



Towards a sustainable future: opportunities and challenges in Power to X and Hydrogen plants development

Next Generation Mobility 2024



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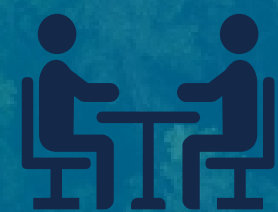


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H₂ **HYDROGEN**

Our experience. Your growth.

RINA today



5800
colleagues



200
offices



70
countries

Who we are



Energy



Marine



Certification



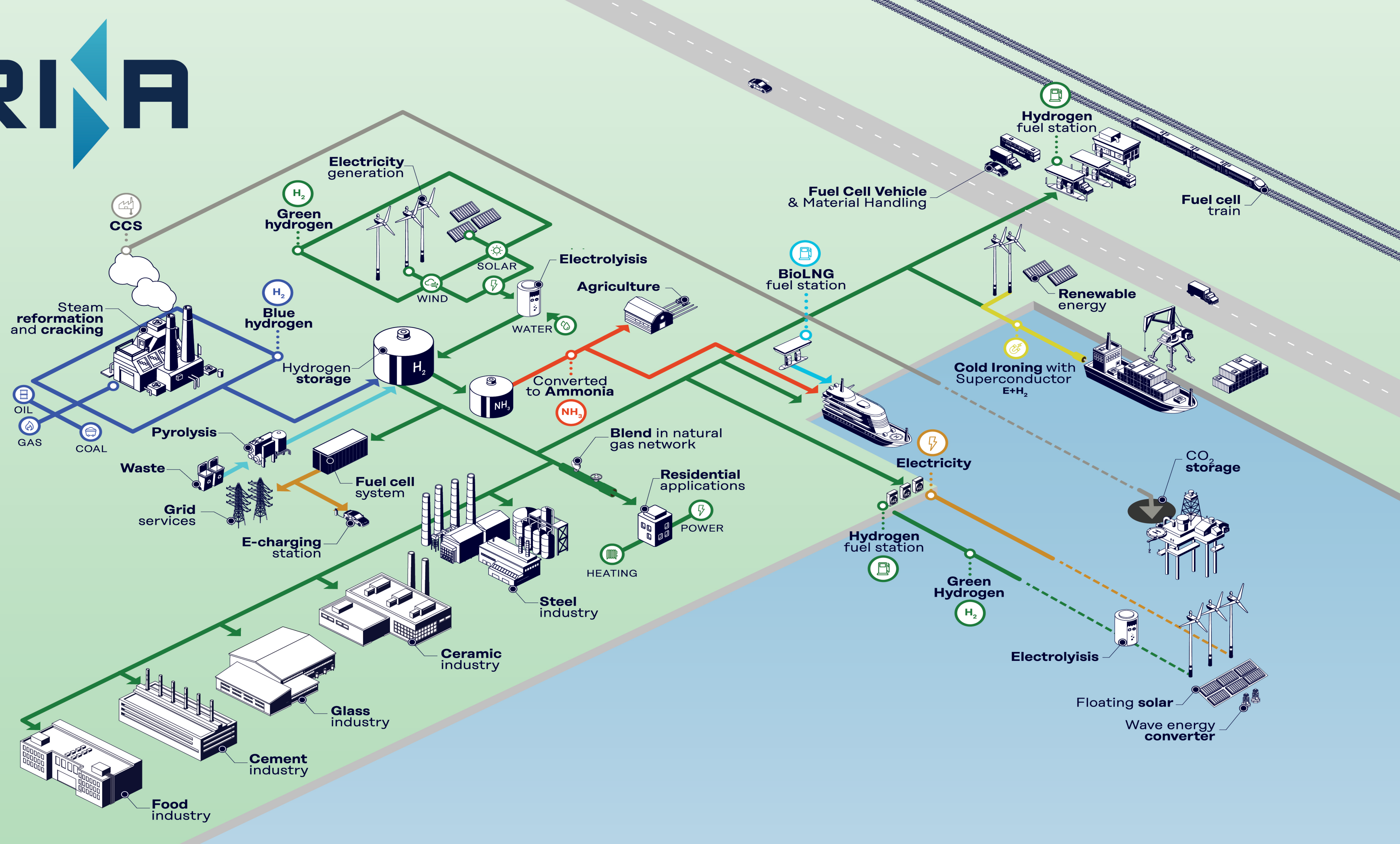
**Infrastructure &
Mobility**



Industry



Real Estate



Power-to-X development key factors

Market scenario & Competitiveness

Current and expected market, demand and production, CAPEX and OPEX

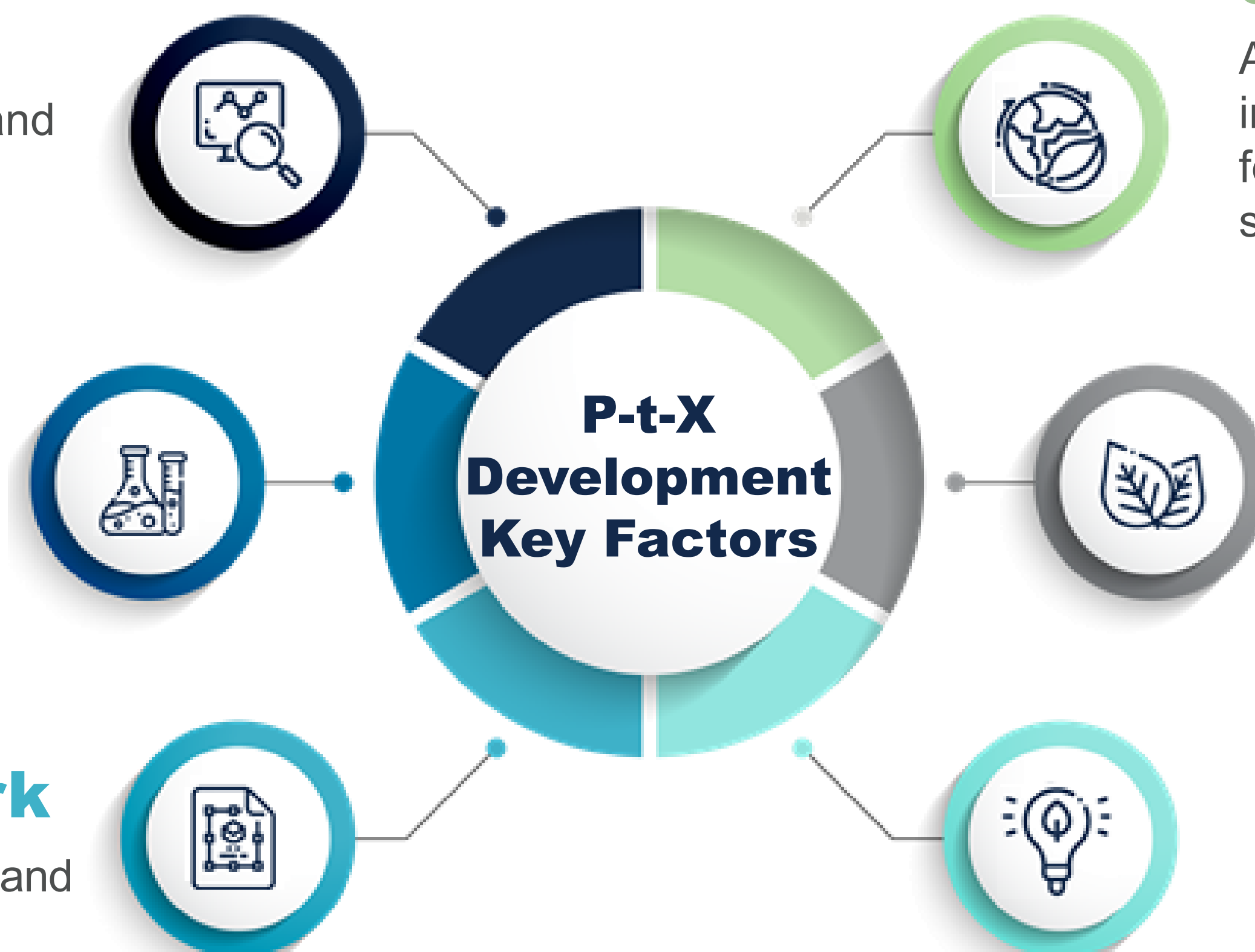
RFNBOs

Analysis of alternative RFNBOs:

