ENTSO-E TYNDP 2026 System Needs Study Workshop

24 June 2025, online

Agenda

NO	SUBJECT	TIME	WHO
	Welcome *Introduction - Purpose of the workshop*	13.00 – 13.10	Patricia Labra, ENTSO-E SDC Chair-elect
	TYNDP 2026 System Needs • ENTSO-E presentation on evolution of the study and priorities for future improvements	13.10 - 13.25	Rodrigo Barbosa, ENTSO-E
	Perspectives on system needs (10 min each) • EC perspective • ACER perspective • What manufacturers need as output from the system needs study to plan ahead – Presentation by T&D Europe • The sustainability perspective – Presentation by RGI • The gas/H2 infrastructure gaps exercise – Presentation by ENTSOG/ENNOH *Questions and discussion (20 min)*	13.25 - 14.35	Maciej Grzeszczyk, EC Stefano Astorri, ACER Jochen Kreusel, T&D Europe Andrzej Ceglarz, RGI Maria Castro, ENTSOG Moderation: Francesco Celozzi, ENTSO-E
	Break	14.35 – 14.45	
	One system perspective • Introduction by ENTSO-E • Complementarity of storage and transmission - presentation by EASE • Offshore infrastructure for the hydrogen sector – presentation by Hydrogen Europe *Questions and discussion (20 min)*	14.45 - 15.30	Franck Dia Wagoum, ENTSO-E Jannis Burger, EASE Isabel Alcalde, Hydrogen Europe Moderator: Franck Dia Wagoum, ENTSO-E
	Next steps and conclusion	15.30 – 15.45	Katerina Macos, ENTSO-E TYNDP StG member

Introduction

The TYNDP is the European electricity infrastructure development plan.

Following the TEN-E Regulation, the study provides a pan-European vision of the future power system and investigates how power links and storage can be used to make the energy transition happen in a cost-effective and secure way.

The Process behind the Ten Year Network Development Plan at ENTSO-E

Union List process led by the European Commission

1 | SCENARIOS

Defining up to three most plausible futures, which we call **Scenarios**

2 | NEEDS

Identification of the needs based on our scenarios. Includes Infrastructure Gaps Report and Offshore Network Development Plans

3 | PROJECTS

Project collection and identification

4 | COST BENEFIT

Cost benefits analysis of projects

5 | SELECTION

Projects of Common Interest (PCI) and **Projects of Mutual Interest (PMI)** Process

15 years of continuous improvement

2012 — **2014**

- Initial projects cost-benefit analysis
- TYNDP becomes **basis for PCI process**

2016

- **1st real common planning study**
- 1st CBAs of storage projects

2018

- **1st joint scenarios with ENTSOG**

2020

- New methodology for the **system needs study**
- Zonal modelling
- Alignment with NECPs process

2022

- Early engagement on methodologies
- Interactive data platforms

2024

- **ONDPs** per sea basin
- Assessment of 2050 time horizon
- Early consultation of engagement plan

2026

- Full implementation of **ACER Framework Guidelines**
- **SRG** integrated in the scenario-building process
- **Joint optimization onshore-offshore**

TYNDP 2026 System Needs

System needs study

Study process overview

Input

2030 grid

Investment candidates
- Cross-border capacity increases
- Storage
- Offshore corridors identified by the ONDP

PEMMDB*

Calculation

Optimisation with Plexos and Antares simulators

Minimum of operational costs + investment costs*

Output

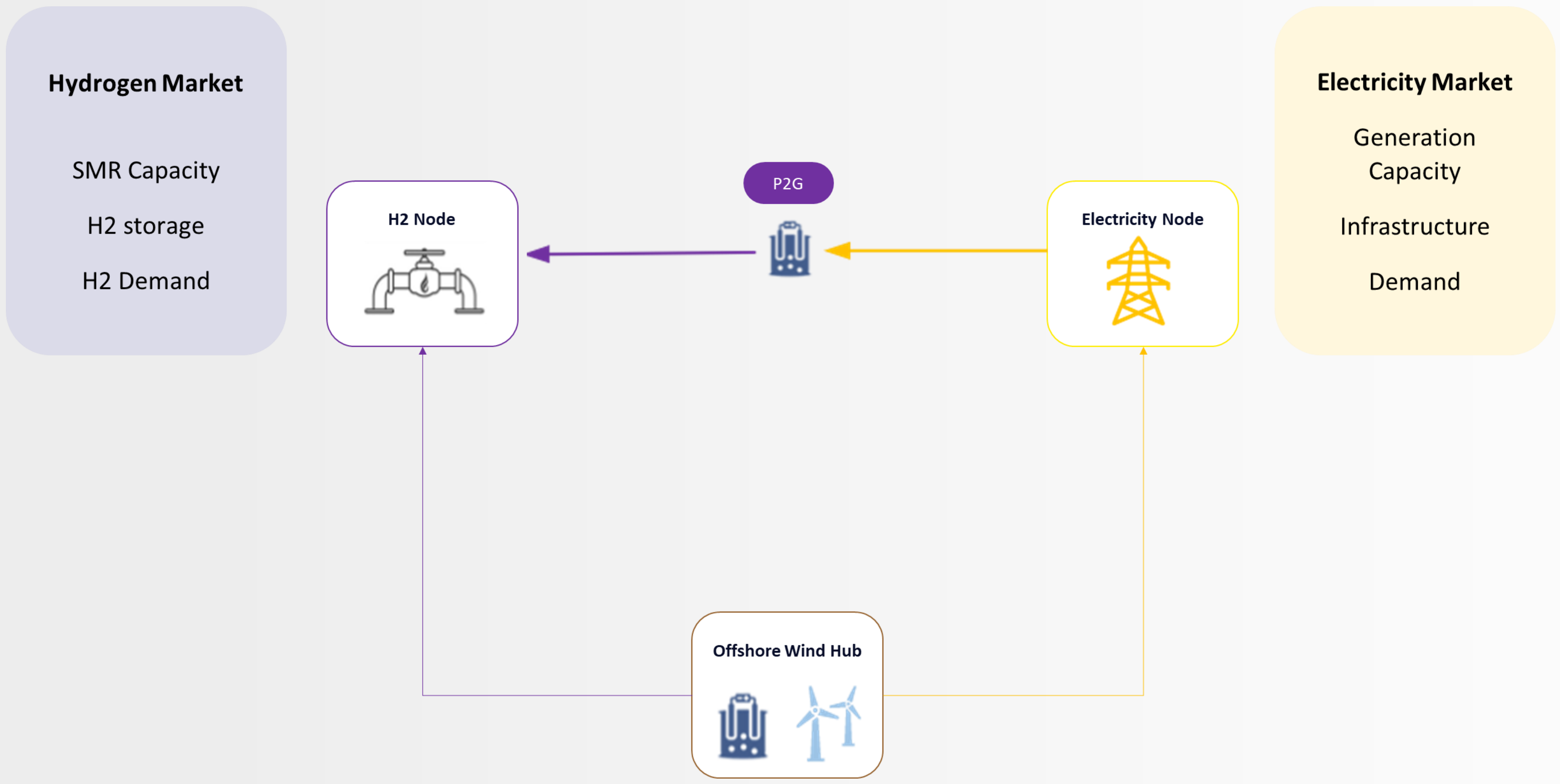
Economic opportunities and infrastructure gaps in 2030, 2040 and 2050

* Scenario National Trends 2030 and 2040, Distributed Energy 2050

* NTC study 2030, zonal study 2040, simplified zonal 2050

System needs study

General Market Modelling Approach



Target of the modelling approach

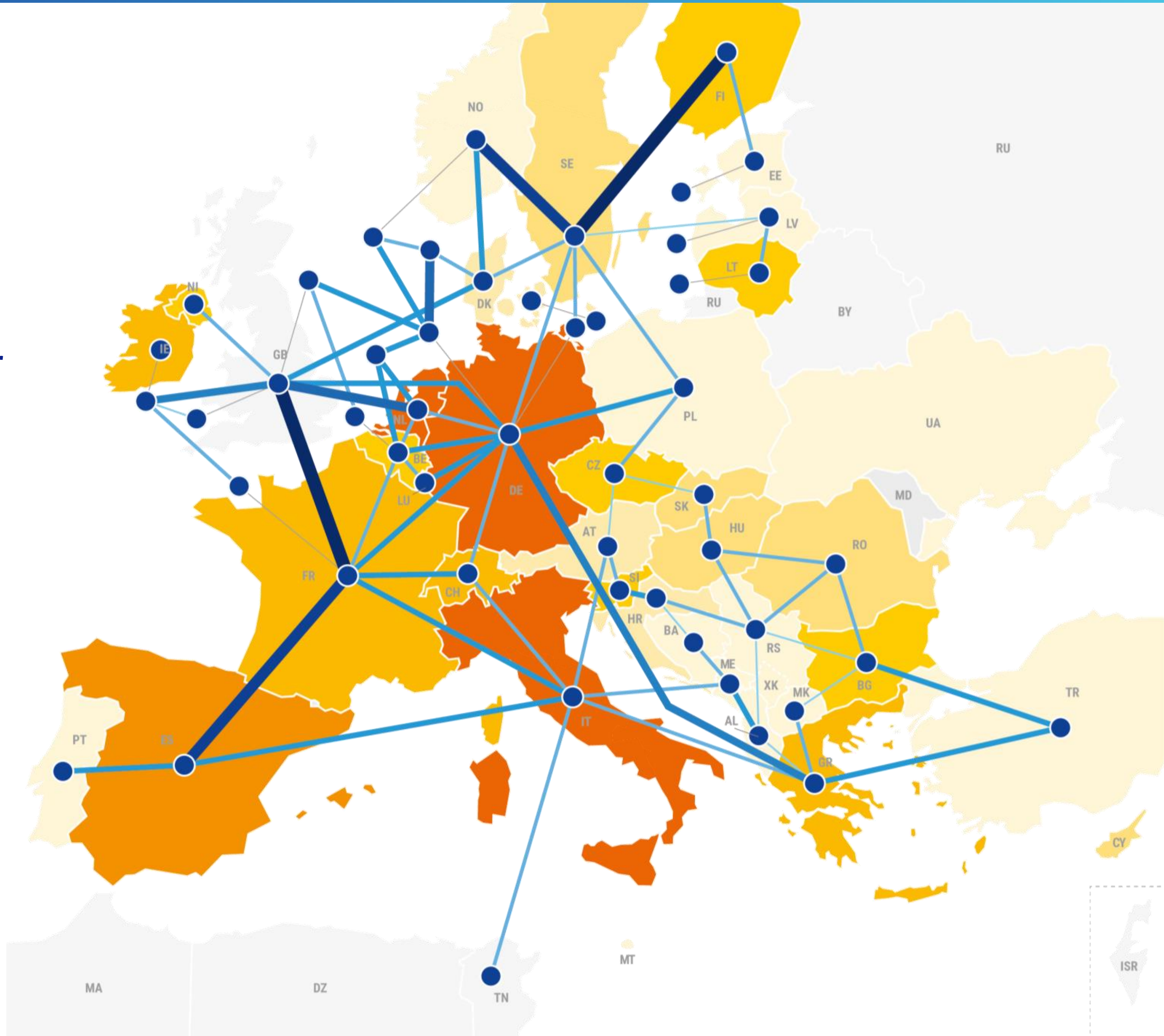
The main objective of the modelling approach of the System Needs study 2024 is to represent the electricity system with adequate granularity and take into account the potential impact from the sector integration data coming from the Scenarios.

The model focuses on the expansion of the electricity infrastructure while considering the interlink with H2 market.

2040 System Needs

By 2040 108 GW of additional cross-border capacity increases additional to the 2030 grid , including 20 GW of offshore hybrid corridors, would minimise the total costs of Europe’s electricity system.

Each euro invested in the electricity grid translates into over 2 euros saved in system costs.



Cross-border capacity increases in 2040 (additional to 2040 starting grid)

- Home Market
- 1 – 500 MW
- 501 – 1,000 MW
- 1,001 – 2,000 MW
- 2,001 – 3,000 MW
- 3,001 – 4,000 MW
- 4,001 – 5,000 MW
- > 5,000 MW

Storage capacities per country in 2040

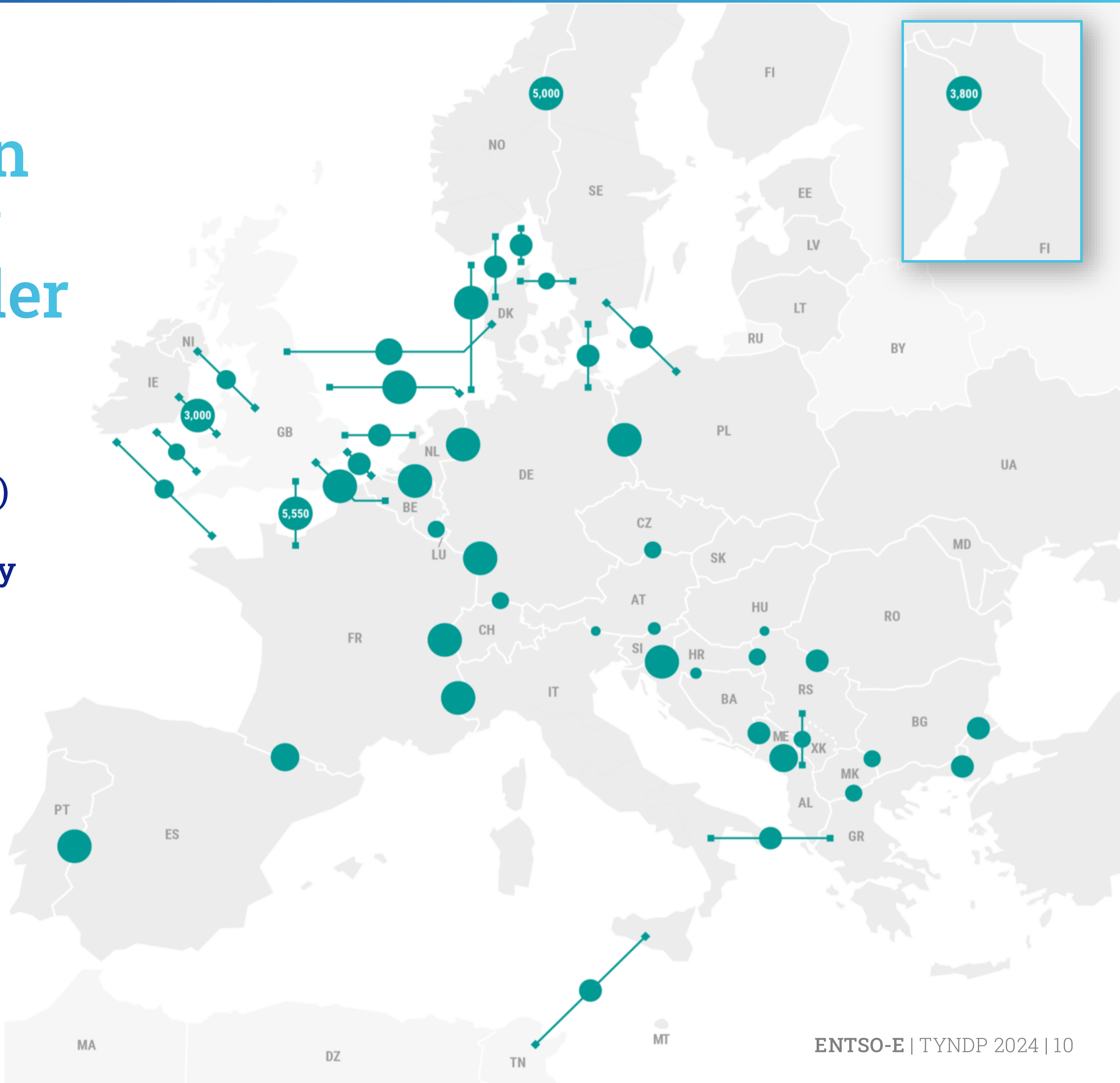
- 0 – 100 MW
- 101 – 500 MW
- 501 – 1,000 MW
- 1,001 – 5,000 MW
- 5,001 – 10,000 MW
- 10,001 – 20,000 MW
- > 20,000 MW

Existing transmission projects address only part of the cross-border needs in 2040

Comparing the TYNDP project portfolio (80 GW of cross-border capacity after 2030) with the optimized grid identified in 2040 (108 GW of additional cross-border capacity needed after 2030) shows a gap of 28 GW.

Infrastructure gaps

Difference between the identified needs in 2040 and existing transmission projects by that time horizon (MW). The bigger the circle, the bigger the opportunity for new solutions to increase cross-border capacity.



Gaps and opportunities for Europe's power system in 2030, 2040 and 2050

Coordinated planning will be needed across sectors.

Non-infrastructure solutions

Addressing tomorrow's challenges will require the parallel development of a diverse range of solutions, including for example storage, the role of prosumers and generation, in addition to reinforcing the transmission grid.

- Demand side response
- Regulation
- Smart Grids
- Storage
- Smart Sector Integration
- Market design
- Operational measures

Electricity infrastructure solutions

Our study uses interconnection transmission capacity and storage and peaking flexibility to express the needs because it is based on electricity TSOs' expertise, data and models, but solutions extend beyond electricity infrastructure.

- Transmission lines
- Energy Storage
- Hybrid solutions

How addressing system needs benefits Europe

What would happen in 2040 if …

We stopped investing in the power system after 2030?

- EU Energy bill rising to 49.5 Billion euro per year
- System instability and risk of blackout
- 473 TWh of renewable energy curtailed each year
- Dependence on fossil fuels with 263 TWh of gas-based power generation per year
- Grid not sufficient → Leads to no decarbonisation

What would happen in 2040 if …

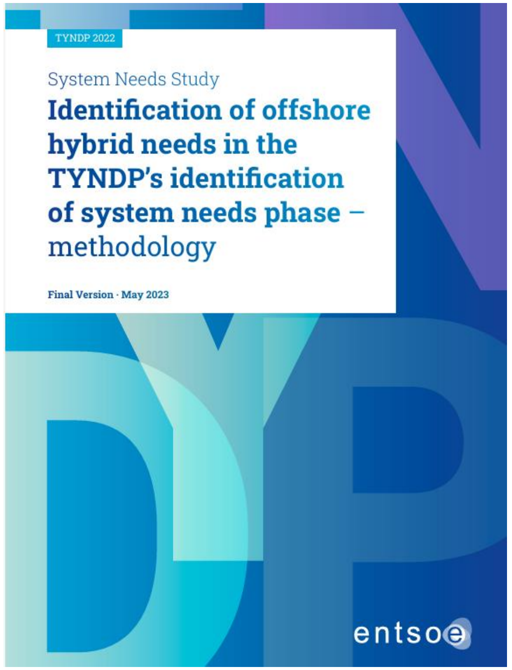
We addressed system needs?

- Investing 6 Billion euro per year cuts generation costs by 13 Billion each year
- Ensuring stability and security of electricity supply in Europe
- Avoiding the curtailment of 130 TWh of renewable energy each year
- Fossil fuels' power generation is reduced by 58 TWh per year
- Grid welcoming the expected development of renewables → CO_2 emissions cut by 31 Mton per year

Why does TYNDP 2026 need a new system needs methodology?

New regulations and expectations impose several innovations on the System Needs Study. In the past editions of the TYNDP several additions were made.

The 2026 methodology should consider the best aspects covered in the past editions in a new way, developing a coordinated modelling approach.



Assessment of offshore project candidates

+

Assessment of offshore hybrid corridors

+

Assessment of full zonal system

Guiding questions to define the methodology (1)

- Assessment of the new methodology should start from existing methodologies
- ENTSO-E intends to perform the study on the central scenario NT+ in horizons 2040 and 2050.

Open points:

- **Impact of cross-border expansion on national systems** should be part of the methodology.
  - Internal grid reinforcements are critical for connecting European regions.
  - Consistency with National Development Plans is key.
- **How to ensure consistency between time horizons**? Considering the impact on model flexibility and granularity.
- **Counterfactual discussion** is important for the correct definition of the starting point and of investment candidates. For example, when assessing hybrid candidates do we need to consider generation with transmission?
- **Perimeter of the analysis:** should we explore needs with third (non-EU) countries?

Guiding questions to define the methodology (2)

- **Starting point assumption:** should the starting point of the study include only mature transmission projects?
- **Definition of the candidates:** what criteria should be considered to identify investment candidates? Filtering of candidates through technical review (i.e. aimed at excluding unrealistic ideas)
- **Integration of the ONDP and of the System Needs study** shows challenges given the differences between the mandates: potentially setting a 2 steps process could favor the integration of the different assumptions characterizing the offshore and onshore systems (1) find economical needs (2) define offshore hybrid.
- **Complexity of the model –** computation time, extraction and clarity of the results etc. the complexity of the models is a challenge that need to be considered in the methodological discussion.
- **Maritime Spatial Planning** should be more strongly included in the methodology (i.e. inclusion of pathway study from 50Hertz) → this is strongly linked and depends on how the selection of candidates is set up for the expansion model.

