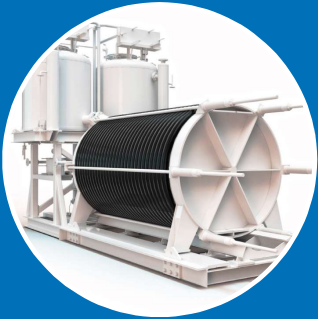
□ TÜV Rheinland Standard H2.21 – Certification approach

1. Starting Point: The determined Product Carbon Footprint (PCF) of hydrogen within its **individual** and **flexible** life cycle boundaries **Cradle to X**
2. X can be any point in the life cycle after Cradle until Grave
3. PCF at point X shall be Zero
4. **Certification → Carbon Neutral Hydrogen**
5. **Additional Certification according to Colour Scheme:**
 - Green Hydrogen
 - Blue Hydrogen
 - Turquoise Hydrogen, plus
 - RED II conformal Hydrogen



TÜV Rheinland green hydrogen certification

□ Applied scopes



All production methods are allowed



All distribution and storage methods are allowed



All appliances are allowed



Separation within life cycle assessment is allowed (e.g. H₂ produced from waste incineration can be separated into biotic and non-biotic share)

Open system requirements

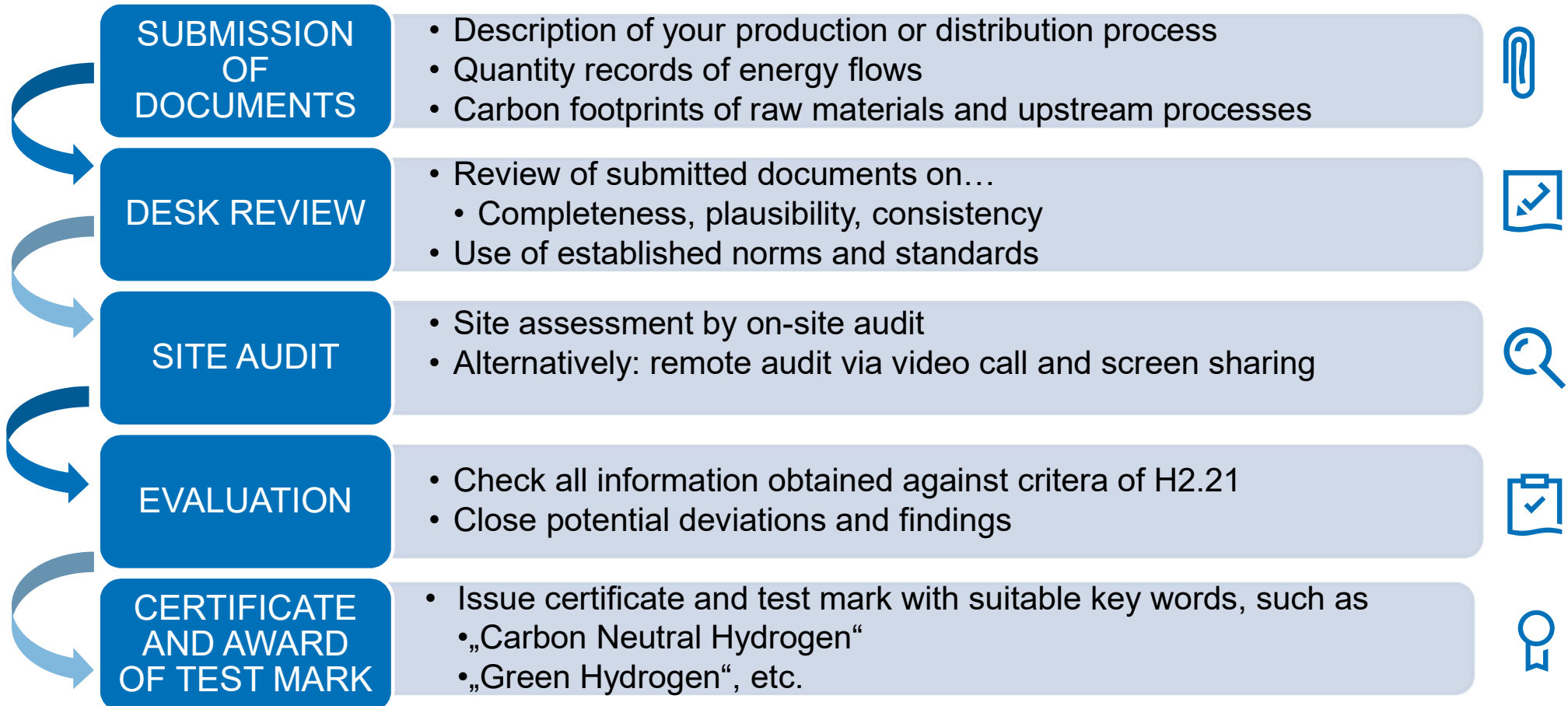
TÜV Rheinland green hydrogen certification