- H2
- Methane
- Ammonia
- Methanol

Regulatory Framework

RED II and Delegated Acts on RFNBO and GHG accounting and key requirements



Sites and locations

Assessments of sites and locations of interest, considering presence of necessary features and potential off-takers and key suppliers

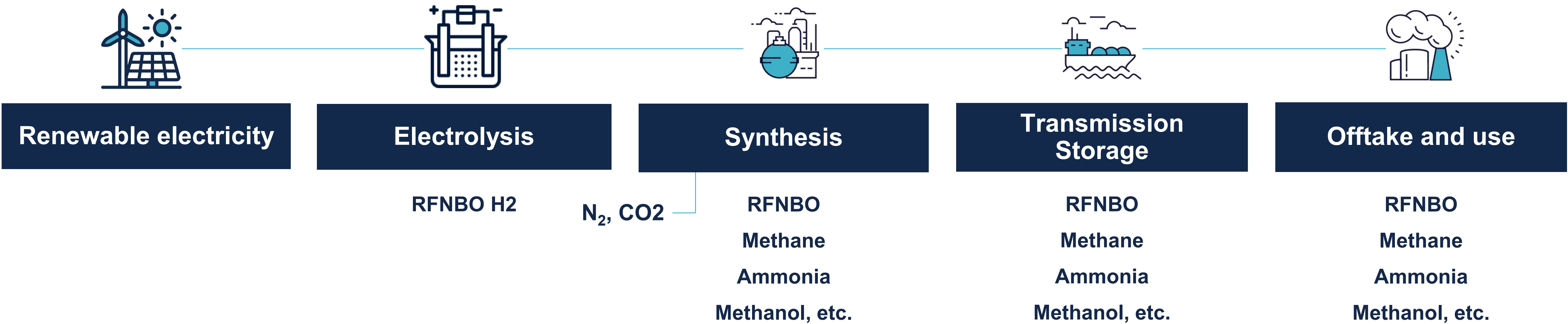
Safety and Environment

HSE studies, Loss prevention & Risk Analysis, Permitting

Technology

Technological analysis and scouting

Traceability of H2 & H2 derivatives supply chain





RED II Delegated Acts on RFNBO & GHG accounting

COMMISSION DELEGATED REGULATION (EU) 2023/1184 & 2023/1185

- ADDITIONALITY
- TEMPORAL CORRELATION
- GEOGRAPHICAL CORRELATION

Case study overview

Pre-Feasibility study for P-t-X plant development

1. Market analysis and Technology scouting

Hydrogen - Methanol - Ammonia

- Current and expected market, demand and production (Global, European, Italian)
- Traditional and new applications
- Production costs
- Focus on Electrolyzers (supply chain, consumptions, etc.)

3. RED II

Analysis of Delegated Acts on RFNBO and GHG accounting and key requirements

5. Permitting

Safety and Environmental Permitting focused on national and international legislation:

- Italian Major Accident Prevention Regulation, i.e. Legislative Decree 105/15 (D.Lgs. 105/15) - Italian transposition of the European Directive 2012/18/UE
- Italian **Fire Prevention Regulations**, Presidential Decree 151/2011 and Ministerial Decree 07/08/2012
- Safety Permitting Procedures
- Annex I-bis of the Legislative Decree 152/2006 (Environmental)