Next steps

Before putting the hands on the keyboard, some discussion is needed on the fundamentals

In the coming weeks ENTSO-E will work on the fundamentals of the methodology discussing the relevant questions that the methodology should answer.

1) Type and number of infrastructure candidates
2) Starting grid and compliance with reference grid
3) Single-year vs multi-year expansion and general flexibility of the zonal model
4) Inclusion of Maritime Spatial Planning
5) Granularity and detail of H2 model

Perspectives on system needs

EC perspective on system needs identification

Maciej Grzeszczyk, ENER C4

TYNDP 2026 – System Needs public workshop

Legal basis and role in the PCI/PMI process

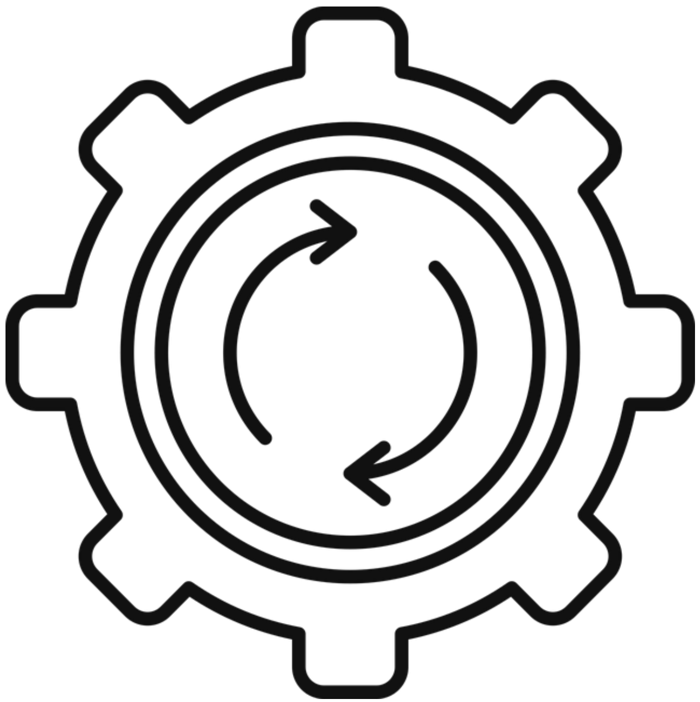
- Article 13 of the TEN-E Regulation
- Under responsibility of ENTSO-E/ ENTSOG
- Subject to extensive consultation process
- Subject to opinion of ACER and opinion of the Commission
- To be considered by the regional groups
- A key input to the needs assessment under the PCI/PMI process

What has worked well

- Well established deliverable of the TYNDP
- Good general overview of the infrastructure gaps
- Good visualisation of the results
- Good indication of overall investment needs and benefits of optimal grids
- Constant development and improvement process
  - Incorporation of ONDPs
  - Storage capacities
  - 2050 horizon

Points for improvement

- Timely publication and consultation
- Move towards a more top-down approach
- More robust methodology to identify all needs
- Higher granularity – cross-zonal needs at national level and gaps at national level
- Exploring different futures
- Better explanation and presentation of the results
- Possible prioritisation of the needs
- Linking specific needs with solutions
- Better integration across sectors
- Better consideration of GETs and non-grid solutions



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Thank you

ACER

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System Needs in TYNDP 2026 – ACER's reflections –

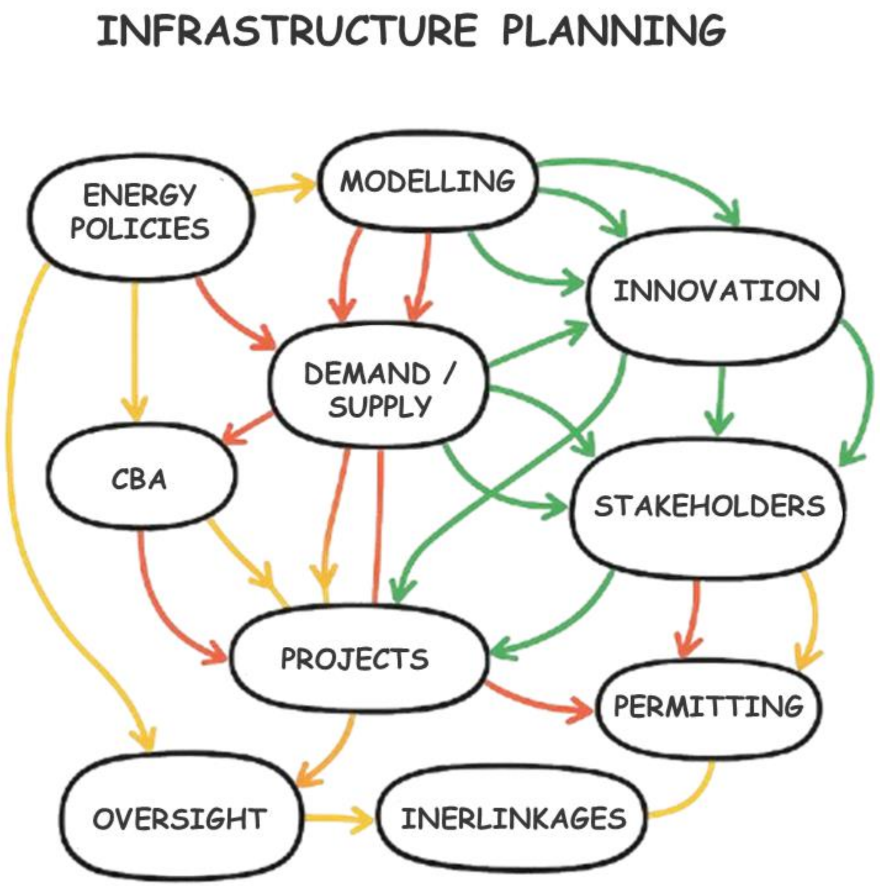
Stefano Astorri – Policy Officer, Energy System Needs

ENTSO-E Workshop on the TYNDP 2026 System Needs Study

June 24, 2025

System Needs: managing complexity & change

- EU infrastructure planning is a **complex** process, **compressed** into 2 years.
- Since 2010, **significant improvements** have been made in methodological aspects and transparency.
- Yet, the energy system is becoming increasingly complex.
- Such complexity requires constant **adaptation** of the tools available and a **multi-year approach** to innovations.
- Beyond scenarios, the approach to needs identification still **differs significantly** across sectors.



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ACER's on ENTSO-E and ENTSOG needs

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PUBLIC

OPINION No 04/2025
OF THE EUROPEAN UNION AGENCY
FOR THE COOPERATION OF ENERGY REGULATORS

of 26 May 2025

ON ENTSO-E's DRAFT TEN-YEAR NETWORK DEVELOPMENT PLAN 2024 AND ON ENTSO-E's DRAFT INFRASTRUCTURE GAPS REPORT 2024

THE EUROPEAN UNION AGENCY FOR THE COOPERATION OF ENERGY REGULATORS,

Having regard to Regulation (EU) 2019/942 of the European Parliament and of the Council of 5 June 2019 establishing a European Union Agency for the Cooperation of Energy Regulators [1] (ACER), and, in particular, Article 4(3)(b) and Article 11(c) thereof,

Having regard to Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity[2], and, in particular, Article 32(2) thereof,

Having regard to Regulation (EU) 2022/869 of the European Parliament and of the Council of 30 May 2022 on guidelines for trans-European energy infrastructure, and, in particular, Article 13(3) thereof,

Having regard to the outcome of the consultation with ACER's Electricity Working Group,

Having regard to the favourable opinion of the Board of Regulators of 14 May 2025, delivered pursuant to Article 22(5)(a) of Regulation (EU) 2019/942,

Whereas:

[1] OJ L158, 14.6.2019, p.22.
[2] OJ L 158, 14.6.2019, pp.92 and 94.

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PUBLIC

OPINION No 05/2025
OF THE EUROPEAN UNION AGENCY
FOR THE COOPERATION OF ENERGY REGULATORS

of 27 May 2025

ON ENTSOG's DRAFT HYDROGEN INFRASTRUCTURE GAPS IDENTIFICATION REPORT

THE EUROPEAN UNION AGENCY FOR THE COOPERATION OF ENERGY REGULATORS,

Having regard to Regulation (EU) 2019/942 of the European Parliament and of the Council of 5 June 2019 establishing a European Union Agency for the Cooperation of Energy Regulators [1] (ACER), and, in particular, Article 11(c) thereof,

Having regard to Regulation (EU) 2022/869 of the European Parliament and of the Council of 30 May 2022 on guidelines for trans-European energy infrastructure[2], and, in particular, Articles 13(3) and 13(6) thereof,

Having regard to the outcome of the consultation with ACER's Gas Working Group,

Having regard to the favourable opinion of the Board of Regulators of 14 May 2025, delivered pursuant to Article 22(5)(a) of Regulation (EU) 2019/942,

Whereas:

[1] OJ L 158, 14.6.2019, p. 22.
[2] OJ L 152, 3.6.2022, p. 45.

Page **1** of **14**

ACER European Union Agency for the Cooperation of Energy Regulators

ENTSO-E Needs: ACER's recommendations

1. ADDRESS RECURRING DELAYS

- ❑ Address roots of delays to ensure the TYNDP can be fully and timely used in the PCI/PMI selection process and by NRAs.

2. FURTHER INCREASE THE TRANSPARENCY

- ❑ Consult Implementation Guidelines early enough to consider stakeholders' view before performing the assessment.
- ❑ Enhance visibility and accessibility of main assumptions.
- ❑ Consult on the grids' composition.

3. STARTING GRID AND EXPANSION APPROACH

- ❑ Differentiate starting grid from CBA reference grids.
- ❑ Realistic starting grid.
- ❑ Expansion based on single optimisation step.
- ❑ Transparent & uniform rules to derive candidates (list should be consulted).

4. ENHANCE GRANULARITY OF IDENTIFIED NEEDS

- ❑ Expand needs analysis to internal reinforcements.
- ❑ Focusing on mid-term (e.g. 2035) and long-term (e.g. 2040), building/aligning with NDPs.

5. ROLE OF SCENARIOS AND CLIMATIC YEARS

- ❑ Assess needs vs all scenarios, for mid-term (e.g. 2035) and long-term (e.g. 2040).
- ❑ For C.Y., adopt a more forward-looking approach.

Thank you.

European Union Agency for the Cooperation of Energy Regulators

info@acer.europa.eu
acer.europa.eu
@eu_acer
linkedin.com/company/EU-ACER/

Perspectives on System Needs

What manufacturers need as output from the system needs study to plan ahead

ENTSO-E TYNDP 2026 System Needs Workshop
online, 24 June 2025

T&D europe

Introducing T&D Europe

Our members

National associations

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T&D europe


To shape the future, we need to imagine it and plan it


Towards Future-Proof Grids

Policy recommendations for Europe's policymakers

Wh ed

T&D Europe Position Paper

How to make it happen?

✓ **A holistic approach: transmission and distribution**

The **transmission** grid and cross border interconnections will play a crucial role in Europe's energy transition and security of supply in the growing renewable generation reality. The development, reinforcement and modernisation of Europe's transmission grids will be critical to integrating large volumes of variable renewables over the coming years.

With the consumer and prosumer in the centre of the energy transition, **distribution** grids have an essential role to play in the future energy system, connecting large amounts of distributed energy resources and new flexible loads.

How to make it happen?

✓ **Planning based on the necessary functionalities of the future system**

The power system of the future will be built on highly distributed resources, reverse power flows and will be much more dynamic than in the past. Network operators therefore will need to offer new, digital functionalities to the users of the grid. These must be rolled out proactively to ensure a future-proof system.

The TYNDP should integrate the common indicators for smart grids at all voltage levels, including both output and input indicators.

How to make it happen?

✓ **Accompanying industrial plans covering hardware and software needs**

Network development plans should be clearly aligned with the National Energy and Climate Plans for all voltage levels and accompanied by industrial plans, specifying the demand from network operators for grid technology, both hardware and software. This would enable the industry to make the business case with a competitive return on equity to add capacity, to organise its supply chain and to recruit and develop the necessary skills.

Europe needs to increase the digitalisation of the entire European electricity system and its value chain to ensure:

- the acceleration of Europe’s energy transition
- the optimisation of the operation of our power system and reduce pressure on the supply chain
- the optimisation of human resources to alleviate the pressure on skills.

How to make it happen?

- ✓ A holistic approach: transmission and distribution
- ✓ Planning based on the necessary functionalities of the future system
- ✓ Accompanying industrial plans covering hardware and software needs

T&D europe

Thank you

The European Association of the Electricity Transmission and Distribution Equipment and Services Industry

+32 2 206 68 67
secretariat@tdeurope.eu

@bettergrids
T&D Europe

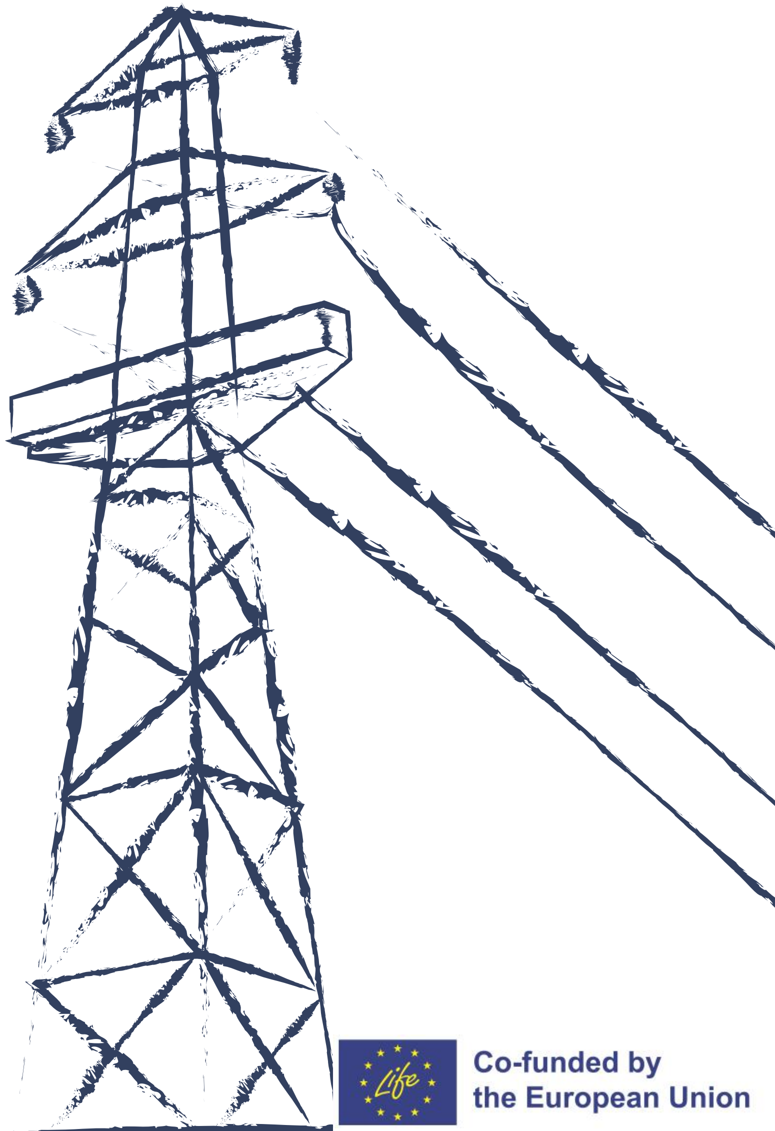
www.tdeurope.eu

The European System Needs and Sustainability aspects

ENTSO-E's workshop on the TYNDP 2026 System Needs Study

Dr. Andrzej Ceglarz
Director – Energy Systems
Renewables Grid Initiative

24 June 2025



Renewables Grid Initiative

Co-funded by the European Union

Renewables Grid Initiative

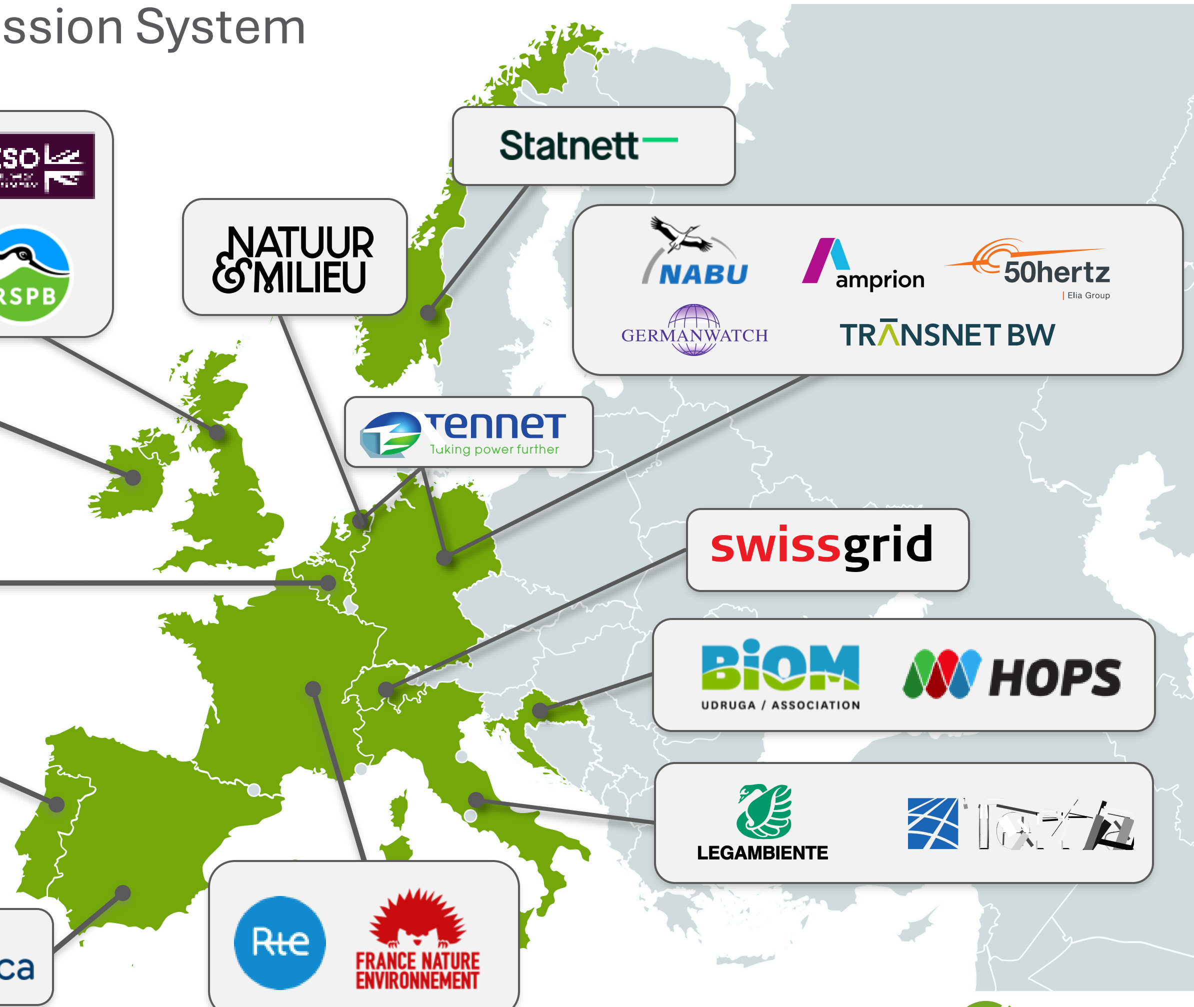
RGI is a unique collaboration of NGOs and Transmission System Operators (TSOs) from **across Europe.**

EUROPEAN ORGANISATIONS

CAN Climate Action Network Europe
WWF
BirdLife International
BirdLife Europe
Bellona Europa
EMBER

SUPPORTING MEMBERS

europacable Try life without us
IUCN
T&D europe



Renewables Grid Initiative

How is our work structured?

We foster knowledge exchange, discussions on the grid infrastructure needs, and the implementation of best practices within **three dimensions:**

GRIDS & ENERGY SYSTEMS

We enable discussions on how to **model, plan and implement** decarbonised and optimised clean energy systems, including different voices in the process.