□ Underlying international standards

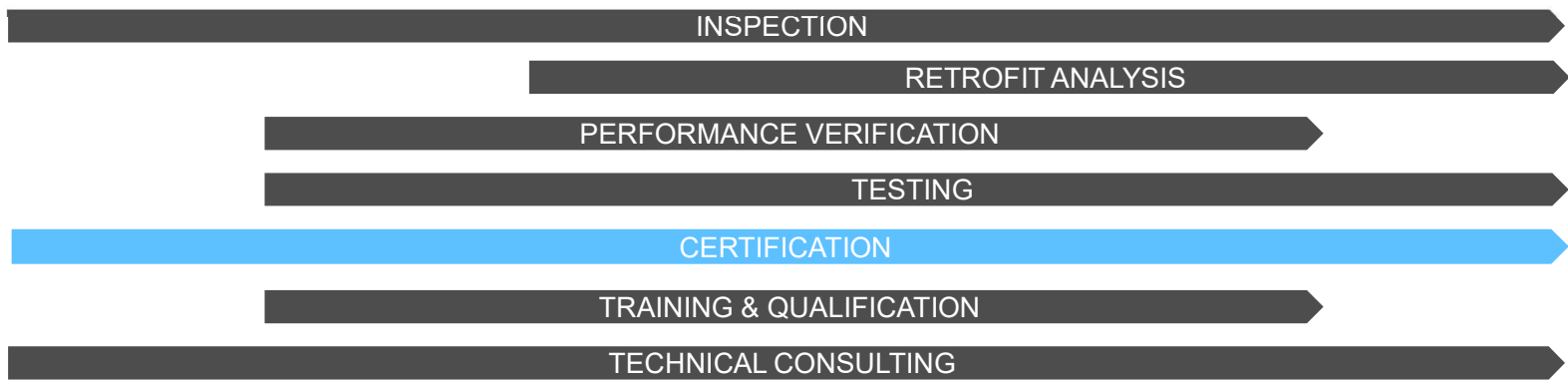
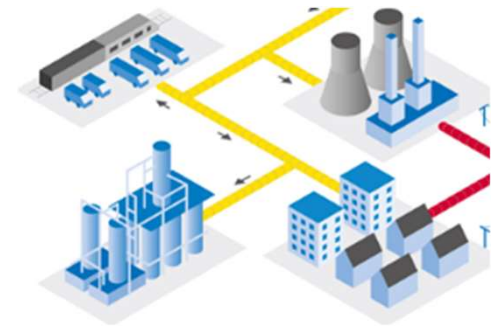
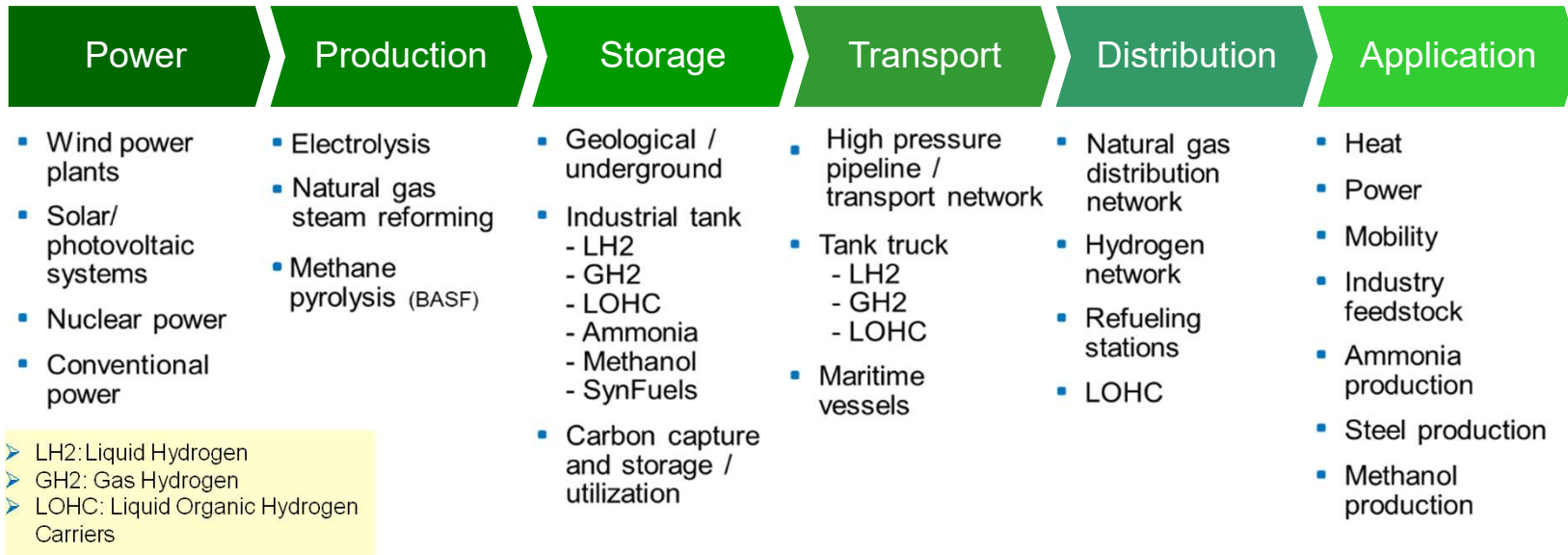
- EN ISO 14064-1
- EN ISO 14064-2
- EN ISO 14064-3
- EN ISO 14067
- EN ISO 14040
- EN ISO 14044
- GHG Protocol, A Corporate Accounting and Reporting Standard
- GHG Protocol, Corporate Value Chain (Scope 3) Accounting and Reporting Standard
- RED II, Standard (EU) 2018/2001 on the promotion of the use of energy from renewable sources, revised version of December 11, 2018.
- 2009/28/EG
- Act for the Expansion of Renewable Energies (Renewable Energies Act - EEG 2021)
- TÜV RHEINLAND QMA H2.21 v1.0.

TÜV Rheinland green hydrogen certification

□ Certification process



Hydrogen value chain technologies & TÜV Rheinland solutions



Manufacturing (factory acceptance)
Asset, material
Purity, efficiency
Gas components, materials
Green Hydrogen, industrial components
Safe handling and work
Risk and safety, simulation

Thank you for Your Attentions!

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