2. Sites identification

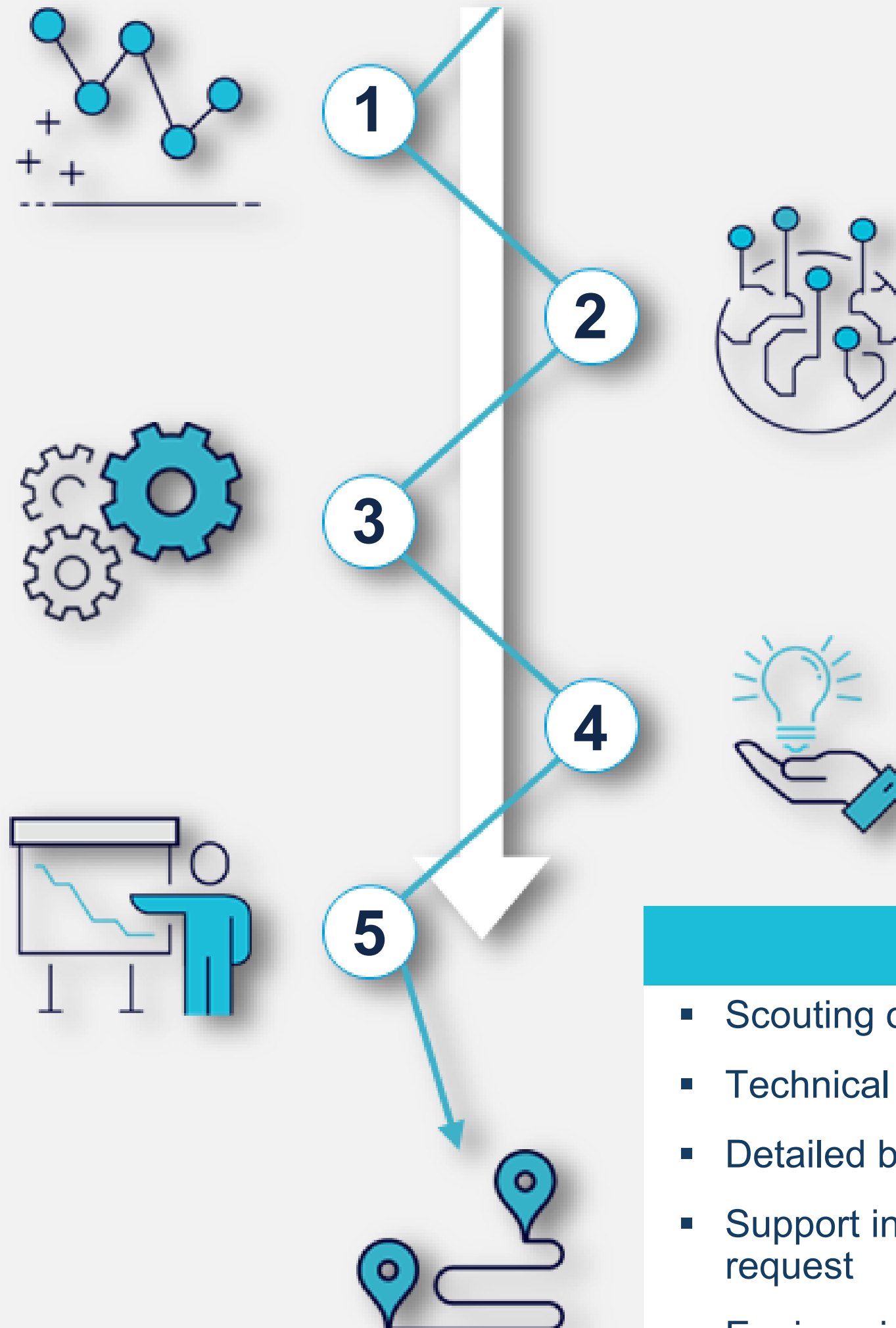
- 30 sites to be evaluated
- Definition of 9 KPIs (i.e. presence of water)
- Sites assessment based on KPIs
- Final prioritization and identification of 3 main sites

4. High-level investment plan

- Analysis of three alternative P-t-X investment scenarios: green H2, e-methanol and green ammonia
- Scenarios applied on the 3 main sites identified
- Investment prioritization

Results and Next steps

- Scouting of public funding
- Technical and financial feasibility studies
- Detailed business plan
- Support in the writing of technical proposals and submission for public funding request
- Engineering Permitting Procurement and Construction Management.