ENERGY & NATURE

We ensure energy systems both onshore and offshore are developed in **coherence with nature and biodiversity**, promoting mitigation, enhancement and restoration measures.

ENERGY & SOCIETY

We include and engage **citizens, civil society and policymakers** on strategies towards full decarbonisation, building capacity on the role of grids within the energy transition.

Ensuring a timely grid development

Need to **expand and modernise electricity grids** to ensure RES integration, electrification, and flexibility

Scarcity of space & other resources

Long-term holistic approach that takes different considerations into account

between Member States

Political momentum, incl. with EU Action Plan for Grids (2023) should be leveraged and maintained

Nature protection & restoration

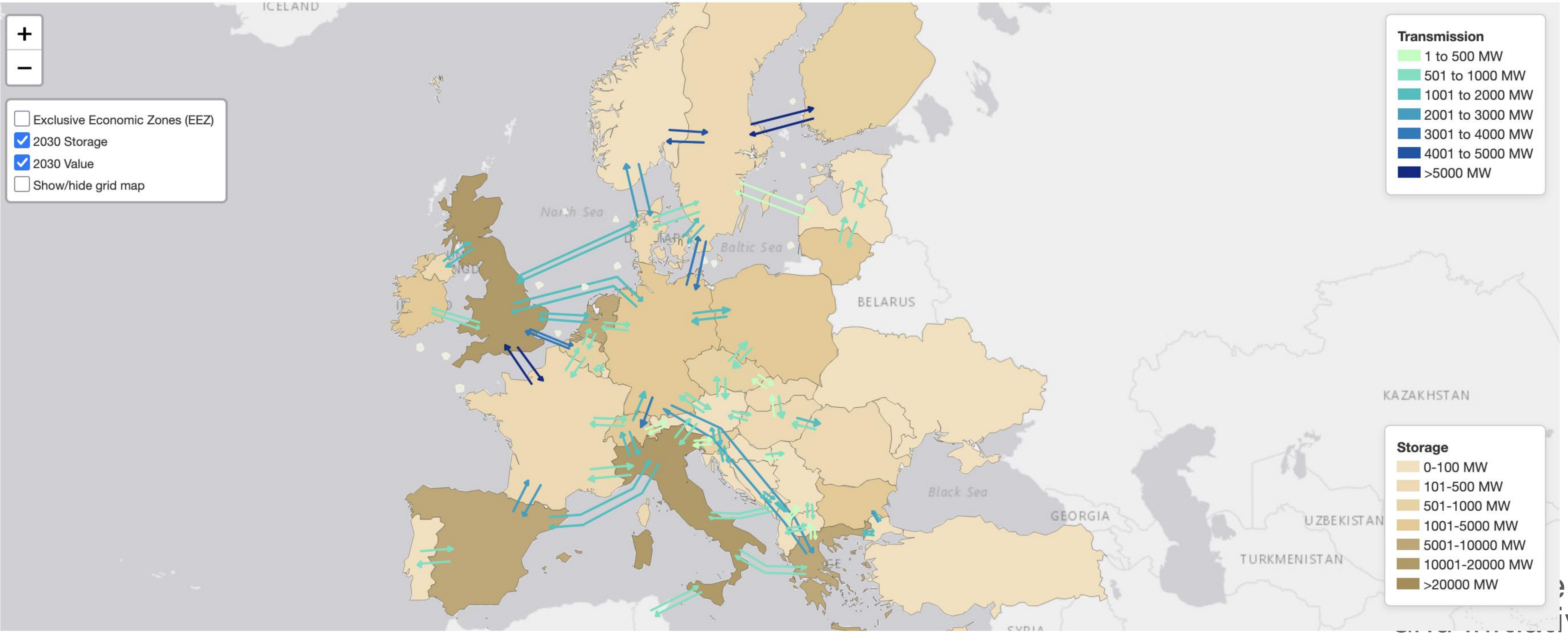
Financing

Assessing future system needs – user perspective

Study Explorer: **System Needs**

Optimal electricity infrastructure | **Energy system indicators**

What electricity infrastructure do we need by: **2030** 2040 2050



User appreciation: inclusion of sustainability aspects

Nature protection & restoration

Scarcity of space

Assessing future system needs – the way forward

Continuation of including environmental aspects in System Needs Studies

- Inclusion of the **2040 climate target** in modelling assessing the needs

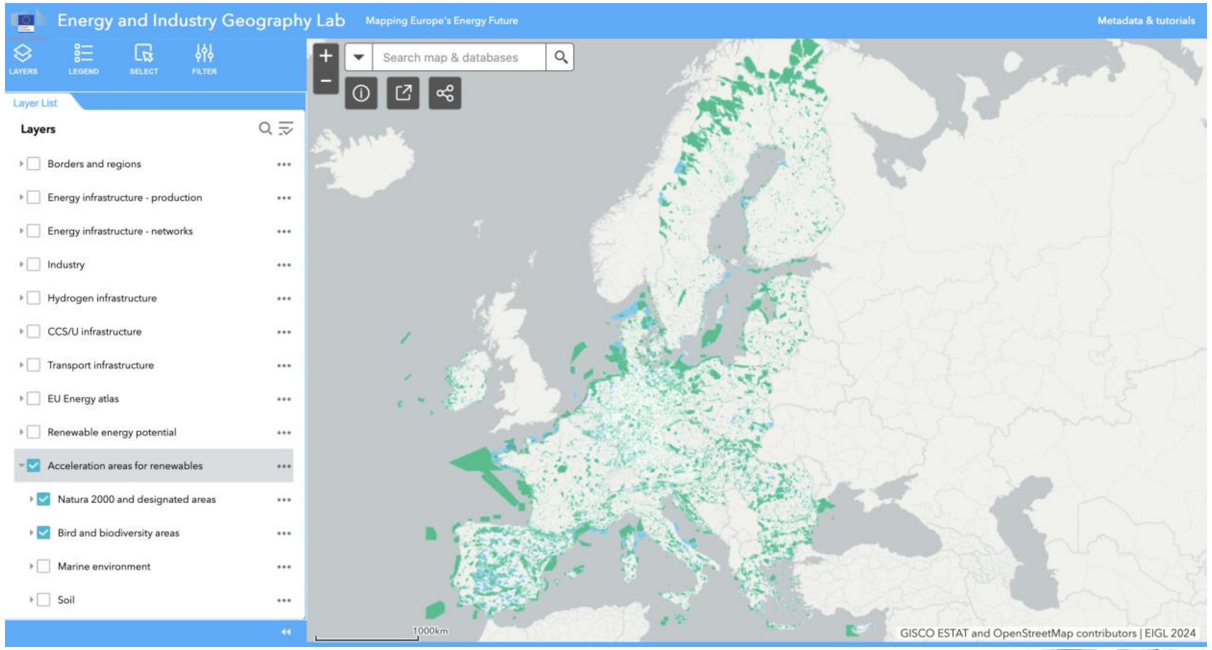
Robust exercise that delivers guidance for MS and project promoters

- Pointing out to **sustainability aspects** while assessing the needs
- Ensuring **alingment** and **harmonisation** across relevant processes, incl. data use:
  - NECPs (incl. updated offshore targets)
  - NDPs
  - MSPs
  - RED III → Renewables and Grids Acceleration Areas + Nature Restoration Plans

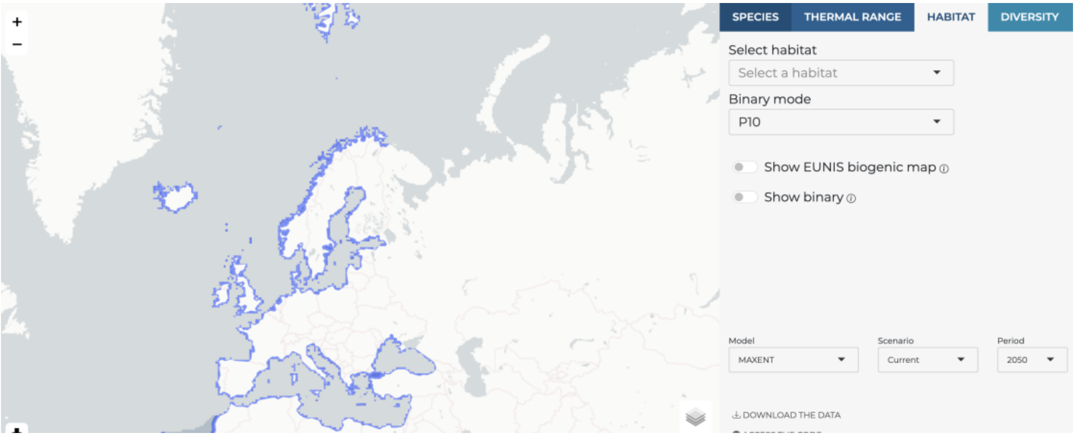
Assessing future system needs – the way forward

Alingining mapping excercises & exploring cross-border opportunities and risks

- Striving for ensuring **consistency** across **planning instruments** onshore and offshore



EC's Energy and Industry Geography Lab



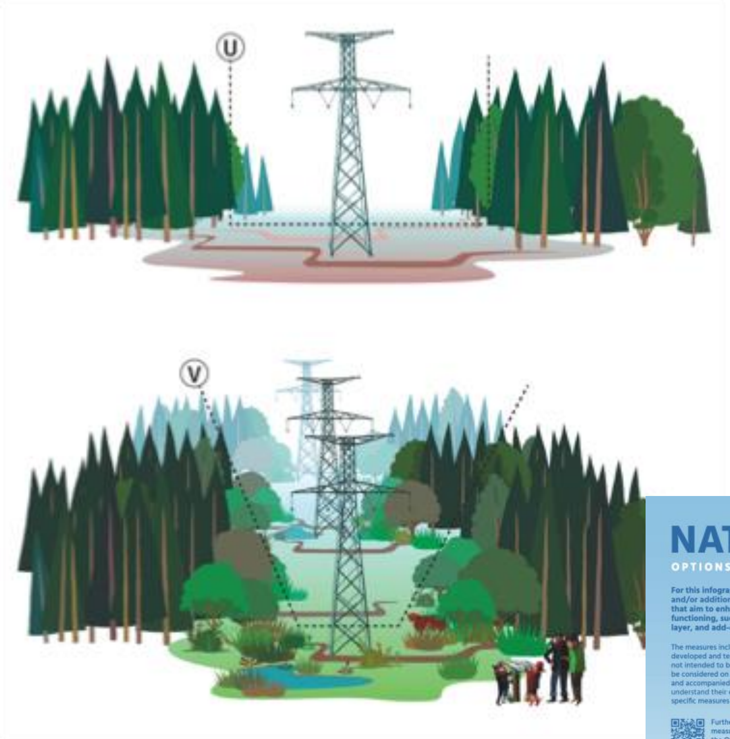
Ocean Biodiversity Information System: MPA Europe Map Platform

Renewables Grid Initiative

Assessing future system needs – the way forward

Understanding the costs of making infrastructure more sustainable

- Reducing **environmental impacts** of the energy **infrastructure** and contributing to **net-positive biodiversity**
- Looking into **Nature-Inclusive Design** options and related **costs**
- Attempting to provide **comperability** between the studies: opening opportunities for project promoters to exchange on existing **nature-friendly options**



Integrated Vegetation Management

Integrated Offshore Planning
Aligning Energy, Nature and Space
EXPERT WORKSHOP
03 July 2025
10:00 - 16:30 CEST
Wind Europe's office
Rue Belliard 40
1040 Brussels
Renewables Grid Initiative
Wind EUROPE
JUST WIND 4 ALL
Funded by the European Union
Co-funded by the European Union

THANK YOU – *LET'S KEEP IN TOUCH!*

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Renewables Grid Initiative

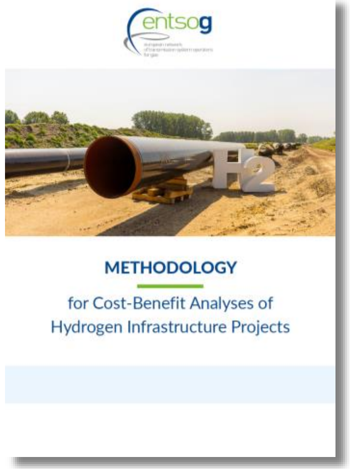
24/06/2025

Hydrogen Infrastructure Gaps Identification Report TYNDP 2024

ENTSO-E TYNDP 2026 System needs study workshop

Maria Castro, Investment Manager, System Development ENTSOG

Context

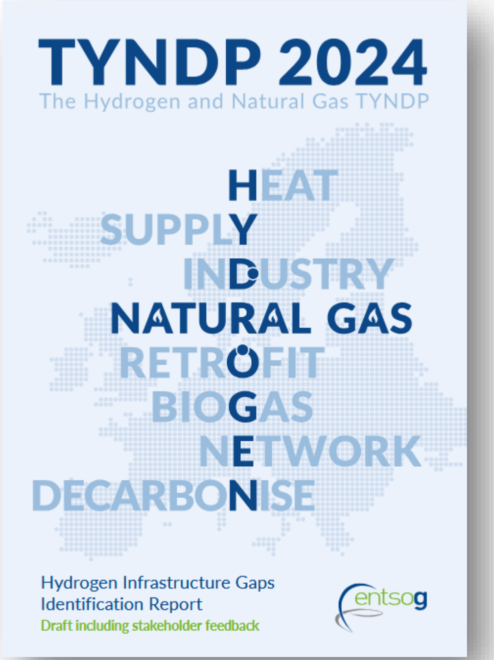


Multi-cycle methodology
Approval process ongoing

Annex D – Methodology for TYNDP 2024

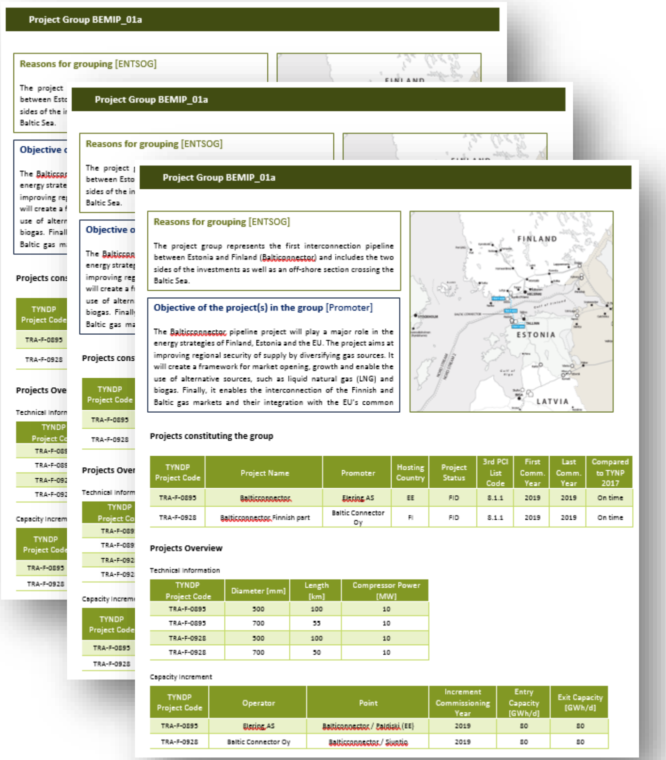
Setting Guidelines and Indicators

Hydrogen Infrastructure Gaps Identification report (H2IGI)



Assess Infrastructure needs

PS-CBA assessments



Assess Projects

H2IGI report – assumptions & modelling

General approach of the IGI

- IGI indicators are used to identify the existence of a regional hydrogen infrastructure gap by observing the effects of such infrastructure gap:
  - IGI indicator 1 is based on hydrogen market clearing price spread
  - IGI indicator 2 is based on curtailed hydrogen demand
- For both IGI indicators, **thresholds are defined to classify if the observation is significant enough to present an infrastructure gap**
- The reason for an infrastructure gap is an infrastructure bottleneck
  - **An infrastructure bottleneck is a physical congestion of the network** that can be observed based on full utilization rates of all relevant transmission infrastructure during certain periods of time
  - An infrastructure bottleneck can in principle be solved by different projects and via different routes. Therefore, **infrastructure gaps have a regional nature**.

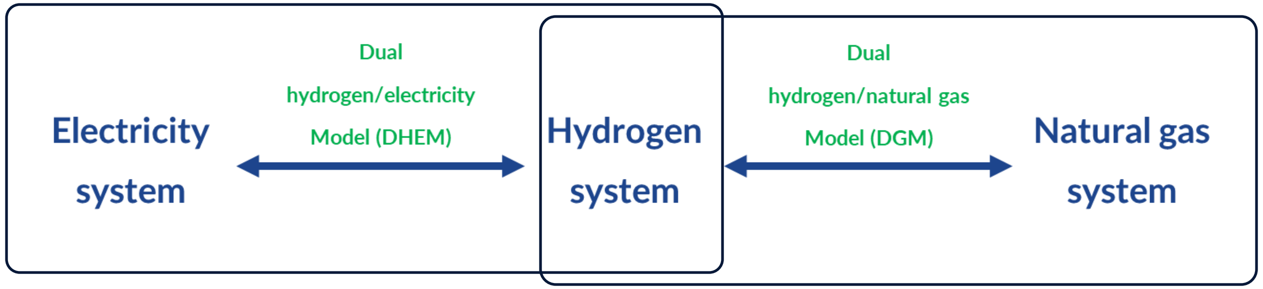
Added value of combining 2 IGI indicators: **only IGI indicator 1 detects if cheaper sources could satisfy demand** and **only IGI indicator 2 helps to identify several curtailed countries « in a row »**.

Modelling in the IGI

- Modelling of **hydrogen infrastructure requires market and/or network modelling of different energy carriers** such as natural gas and electricity, given the foreseen interlinkages between the energy carriers.

How much electrolytic hydrogen can be produced?

How much gas and hydrogen is needed for power plants?



Is there sufficient natural gas available for SMR/ATR at the needed locations?

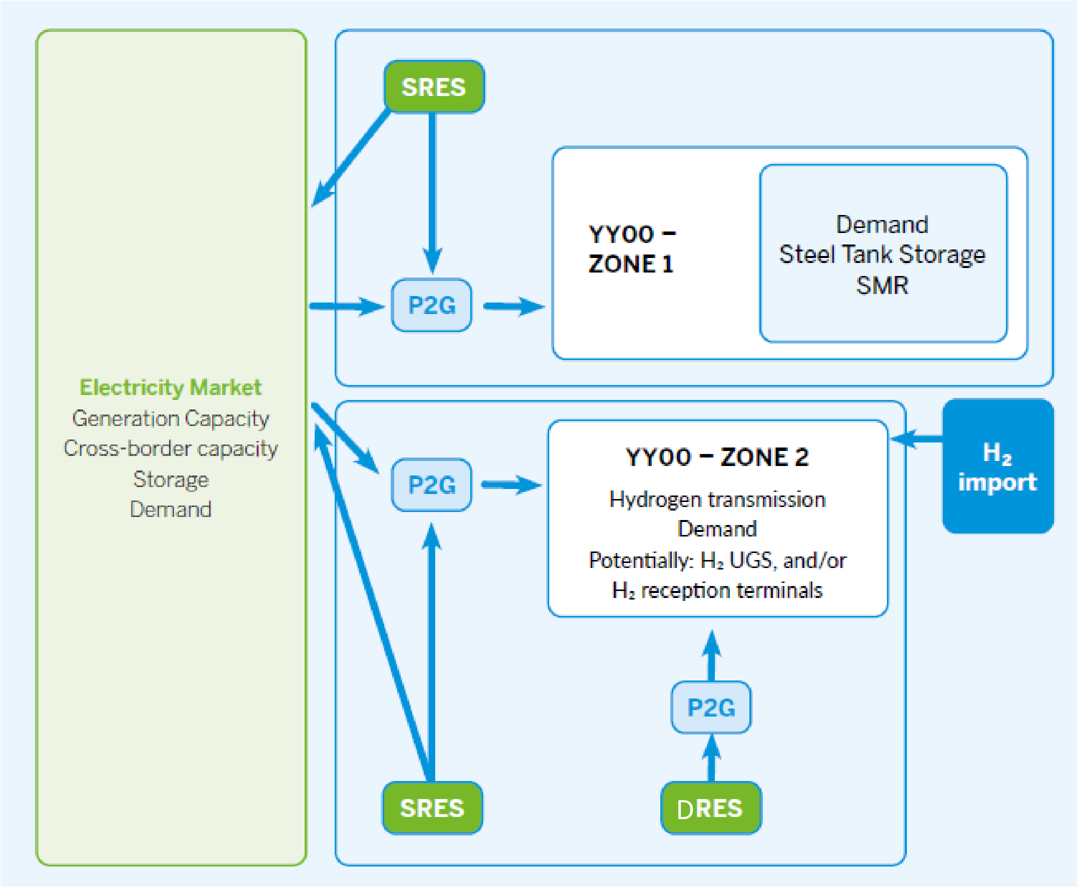
- Simulations' objective is to minimise the overall cost of the systems

All market assumptions considered in the DHEM are defined in the TYNDP 2024 Annex D1 (based on the NT+ scenario)

All additional information needed for the IGI is defined in the TYNDP 2024 Annex D2

The draft TYNDP 2024 IGI report is only based on the DHEM. In the meantime, additional assessments have shown that the use of the DGM will not change the relevant results provided by the DHEM.