Case study

Investment plan – Scenarios comparison and key results

P-to-X	Investment (mln €)	Average annual production (ton/year)	Levelised Cost (€/ton)	Reference Levelised Cost (€/ton)	Levelised cost from Fraunhofer Institute – Spain case (€/ton)*
Green H ₂	≈ 83	6,765	≈ 5,500	4500 – 4750 ^a	4,700
e-MeOH	Without CC	36,230	≈ 1,580	760-1500 ^b	1,225
	With CC		≈ 1,430		
Green NH ₃	≈ 130	38,220	≈ 1,240	520-1610 ^c	1,065

Source: **a:** PWC - The green hydrogen economy Predicting the decarbonisation agenda of tomorrow. **b:** IRENA – Innovation Outlook Renewable Methanol 2021. **c:** Industrial & Engineering Chemistry Research · October 2018 – “Green” Ammonia: Impact of Renewable Energy Intermittency on Plant Sizing and Levelized Cost of Ammonia

*Fraunhofer Institute for Solar Energy Systems ISE – Power-to-X Country Analyses, 2023 – Spain LCOE (PV) 33-34 €/MWh – LCOE (Wind) 55-64 €/MWh

Note: **All the indicators will have an accuracy level with the following range: Lower bound -30%, Upper bound +50%** according AACE® International Recommended Practice No. 56R-08 - COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE BUILDING AND GENERAL CONSTRUCTION INDUSTRIES.

WACC equal to 8.61%: Damodaran Green & Renewable Energy Capital Cost Europe, average 2021-2022-2023, plus an innovation premium of 3%.

Case study

Investment plan – Scenarios prioritization

Site 1

KPI

- Number of potential off-takers: 2 points
- Presence of harbor: 3 points
- Presence of brownfield sites: 0 points
- Proximity to H₂ Valley: 3 points
- Proximity to CO₂ capture: 3 points
- Proximity to fertilizer production plants: 0 points

Investment prioritization

1. **Green Hydrogen production**
Off-takers, H₂ valley, harbor
2. **E-methanol production**
Potential CO₂ capture, harbor, H₂ valley, off-takers
3. **Green Ammonia production**
Harbor, H₂ valley

Site 2

KPI

- Number of potential off-takers: 2 points
- Presence of harbor: 3 points
- Presence of brownfield sites: 1 points
- Proximity to H₂ Valley: 3 points
- Proximity to CO₂ capture: 3 points
- Proximity to fertilizer production plants: 0 points

Investment prioritization

1. **Green Hydrogen production**
Off-takers, H₂ valley, harbor, brownfield
2. **E-methanol production**
Potential CO₂ capture, harbor, H₂ valley, brownfield
3. **Green Ammonia production**
Harbor, H₂ valley, brownfield

Site 3

KPI

- Number of potential off-takers: 2 points
- Presence of harbor: 3 points
- Presence of brownfield sites: 0 points
- Proximity to H₂ Valley: 3 points
- Proximity to CO₂ capture: 3 points
- Proximity to fertilizer production plants: 1 points

Investment prioritization

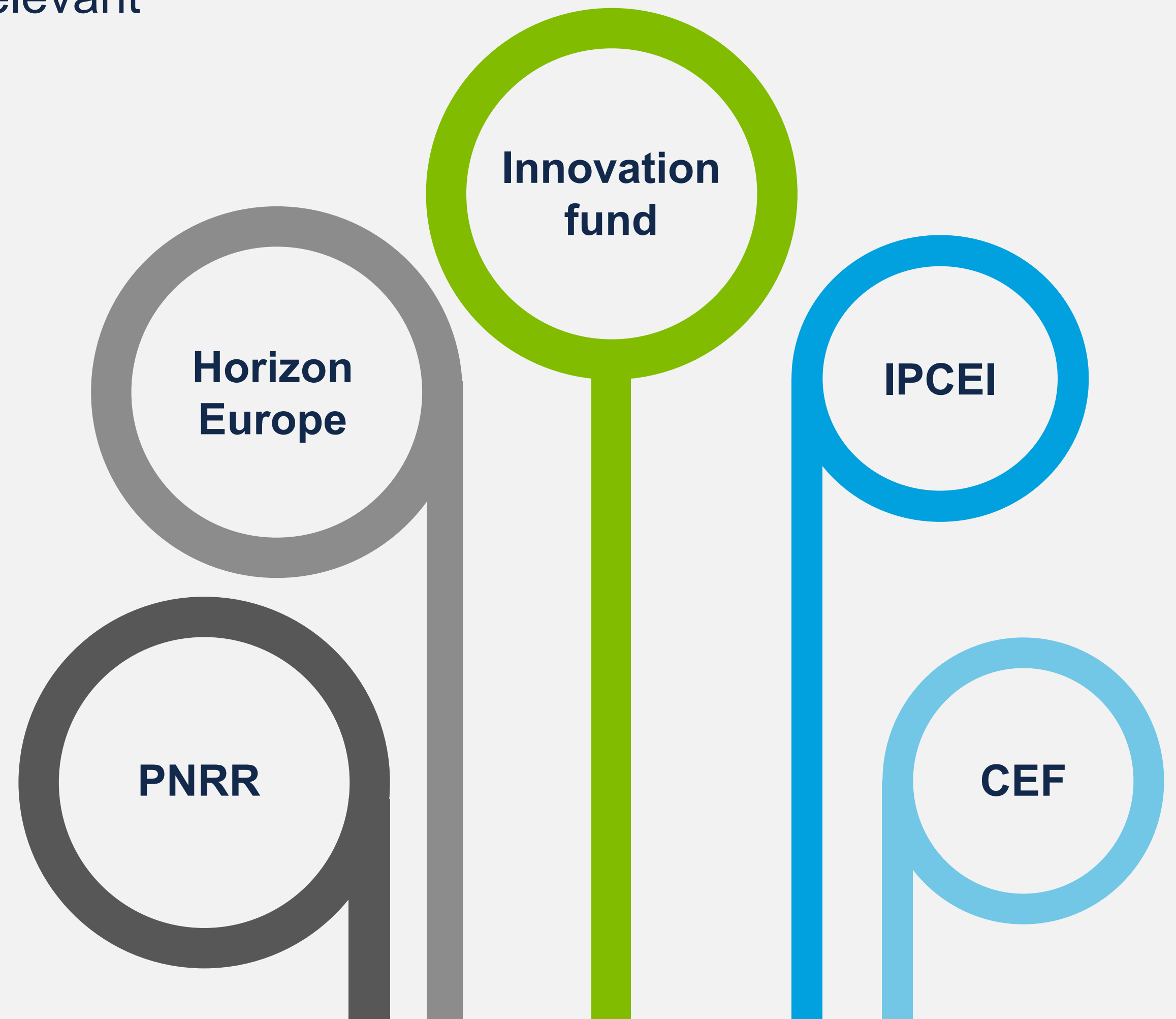
1. **Green Hydrogen production**
Off-takers, H₂ valley, harbor, brownfield
2. **Green Ammonia production**
Fertilizer producers, harbor, H₂ valley, brownfield
3. **E-methanol production**
Potential CO₂ capture, harbor, H₂ valley, brownfield

Case study

Conclusions and Green Finance for Hydrogen



- Analysis shows that Italy present several sites with relevant key features, potentially feasible for a P-t-X facility
- Green hydrogen economy is currently developing in Italy (hydrogen valleys) and is envisaged to grow further in the next decades
- Levelized Cost of production of green hydrogen and derivatives fuels is strictly related to CAPEX and electricity costs
- P-t-X projects could be feasible for public funding which will help in a de-risking and make private investments more attractive



Conclusions

Power to X and low-carbon hydrogen plants development represents one of the most **complex but also promising challenges of the global energy transition**

Complying with regulations, addressing permitting constraints and managing safety and environmental issues requires a **flexible and tailor-made methodological approach** for each project

RINA stresses that **there is no “one size fits all”** and each project has to be assessed and planned to optimize costs and ensure competitiveness on the market

Public and private support will still be needed at many stages, but as **technology advances**, green hydrogen has the potential to become a key component of a sustainable energy future

Thank you!

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