Dual hydrogen/electricity modelling (DHEM) in the IGI



DRES: dedicated Renewables for electrolysers; SRES: shared Renewables with the electricity market

Electricity and Hydrogen systems and represented through interlinked topology

- **Hydrogen Zone 1**

  Hydrogen supply, demand and storage that can be linked without requiring connection to the main hydrogen transmission infrastructure

- **Hydrogen Zone 2**

  Represents the main hydrogen transmission infrastructure

Installed electrolyser and SMR capacities

Inelastic hydrogen demand

Hydrogen-based power plant capacities

All information about the electricity system

Sourced from TYNDP 2024 NT+ scenario

Difference between TYNDP 2024 NT+ scenario and IGI model caused by consideration of inputs from project promoters, i.e., updated hydrogen import, transport, and storage infrastructure

Dual hydrogen/electricity modelling in the IGI

Merit Order of hydrogen supply sources

- **2030**

1: Electrolysis from renewables

2: Electrolysis from nuclear

3: Imports from North Africa (only in Advanced hydrogen infrastructure level)

4: SMR with CCS

5: SMR without CCS (limited to local consumption in Zone 1)

6: Imports via terminals

- **2040**

1: Electrolysis from renewables

2: Electrolysis from nuclear

3: Imports from North Africa

4: SMR with CCS

5: Imports from Norway

6: Imports from Ukraine

7: SMR without CCS (limited to local consumption in Zone 1)

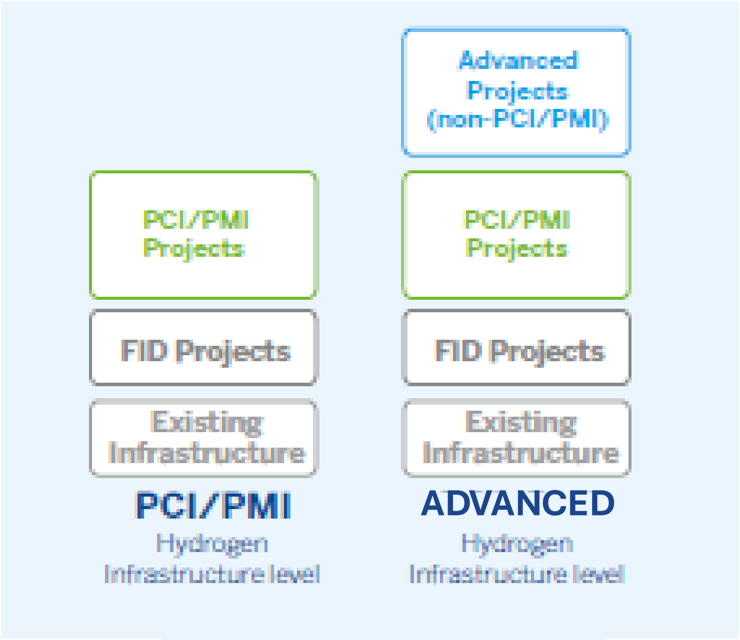
8: Imports via terminals

Supply prices from storages depend on the availability of other supply sources

Reference infrastructure in the IGI

Two hydrogen infrastructure levels are assessed in the IGI report:

- **PCI/PMI hydrogen infrastructure level:** containing (existing) hydrogen infrastructure, FID(*) projects and projects part of the 6th PCI/PMI list under hydrogen infrastructure category.
- **ADVANCED hydrogen infrastructure level:** containing PCI/PMI hydrogen infrastructure level and Advanced (**) projects.



(*) *FID status based on TYNDP 2024 project collection*

(**) *Advanced status based on TYNDP 2024 project collection*

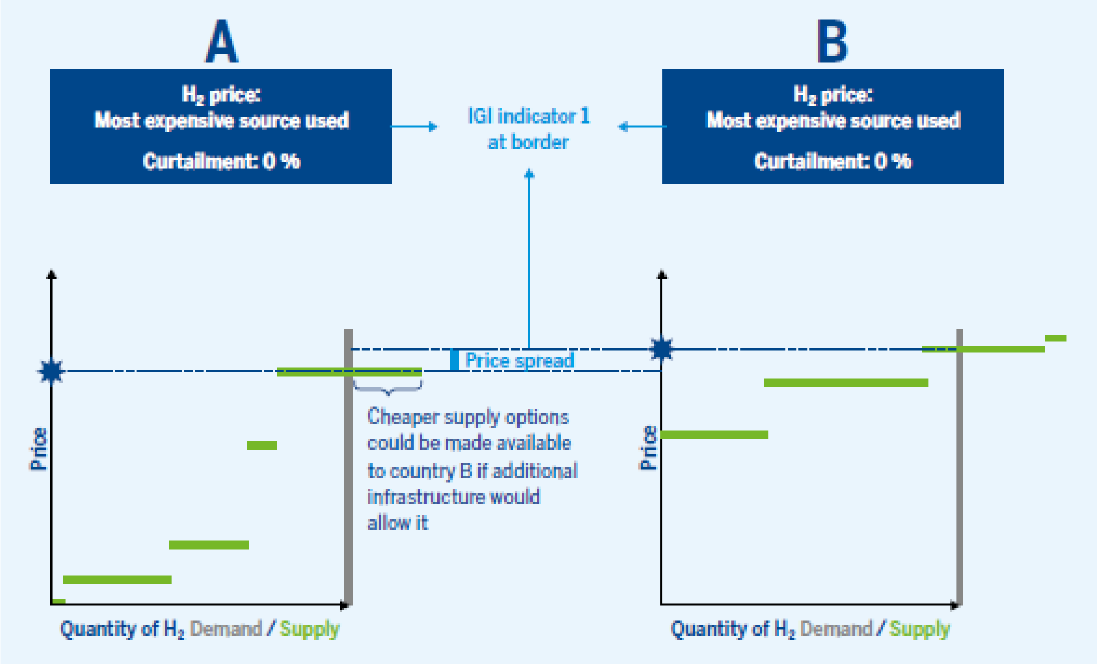
The level of price conversion and demand satisfaction identified in the IGI is achieved thanks to the projects considered in the hydrogen infrastructure levels

H2IGI report – indicators

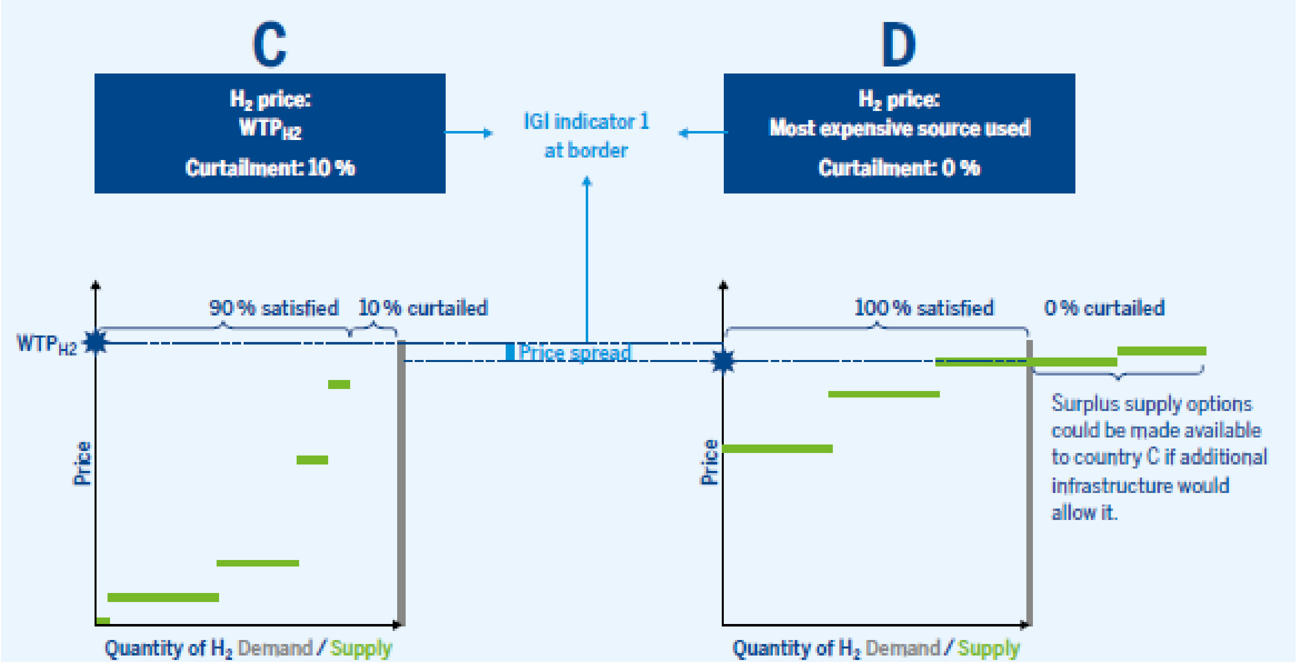
IGI Indicator 1: Hydrogen Market clearing price spreads

➢ IGI indicator 1 aims at identifying hydrogen infrastructure gaps by **assessing Zone 2 nodes of different countries based on differences in hydrogen market clearing prices between these nodes.**

Example 1:



Example 2:



IGI Indicator 2: Hydrogen Demand Curtailment Rate

Indicator 2.1

- IGI indicator 2.1 aims at identifying infrastructure gaps by measuring the hydrogen demand curtailments of individual nodes during the reference weather year (1995), and without infrastructure or source disruptions.
- Threshold: A yearly average hydrogen demand curtailment rate of more than 0%.

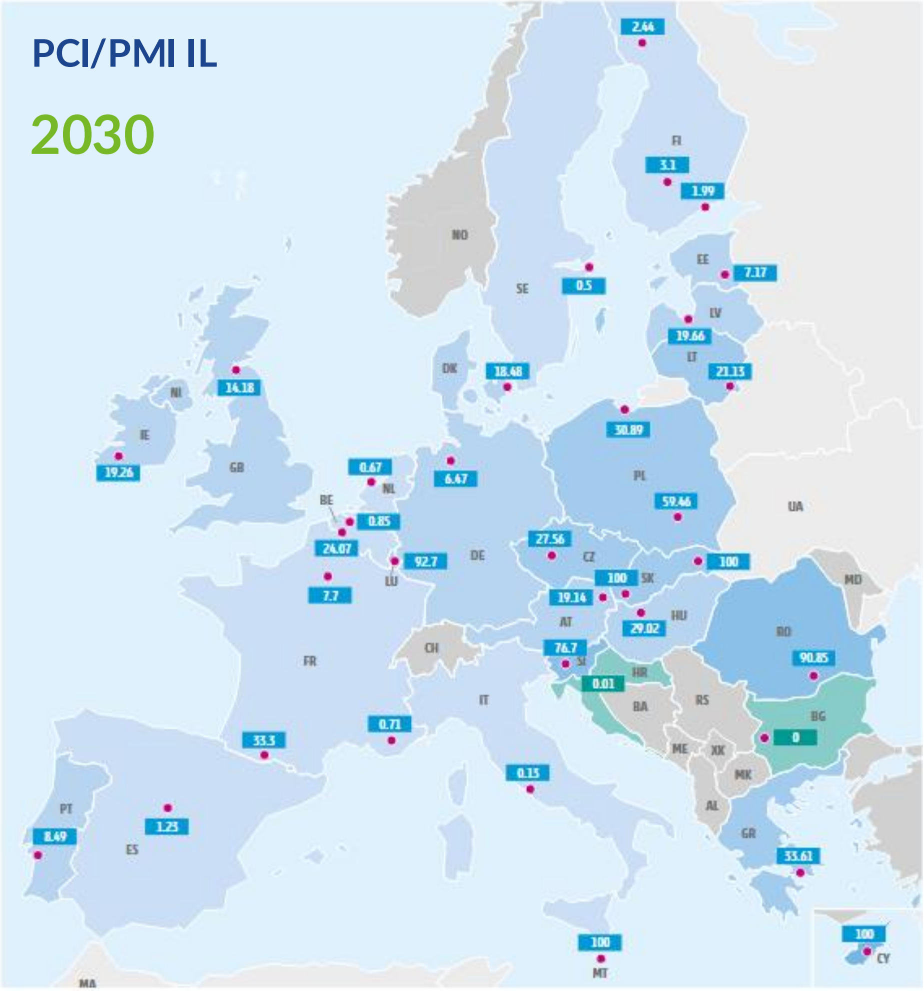
Indicator 2.2

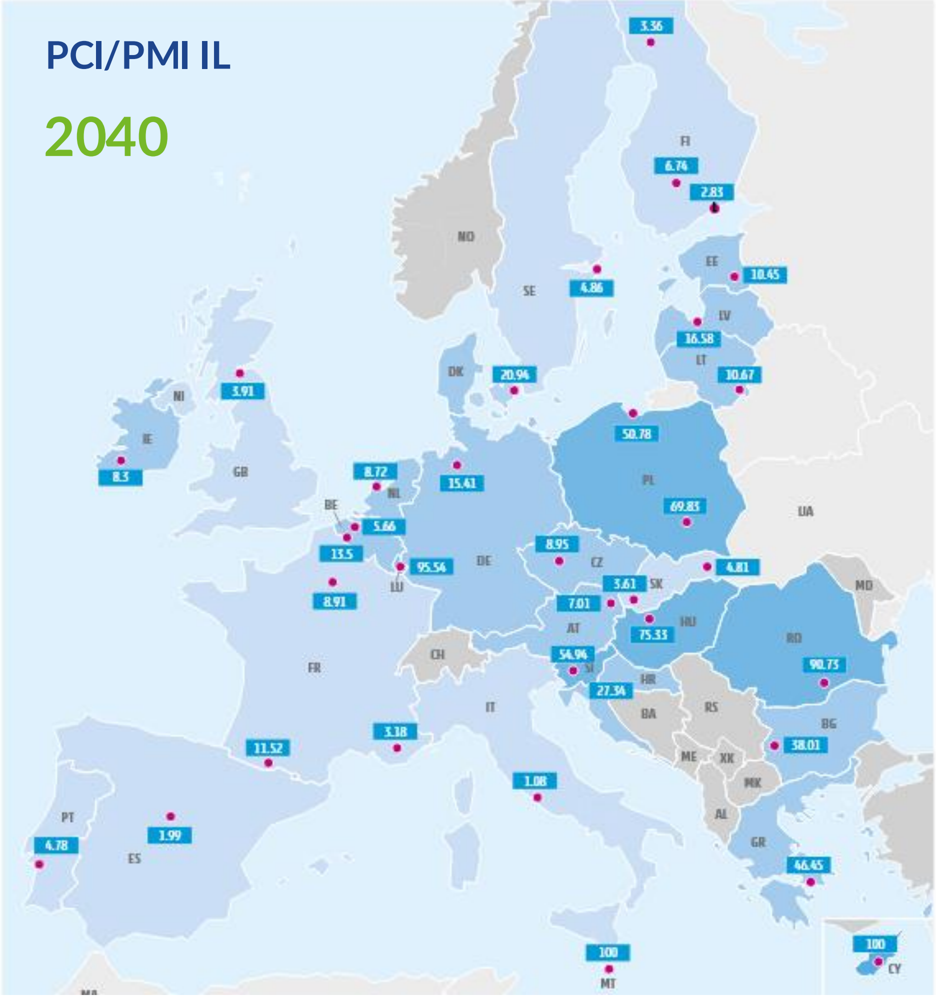
- IGI indicator 2.2 aims at identifying infrastructure gaps by measuring the hydrogen demand curtailments of individual nodes during the stressful weather year (2009), and without infrastructure and source disruptions.
- Threshold: A yearly average hydrogen demand curtailment rate of more than 3%.

Hydrogen Demand Curtailment can be caused by structural undersupply of Europe with hydrogen as well as missing internal infrastructure like pipelines and storages

IGI Indicator 2: Hydrogen Demand Curtailment Rate

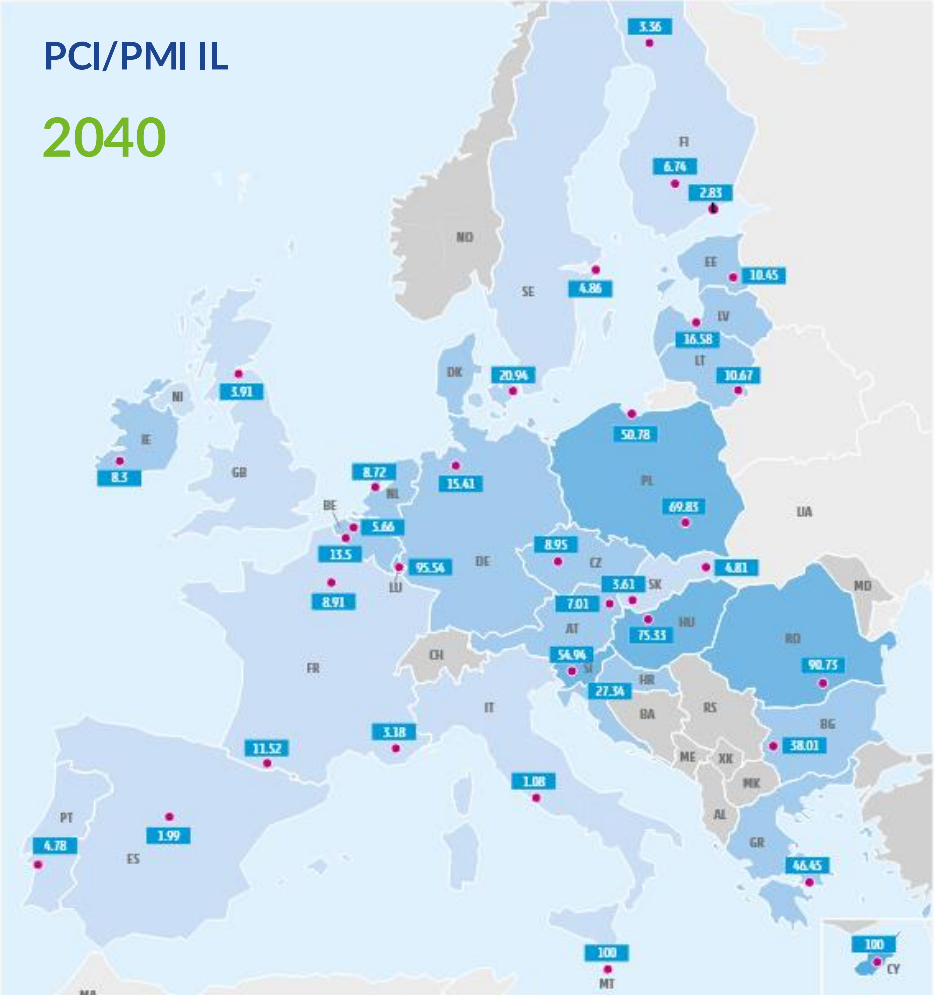
Example: IGI indicator 2.1

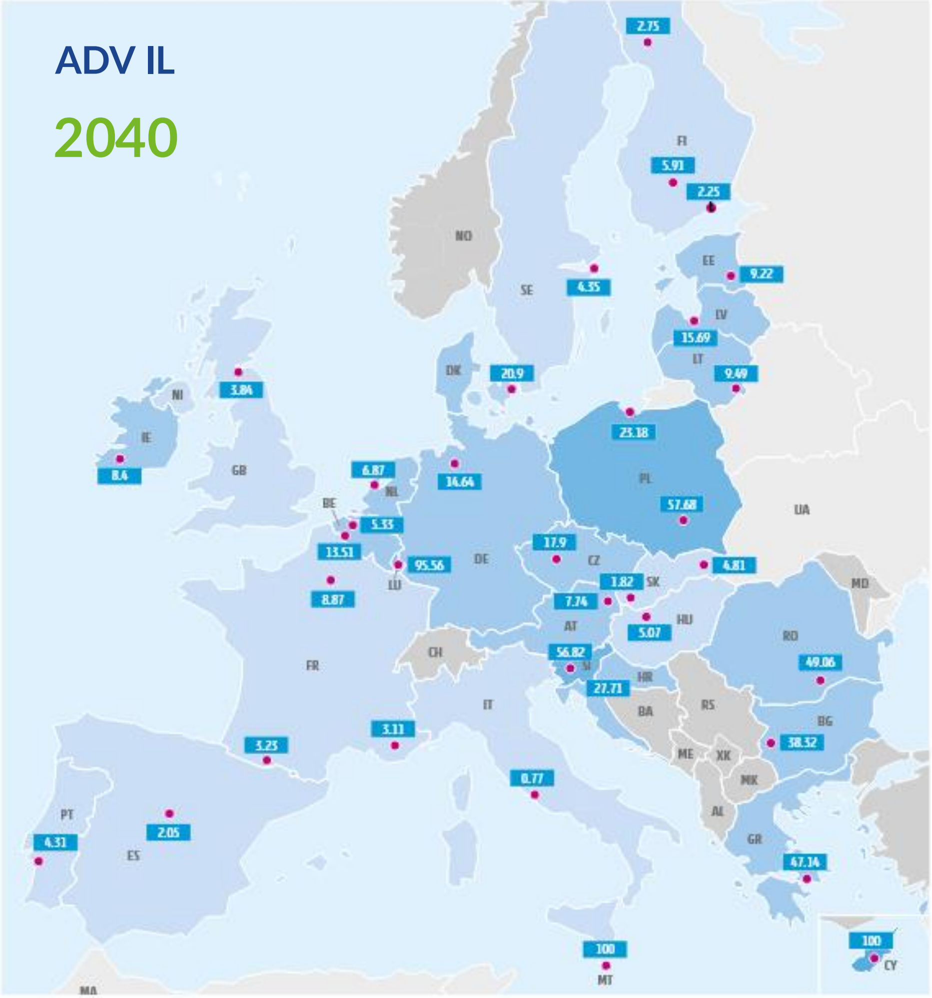




IGI Indicator 2: Hydrogen Demand Curtailment Rate

Example: IGI indicator 2.1





Thank you for your attention

Maria Castro, Investment Manager ENTSOG

Maria.castro@entsog.eu

ENTSOG - European Network of Transmission System Operators for Gas
Avenue de Cortenbergh 100, 1000 Bruxelles

www.entsog.eu | info@entsog.eu

One system perspective

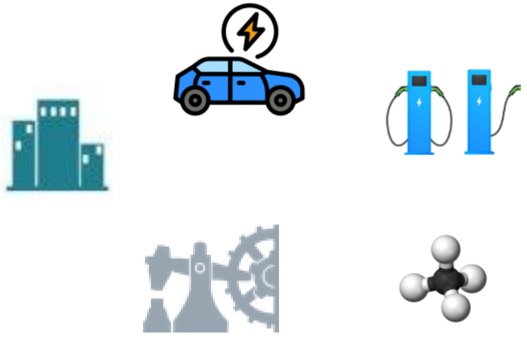
Foundations of the TYNDP 2024 Scenarios for a One-System view

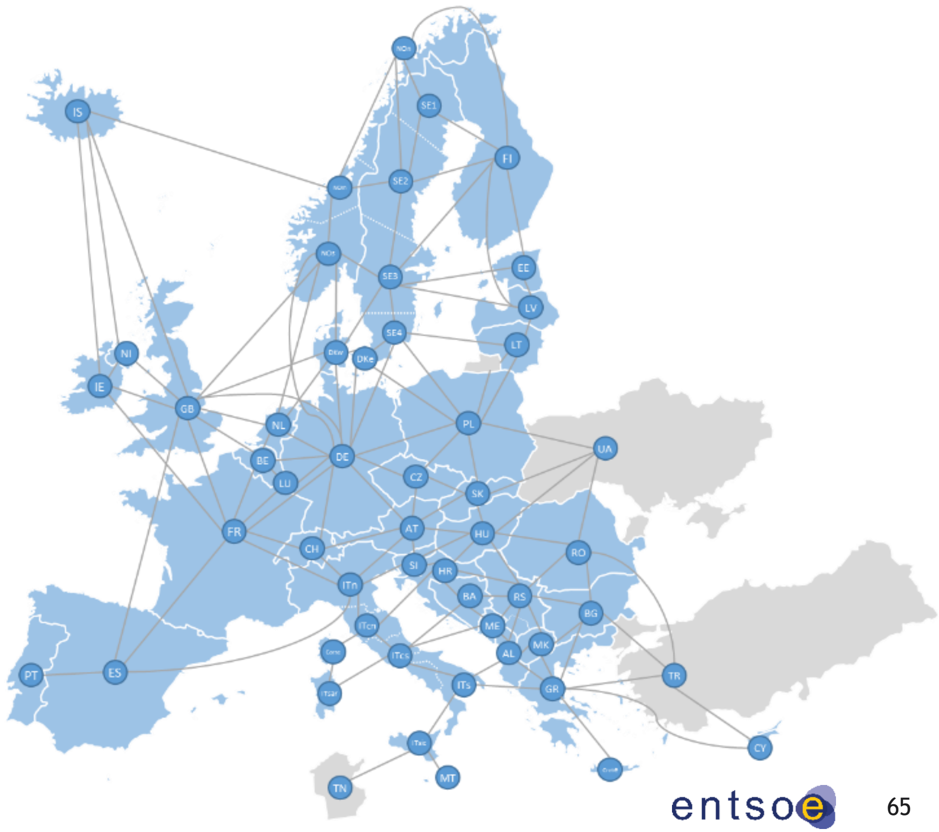
- **Holistic Sector-Coupling**
  Several power-to-gas configurations studied, embedded EV and prosumer (including district-heating) nodes capture interdependencies between electricity, hydrogen and heat

- **Explicit Offshore Hubs**
  56 offshore zones model wind farms, electrolysers, cables and pipelines, letting the model choose electricity vs. hydrogen transport or a hybrid strategy

- **Multi-Temporal Storage Integration**
  From seasonal salt caverns to daily batteries and pumped hydro (open/closed loop), storage assets are co-optimized with generation and transmission

- **Zonal Granularity of Climatic Conditions & Climate Stress-Testing**
  Renewables production derived from PECD zones and 3 representative climate years (1995, 2008, 2009) ensure both geographical fidelity and resilience, even under Dunkelflaute conditions.

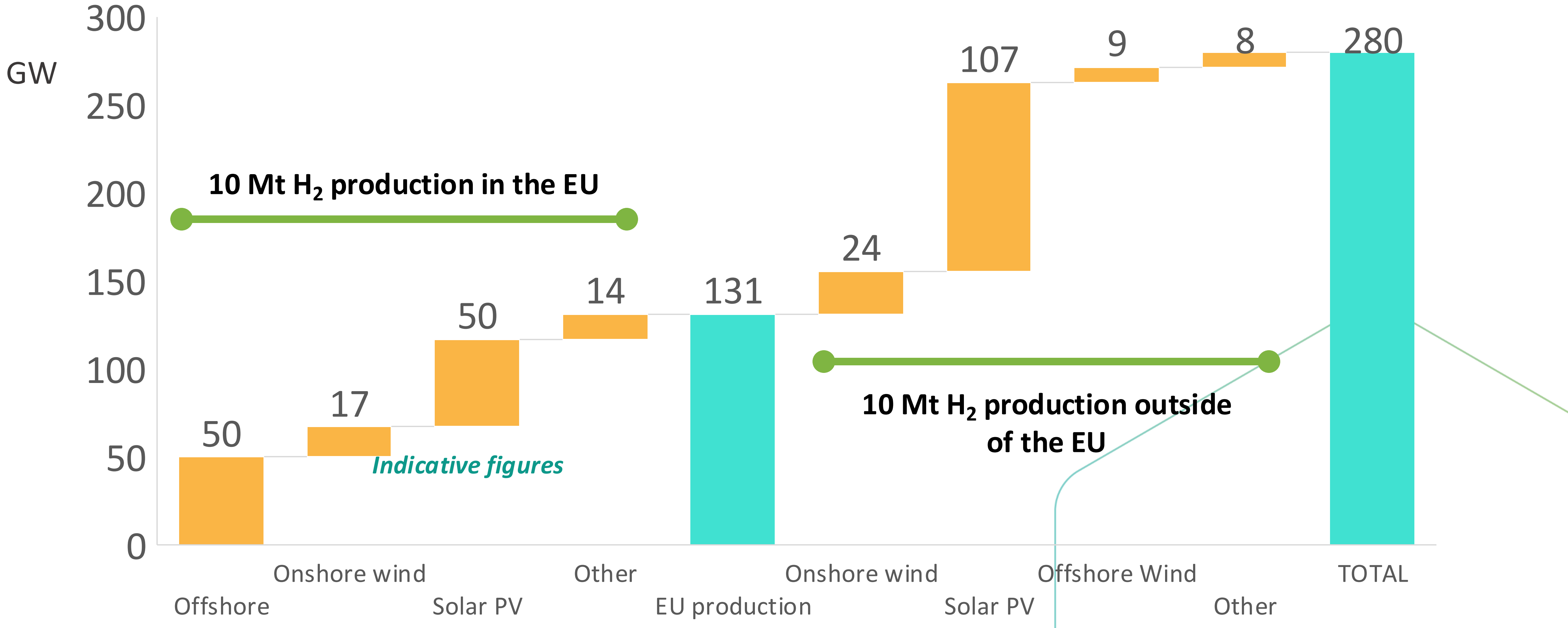




Offshore infrastructure for the hydrogen sector – presentation by Hydrogen Europe

Hydrogen Europe

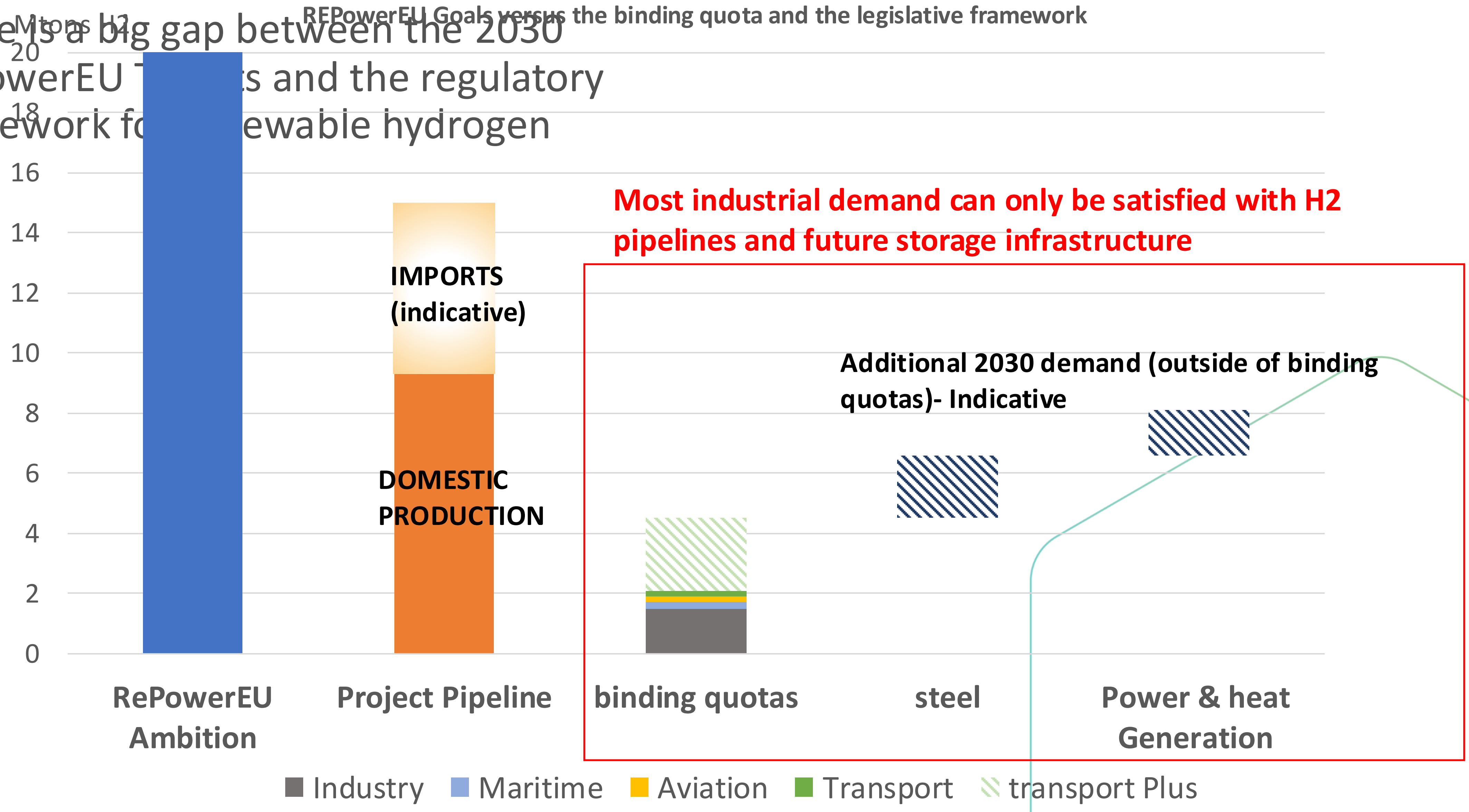
Required electrolysis capacity by 2030 to meet REpowerEU targets

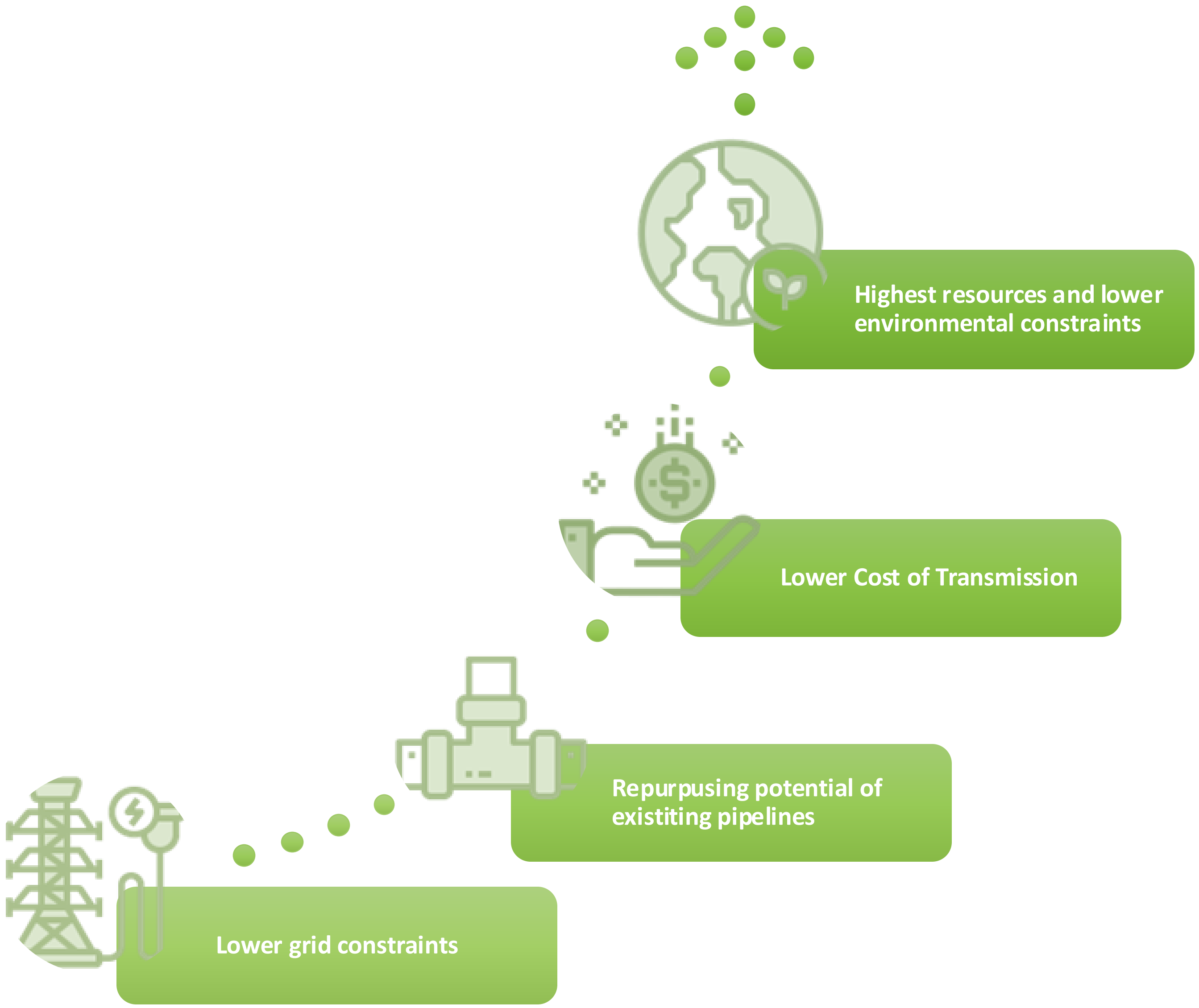


Source: Hydrogen Europe

Assuming: Capacity utilization factors of 5,000h for Offshore wind, 2,900h for onshore Wind, 2,000h for solar PV and 7,000 for grid connected electrolysers

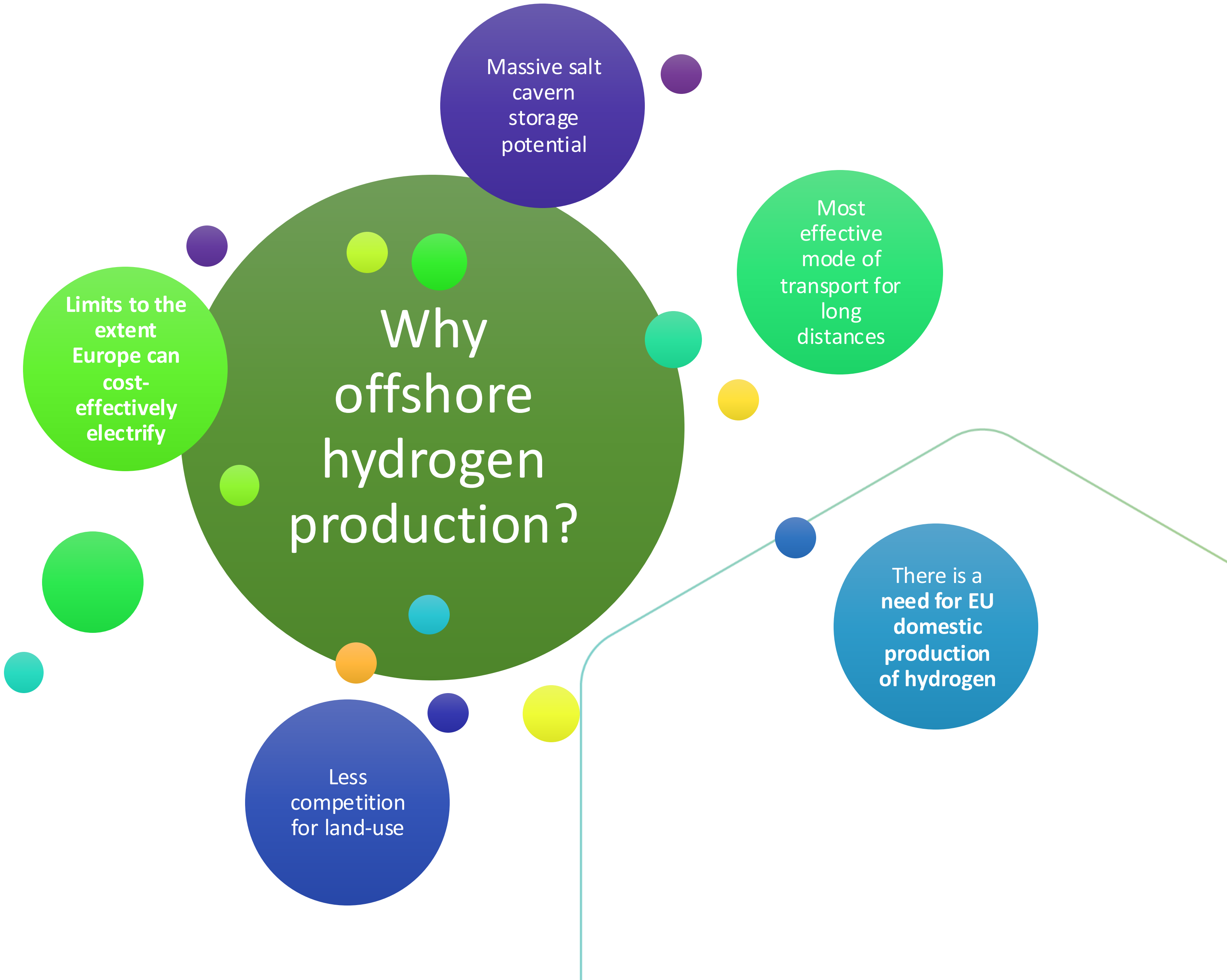
There is a big gap between the 2030 RepowerEU T… s and the regulatory framework fo… ewable hydrogen




Highest resources and lower environmental constraints
Lower Cost of Transmission
Repurpusing potential of existiting pipelines
Lower grid constraints

Why Hydrogen offshore production?

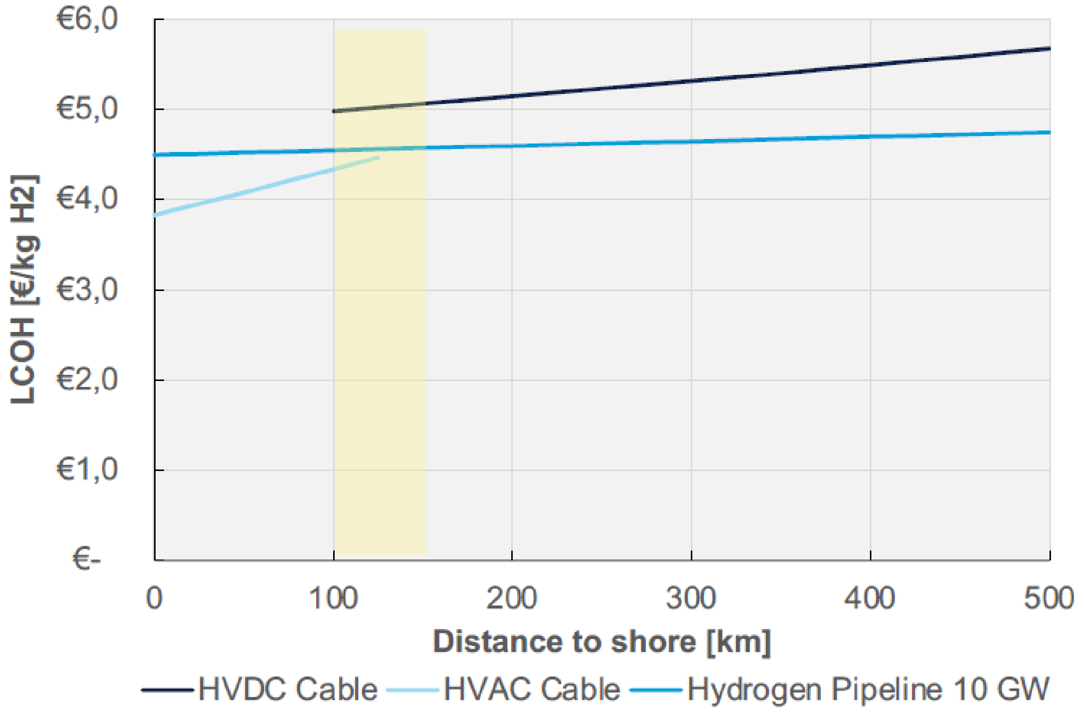
- Hydrogen is another source od demand for RES electricity, it helps tackle the cannibalisation effects of renewable and reduce curtailment hours.
- Hydrogen can be a complementary pillar of energy supply and long-term energy storage.



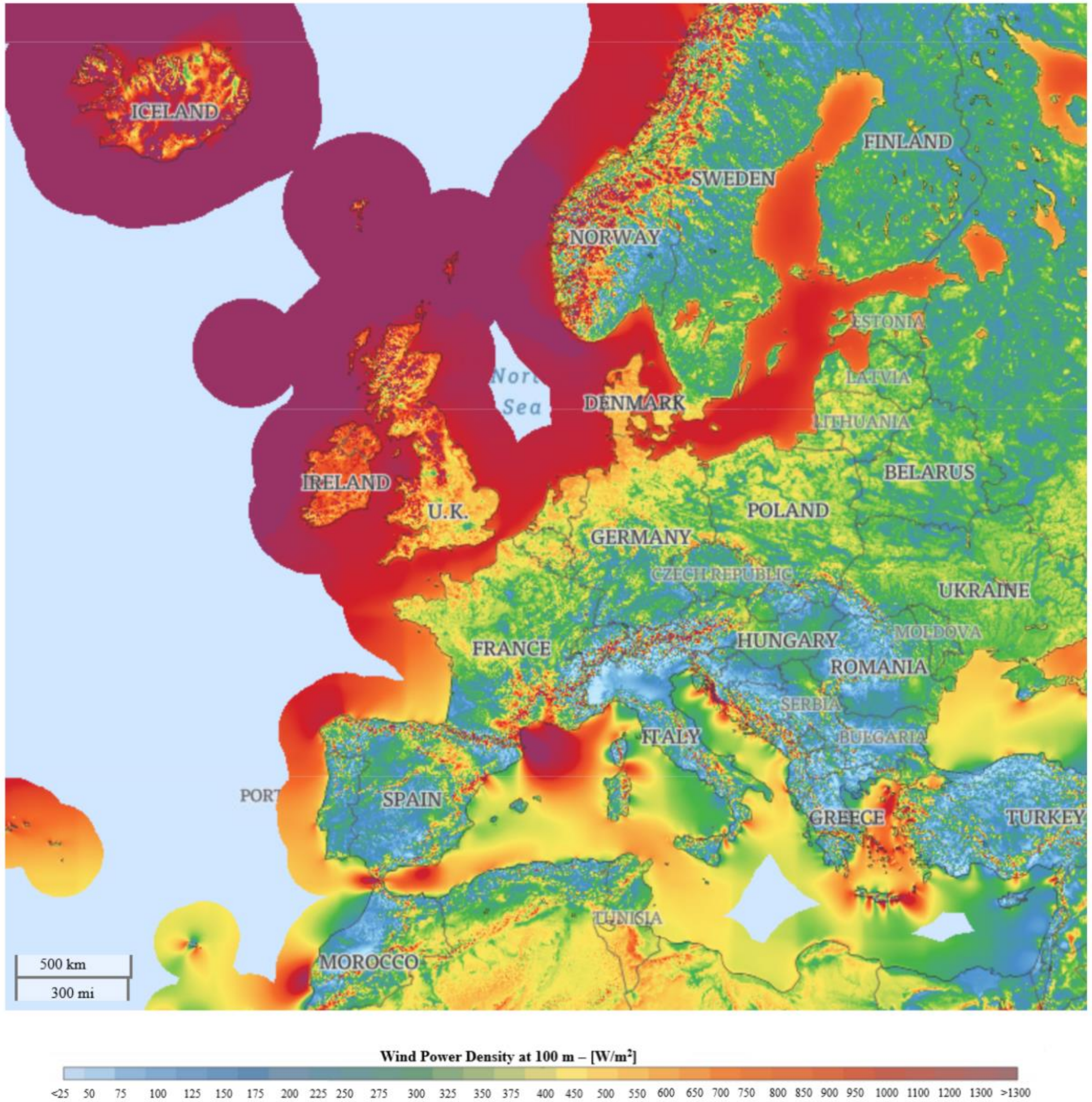
Why Offshore hydrogen production

H2 untaps massive RES potential on remote locations

LCOH from offshore wind by transmission vector in 2030

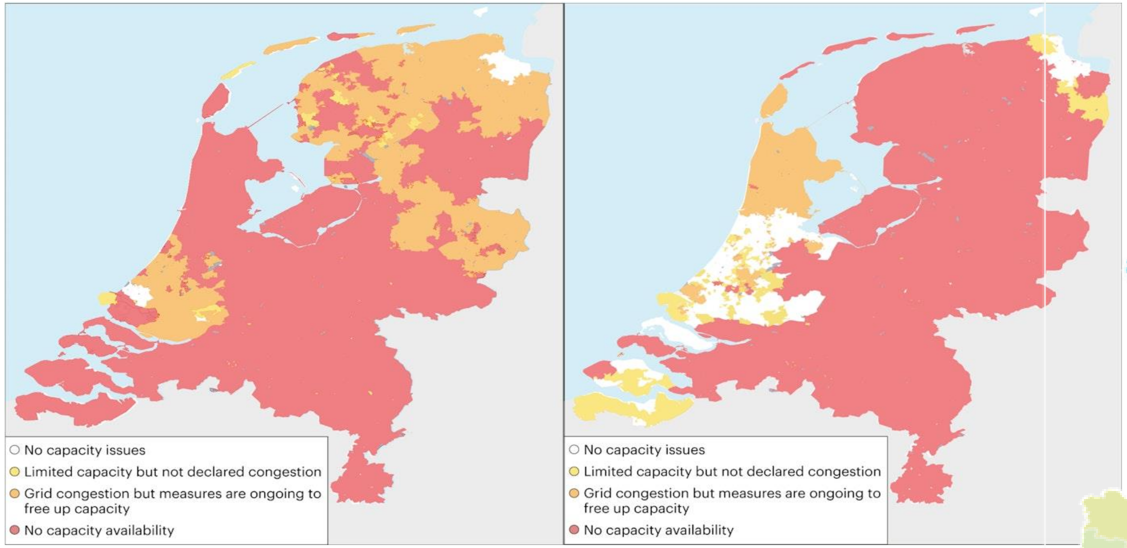


Source: DNV



Why Offshore hydrogen production

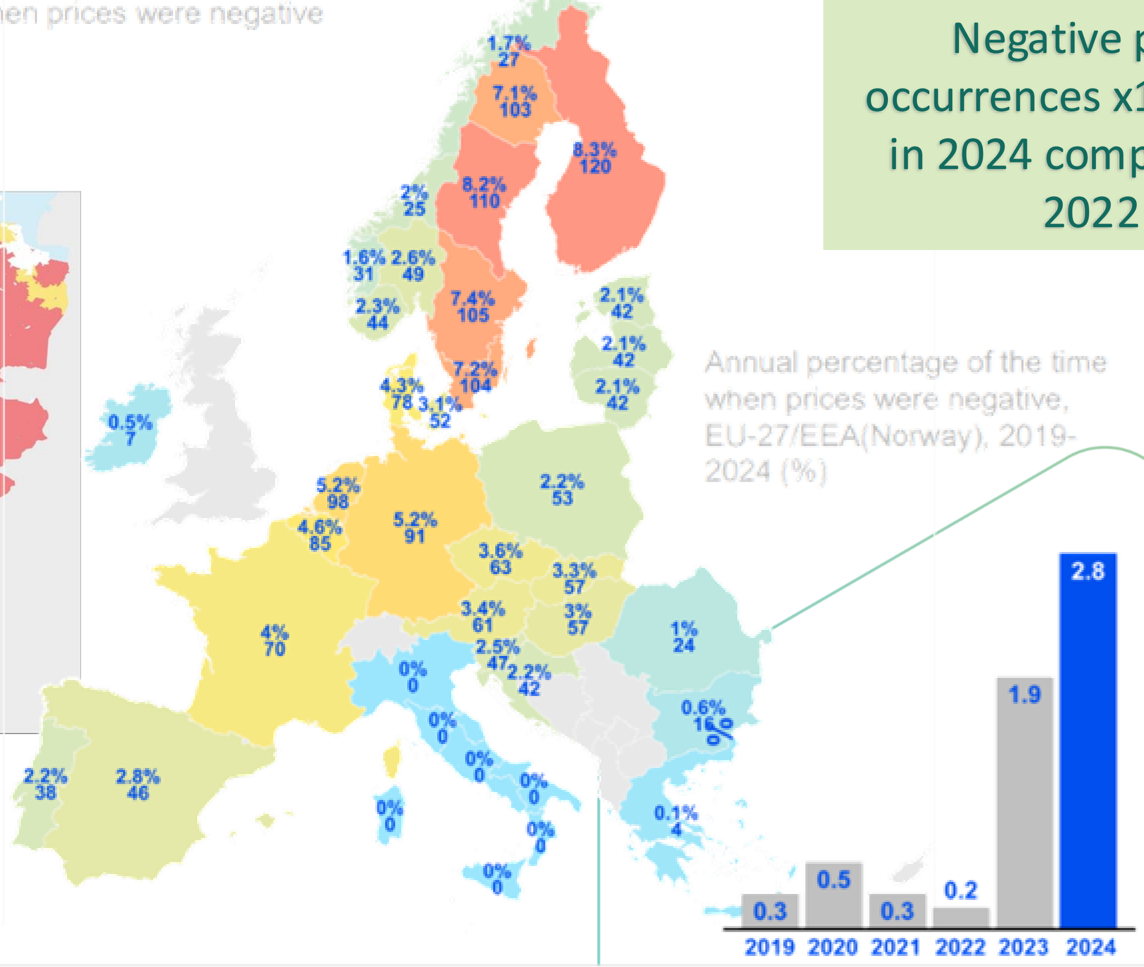
H2 enables RES integration ONSHORE



Source: TenneT.

Surge in negative electricity prices across the EU in 2023 intensifies further in 2024

Percentage of the time and number of days when prices were negative
EU-27/EEA(Norway), 2024



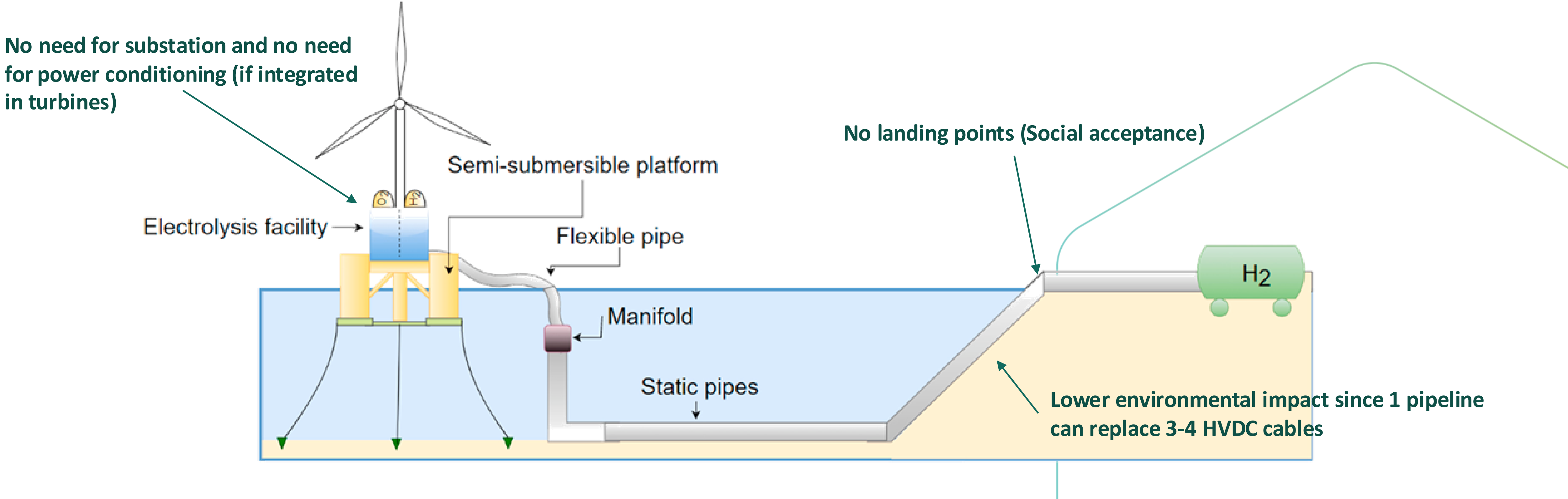
Negative price occurrences x18 folded in 2024 compared to 2022

Source: ACER, TTE Council Ministerial – Council Presidency of Poland.

Why Offshore hydrogen production

Lower power grid constraints

Grid connection	Storage
• "Faster" permitting process due to less grid constraints (no grid connection permits) and no competition to obtain grid access permits	• Capacity to store hydrogen in the pipeline (by increasing compression) • Access to large geological storage sites (salt caverns and depleted gas reservoirs offshore)



Why Offshore hydrogen production

Lower cost of Transmission – Repurposing Potential

H2 pipeline up to x3 time cheaper than electrical connection

The cost to supply and install the hydrogen pipeline is estimated at roughly **£1m/ km**. This compares favorably with the cost to supply and install 220kV export cable of roughly £1m/ km and a 1.2GW windfarm requiring three to four cables, giving an export cable supply cost of **>£3m/km**.

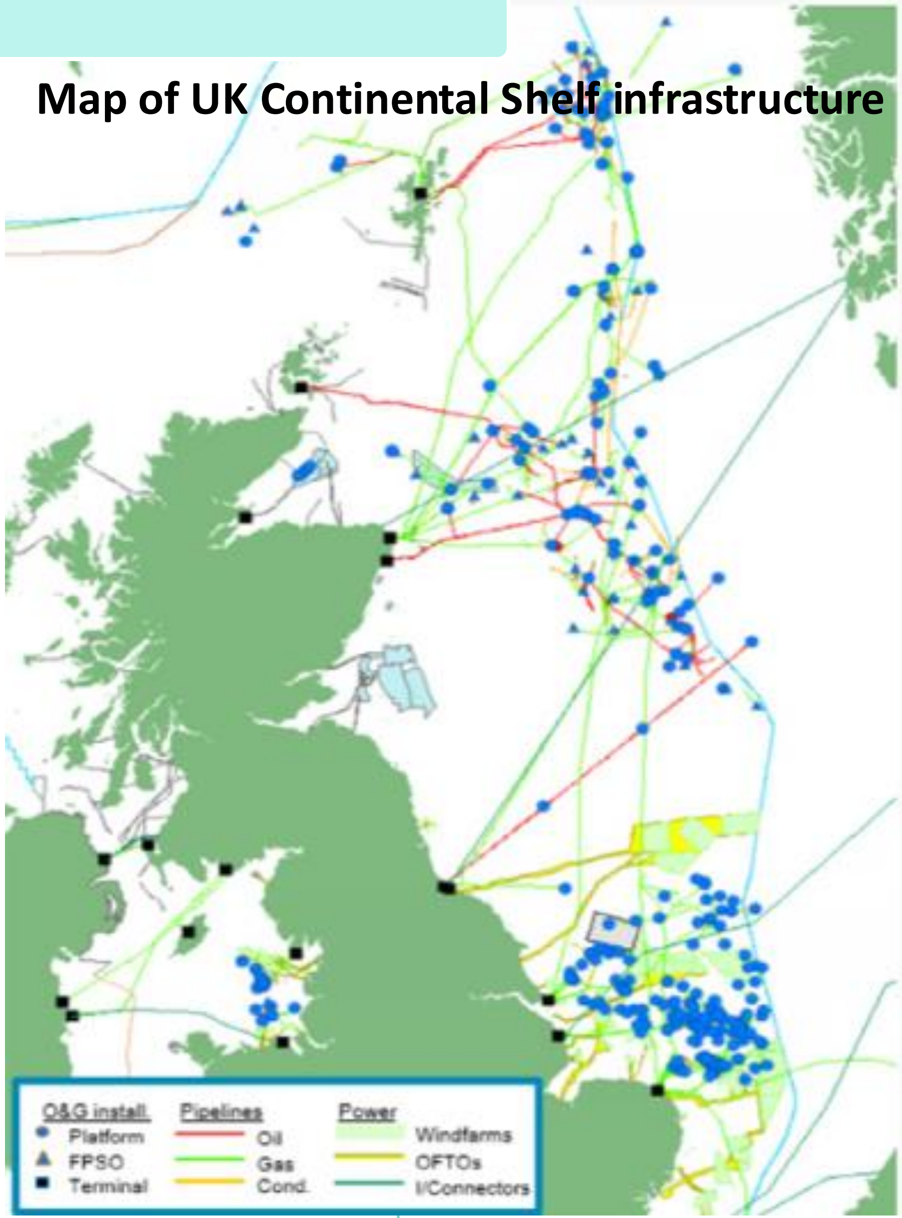
Repurposing of existing infrastructure can be around 1/3 of developing new Hydrogen pipelines

If retrofitting of existing O&G pipelines is also considered, then the cost can drop even lower.

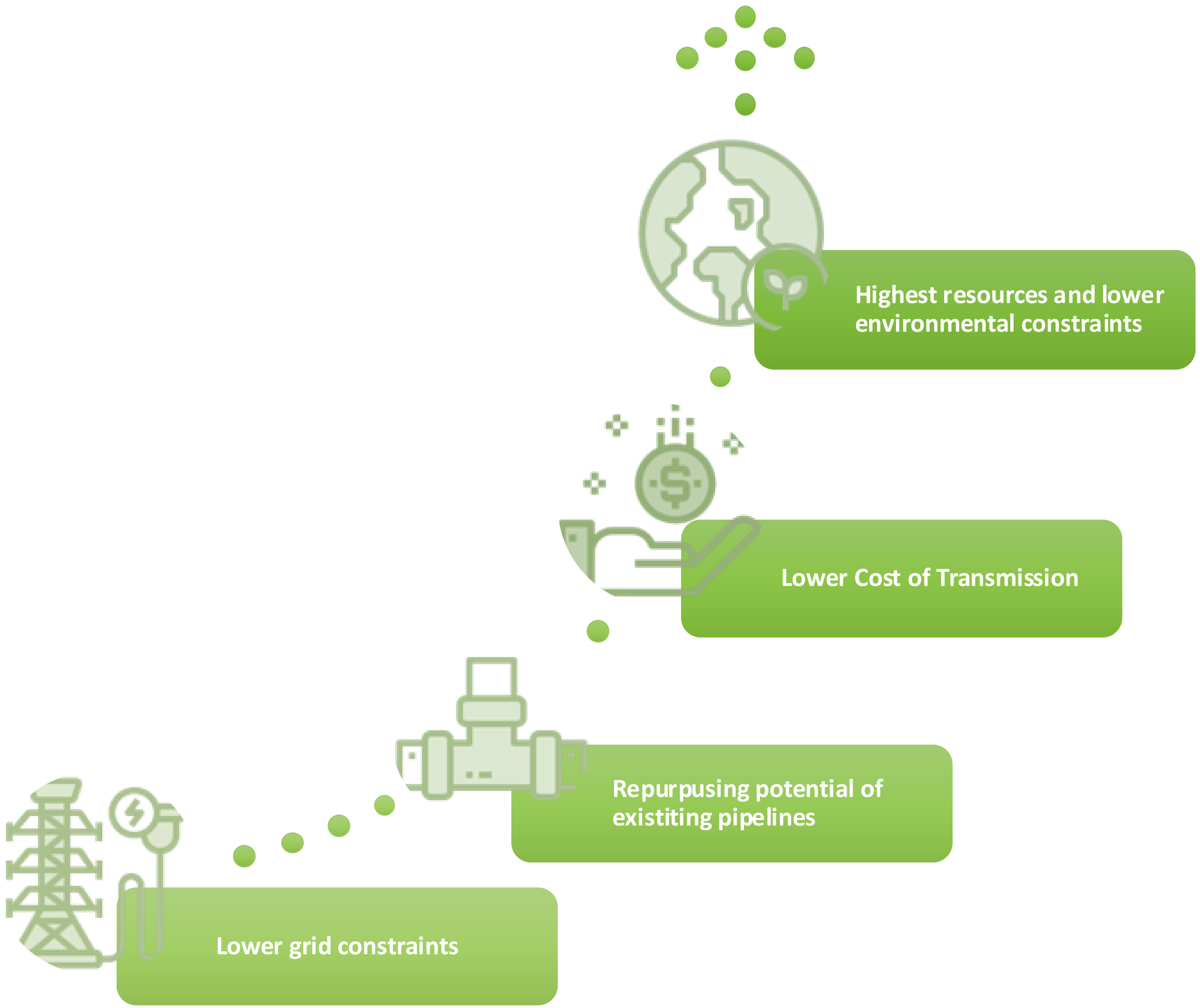
Integration with Offshore Infrastructure

Offshore hydrogen production could potentially be integrated with existing or planned offshore infrastructure, such as oil and gas platforms or subsea pipelines.

Map of UK Continental Shelf infrastructure



Source: OFFSHORE WIND AND HYDROGEN, Solving the integration challenge, ORE Catapult, 2020



Highest resources and lower environmental constraints
Lower Cost of Transmission
Repurpusing potential of existiting pipelines
Lower grid constraints

Offshore hydrogen configurations

Hydrogen Europe

1

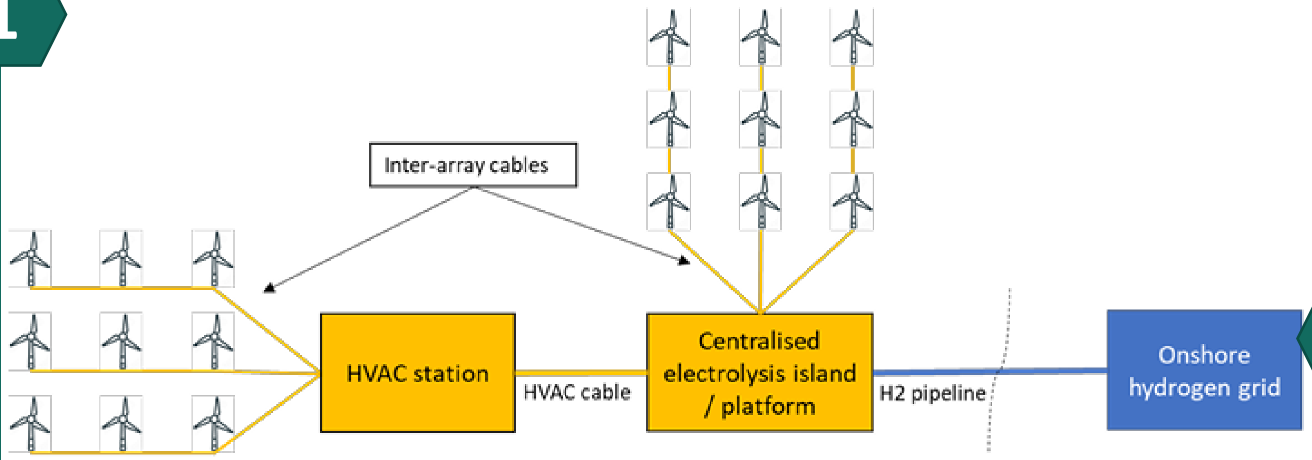


Figure 9: Schematic overview of electrolysis on an energy island

2

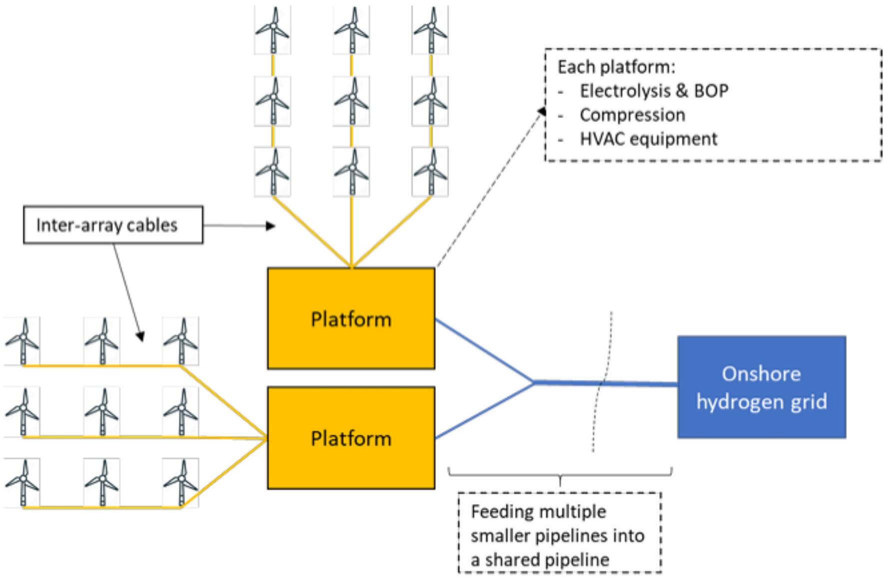


Figure 10: Schematic overview of electrolysis on an offshore platform

3

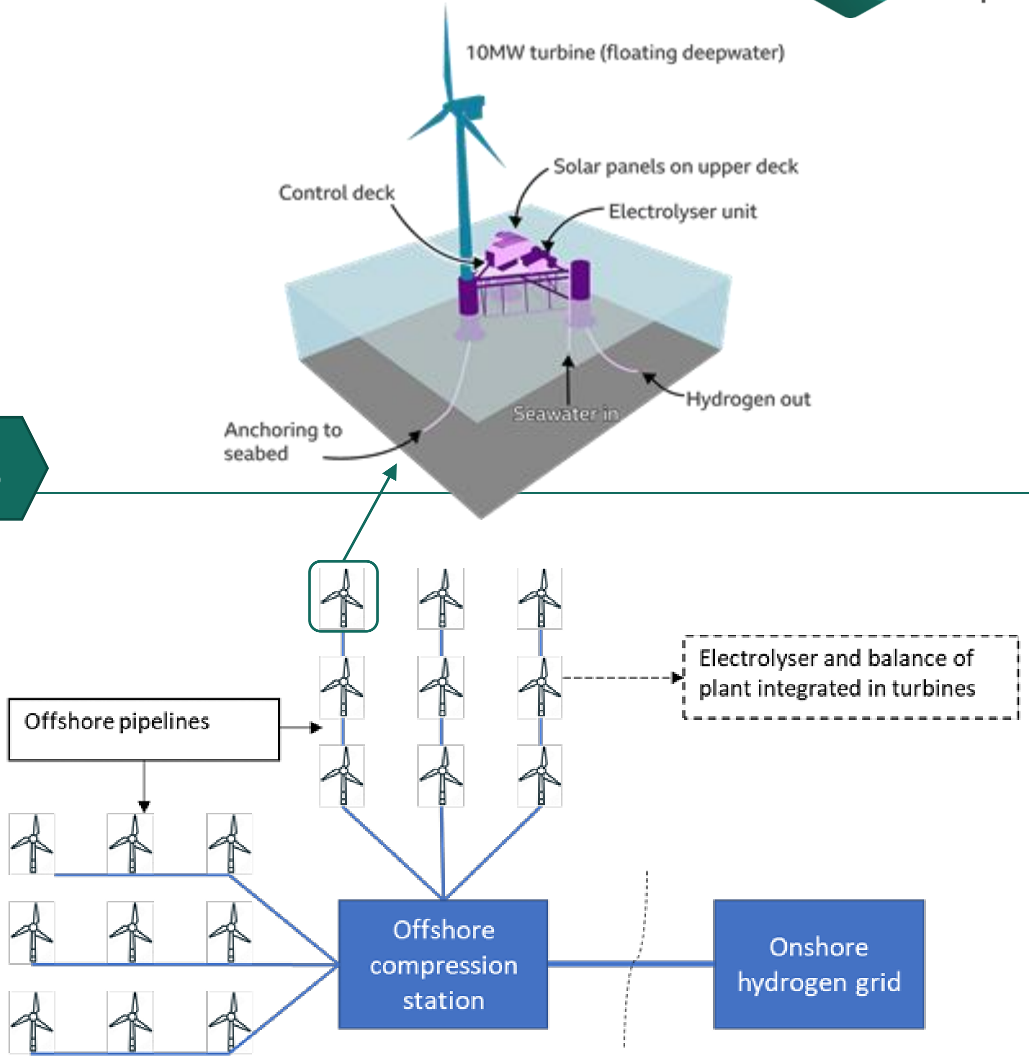
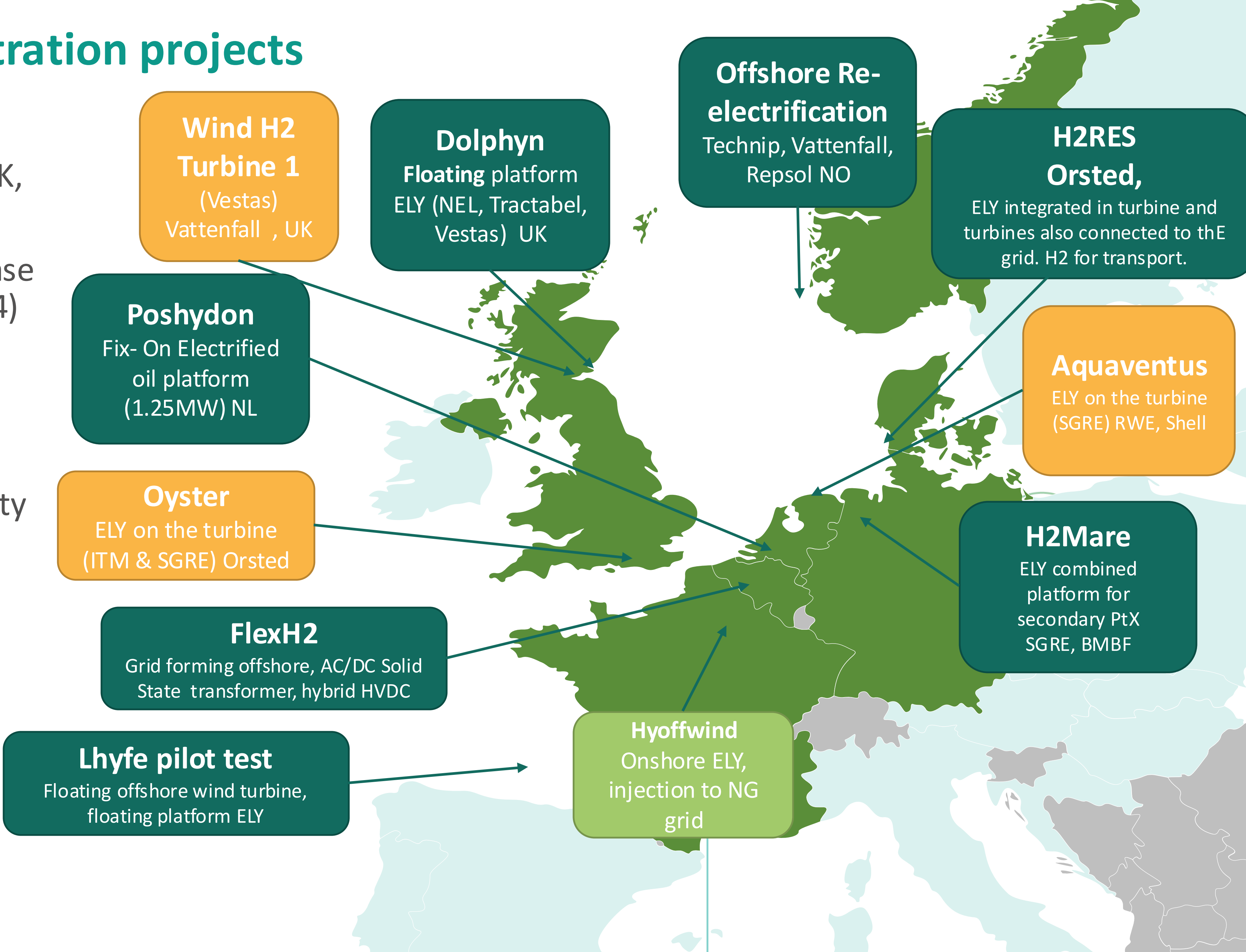


Figure 11: Schematic overview of integrated offshore electrolysis

Source: Offshore wind system integration 2030-2040, December 2021, Netherlands Enterprise Agency, Guidehouse & Berenschot

Ongoing Demonstration projects

- Leading countries: NL, UK, NO, DE and FR
- Early Demonstration phase (first results toward 2024)
- Main topics:
    - Offgrid operation
    - Direct integration
    - Corrosion & durability



Source: Hydrogen Europe

Breakthrough in Offshore Hydrogen Production: Chinese Scientists Generate Green Hydrogen Directly from Seawater

Innovative Technology

Wind-powered membrane-based system

Sea Water in-situ electrolysis with a membrane system

Survived extreme weather

Stable >240-hour hydrogen production

Reliable 3.200-hour demo

Largest demonstration project at industrial scale

HOPE Project: Hydrogen Offshore Production for Europe

Hydrogen Europe

The HOPE project aims to demonstrate the technical and financial viability of large-scale offshore hydrogen production. It will export green hydrogen via a composite pipeline to meet regional demands.

Sealhyfe

- Location: North Sea, off the port of Ostend, Belgium in an offshore testing zone aiming to be the nerve centre of the green hydrogen industry in Belgium
- Expected to be operational: 2026
- Grant Agreement: €20 million from the European Commission
- Expected Production: 10 MW unit, up to 4 tonnes of green hydrogen daily

Innovations:

Recycled Offshore Barge: Second-hand jack-up barge for the production unit.

10 MW PEM Electrolyser: First of its size to be installed offshore.

Seawater Treatment System: Low-energy and compact system using heat from the electrolyser.

Underwater Flexible Hydrogen Pipeline: Over a km long thermoplastic composite pipeline to transport hydrogen.

Lhyfe · Alfa Laval · Plug · Strohm · NEW · ERM · POM West-Vlaanderen · cea · DWR eco enabling eco innovation

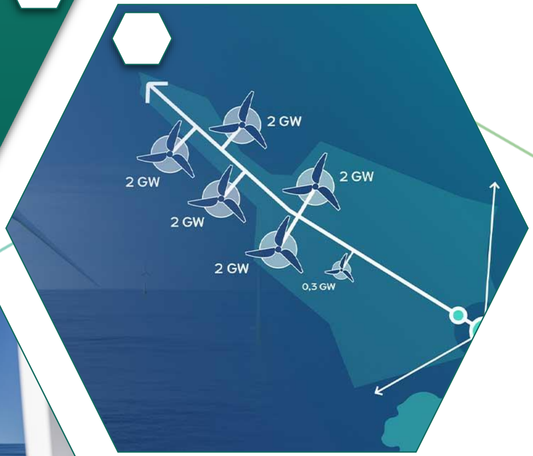
Conclusions

How can we support the development of offshore hydrogen?

We need more **dedicated market mechanisms** (tenders and auctions for offshore hydrogen production).

We need **regulatory flexibility** for the first demonstrators and pre-commercial projects

ONDP exercise to study how to better integrate OFFSHORE production into the ONSHORE grid



We need a SYSTEM INTEGRATION perspective on TYNDP

Thank You

Av. de la Toison d'Or 56-60
Brussels / Belgium

secretatariat@hydrogeneurope.eu
hydrogeneurope.eu

Guiding questions for the discussion

- Where do you see the greatest value in co-locating storage with existing transmission corridors or reinforcing grid links to unlock distributed flexibility?
- How can we best coordinate investments in grid reinforcement versus new storage assets to optimize both security of supply and cost-effectiveness?
- How should the methodology capture multi-purpose offshore solutions (e.g. subsea cables feeding electrolyzers versus dedicated hydrogen pipelines) to reflect real-world project feasibility?
- Are three representative weather scenarios adequate to capture resilience needs ? Should something be done in addition?

Conclusion and next steps

Workshop Overview - Key Stakeholder Perspectives

Today's workshop brought together diverse stakeholders to discuss the methodology and perspectives for the TYNDP 2026 System Needs Study.

Multi-Stakeholder Collaboration

European Commission

Role-giving perspective as part of the infrastructure framework, providing regulatory guidance and policy direction.

ACER

Calls for improved transparency, realistic starting grids, early stakeholder consultation, and emphasis on internal reinforcements.

T&D Europe

Demonstration of manufacturer requirements from system needs study outputs for strategic planning.

RGI

Highlights on achieving sustainability in grids through effective spatial planning strategies.

ENTSOG

Presentation on Hydrogen Infrastructure Gaps Identification methodology and output indicators.

EASE & Hydrogen Europe

Focus on storage-transmission complementarity and offshore hydrogen production for REPowerEU targets.

TYNDP Evolution Since 2012

The Ten-Year Network Development Plan has undergone continuous improvement and expansion.

Joint Planning Integration: Collaboration with ENTSOG for comprehensive energy system planning within Scenario Building

Offshore Network Development: Recognition and integration of offshore renewable energy infrastructure

Electricity Infrastructure Focus: Systematic approach to transmission network expansion

Sector Integration: Cross-sector coordination for optimal energy system development

Long-term Vision: Strategic planning horizons for 2030, 2040, and 2050

Gap Analysis: Systematic identification of infrastructure gaps and opportunities

TYNDP 2026 Methodology

New Approaches

Key Focus Areas:

- **Regulatory Adaptation:** Methodology will reflect upon recent regulatory changes and increased complexity
- **Stakeholder Integration:** Enhanced consultation processes based on today's workshop insights
- **Transparency Enhancement:** Improved clarity in methodology and decision-making processes

Draft methodology development is starting and will follow today's workshop discussions

Next steps - TYNDP 2026 milestones

Today
Workshop on system needs study methodology

Ongoing
Public consultation on Scenarios input data, parameters and methodologies

July-Dec 2025
Drafting and testing of system needs methodology

Q4 2025
Draft Scenarios 2026 are shared with Stakeholders Reference Group for consultation

January 2026
Release of draft system needs study methodology, for consultation. Feedback will be considered in TYNDP 2028.

April 2026
Release of draft scenarios

December 2026
Release of draft TYNDP 2026 for consultation

By early Q3 2027
Final TYNDP 2026

>2 years development cycle with multiple consultation phases

Thank you

We thank everyone who contributed to today's discussions and outcomes.
Contact us at tyndp(a)entsoe.eu

Workshop Success Through Collaboration

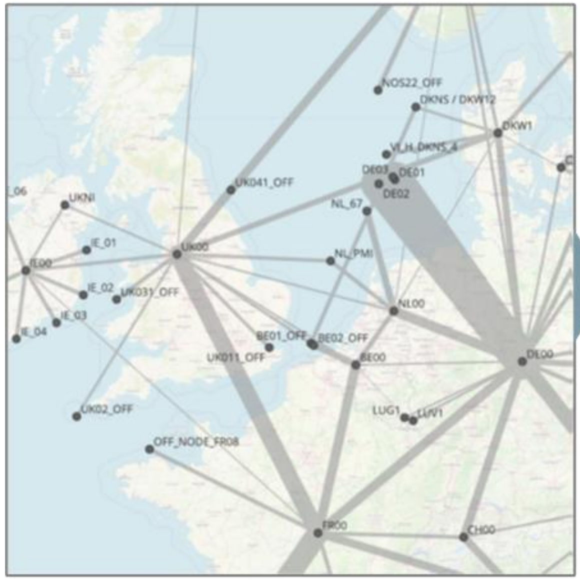
See you soon for the next steps in TYNDP 2026 development!

Backup

The ONDP expansion, summarized in four passages

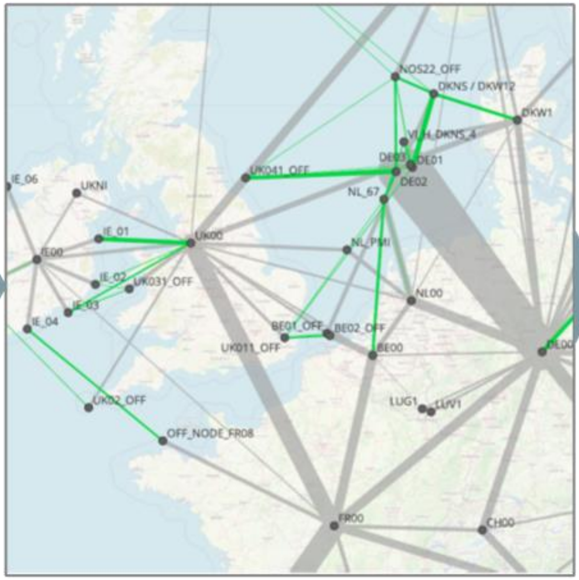
Schematic Visualisation:

1 *Creation of the starting grid* *

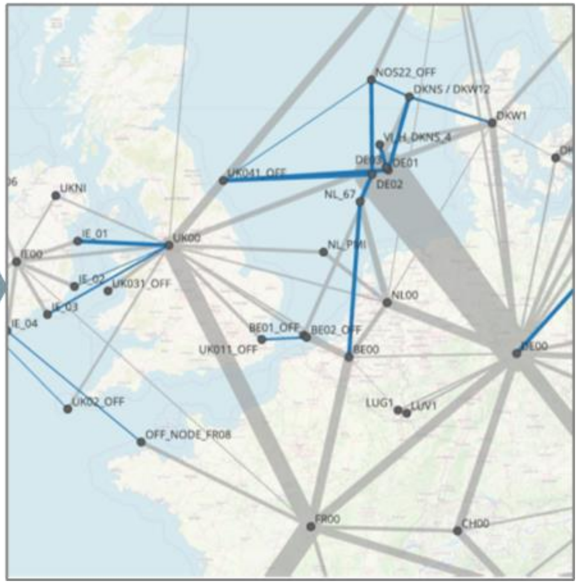


2 *Identification of expansion candidates*

3 *Linear optimisation* **



4 *Post-processing in regional groups*



* 2030 for 2040
2040 for 2050

109 candidates for 2040
268 candidates for 2050

** minimize TOTEX

*** check plausibility and adjust

ONDP 2024: choice of the Scenario

What happened since the last exchanges with the SDC?

Advantages:
- Models are ready and available
- Independency from TYNDP24 timeline
- no break in narrative between 2040 and 2050;

Attention points:
- Coherency of the ONDP (T22) and Scenarios (T24)
- Integration with the IoSN might be more challenging as the IoSN builds on
  - the MSs offshore targets (via T24 Scenarios)
  - ONDP infrastructure outcomes (T22 models)

=> **Good communication will be needed.**

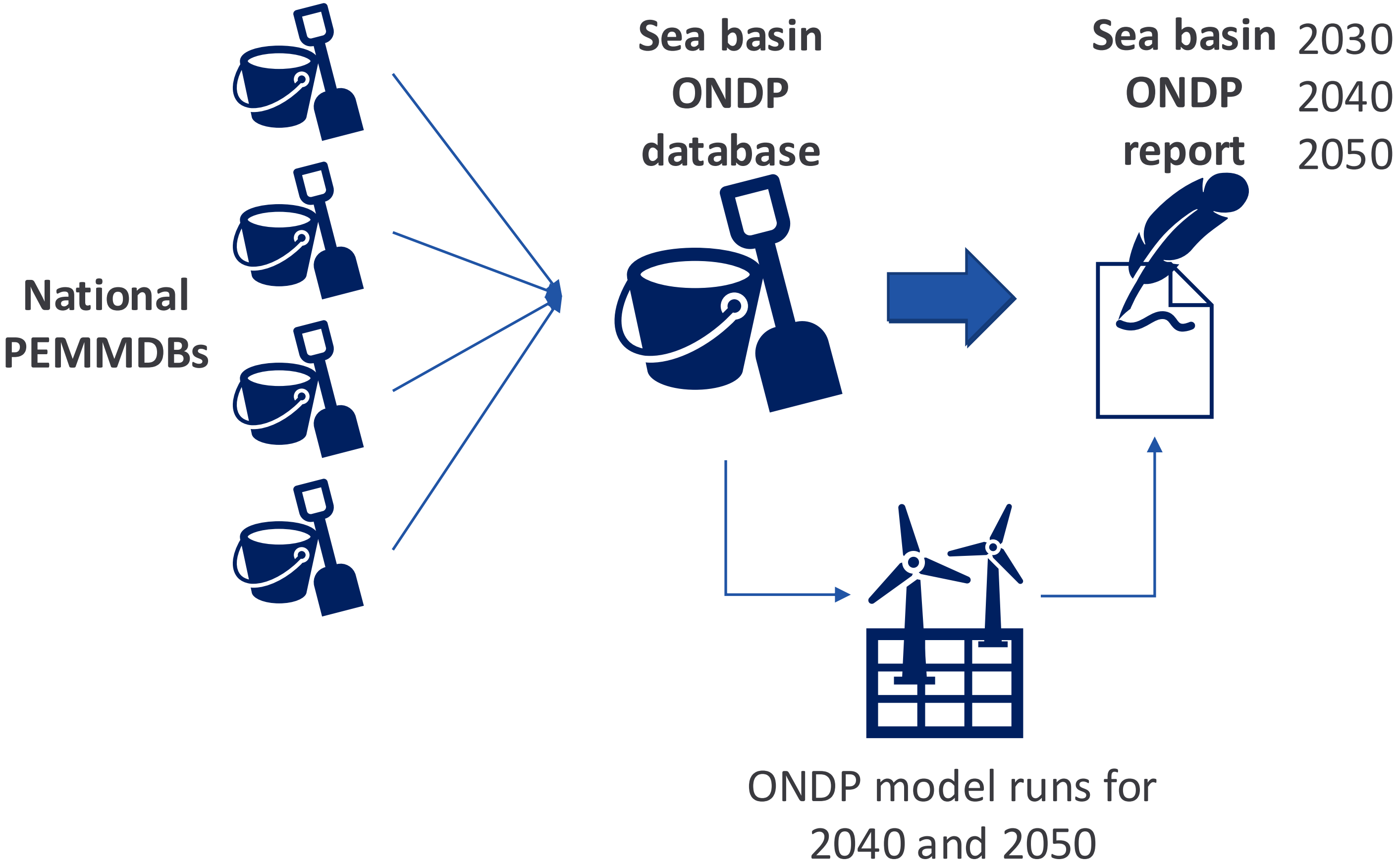
✗
- NT+2030 → 2030 ONDP
- NT+2040 → 2040 ONDP
- $DE2050_{ONDP}$ → 2050 ONDP

✓
- NT+2030 → 2030 ONDP
- TYNDP22 DE2040 → 2040 ONDP
- TYNDP22 DE2050 → 2050 ONDP

Data gathering and Model Preparation

The first step is to ensure that adequate data on offshore are available, and that the T22 model is updated

The PEMMDB is the starting place to gather the data on offshore capacities. However, as the **reports should be drafted per sea basin**, the data from the different PEMMDBs should be grouped in order to understand which infrastructure is relevant per each basin, in the different timeframes.

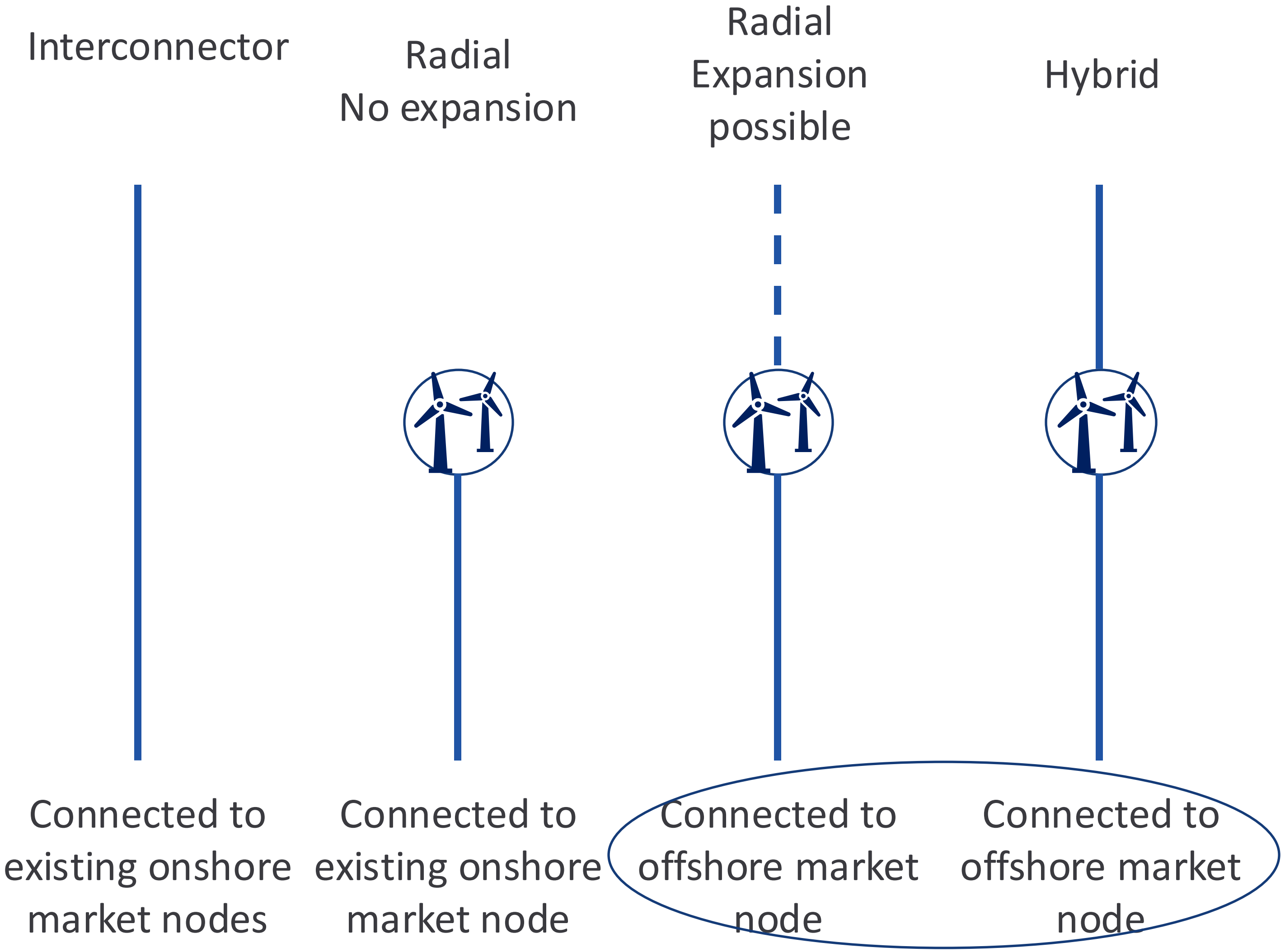


The ONDP databases, are being filled by RG members, each per the respective country, with the data on offshore generation and transmission infrastructure.

The data included will be the basis for the reports, and the related supporting modelling

Data gathering and Model Preparation

The offshore generation nodes was “mounted” on top of the existing model, based on the node-list provided by RGs



The ONDP databases have dedicated sheets to gather information i) on generation capacities and ii) transmission infrastructure, (to define how the generation nodes are initially connected).

In parallel to the data-extraction from the PEMMDB, RG should also **define the list of generation nodes in each sea basin.** The objective of the expansion loop is to find and size the infrastructure connecting these offshore generation nodes and the size of connections the onshore system.

Candidates were selected with 2 criteria

1) Geographical proximity of the nodes
2) Direct interest from TSOs

Central model runs for 2040 and 2050 ONDPs

An expansion loop based on linear optimization can offer a suitable approach, compliant with the expected level of detail of the results.

Aggregation criteria for the starting offshore grid

- Offshore nodes include both hybrid and radial connections (available for expansion)
- Transmission infrastructure of the hybrid projects, expandable radial connections and interconnectors

Costs composition

- CAPEX of the investment option
- Expectation of OPEX

Approximations

- Variables representing branches are continuous variables
- Power flows in the network lines obey Kirchhoff's first law only
- Only uncertainties relating to consumptions and availability of generation units are considered.

PROS

- Fast
- Versatile
- Level of detail matching the needs of the mandate

CONS

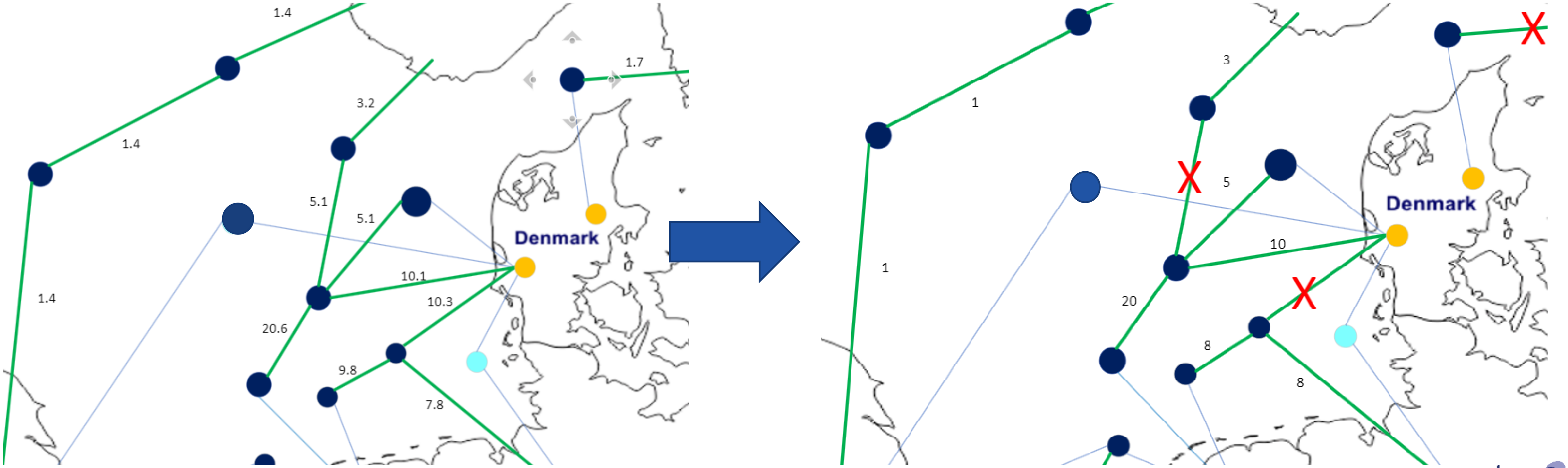
- Costs of infrastructure do not grow linearly with size
- No onshore reinforcement assessment *(either method in this edition)*

Post processing of the outcomes and drafting of the reports

The reports will be drafted starting from the content of the PEMMDB/ONDP databases (2030) and the outcomes of the simulations (2040 and 2050).

The post processing of the results from the modelling runs have two main targets

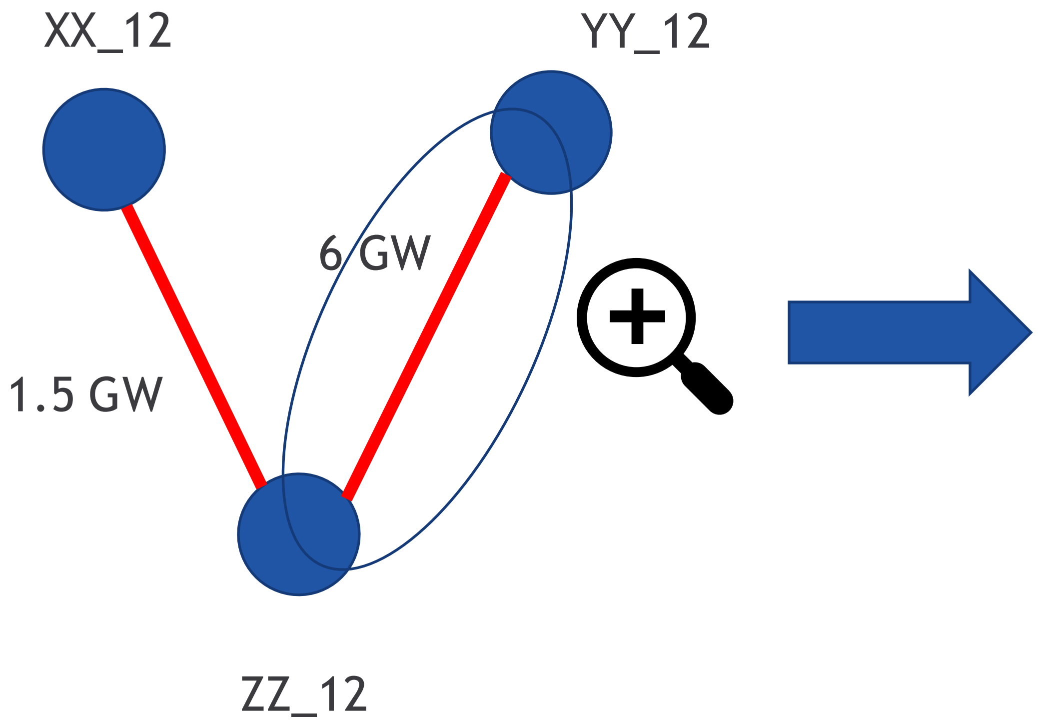
1. Assess which new connections make sense
2. Assess the size of the corridors, do a sanity check, eventually adjust them to discrete values



Step 3 – Post processing of the outcomes and drafting of the reports

The post processing of ONDP simulations delivered a list of offshore candidates for the IoSN2024, which will integrate the offshore methdology tested during the 2022 process.

Each corridor found offer a base to assess the possibility to investigate investment candidates in the IoSN 2024. The target is to limit the number of candidates to the ones that really make sense, ensuring a manageable running time for the IoSN model.



Project name	Border	NTC (A-> B)	NTC (B->A)
Project 1	ZZ_12-YY_12	2000 MW	2000 MW
Project 2	ZZ_12-YY_12	1500 MW	2000 MW
Project XXX	ZZ_12-YY_12	2000 MW	2000 MW
…	…	…	…

IoSN 2022 offshore methodology

1 - Why this study into IoSN framework ?

IoSN aims to show where action is needed by 2040 to ensure continuous access to electricity throughout Europe

Some of the identified needs are already covered by concrete TYNDP interconnector projects

In 2022 there were 93 GW of needs identified between 2025 and 2040, transmission projects currently under conception or development address about 43 GW (on some borders, more than one project compete sometimes to address the same need)

Storage and flexibility were tackled into IoSN T2022

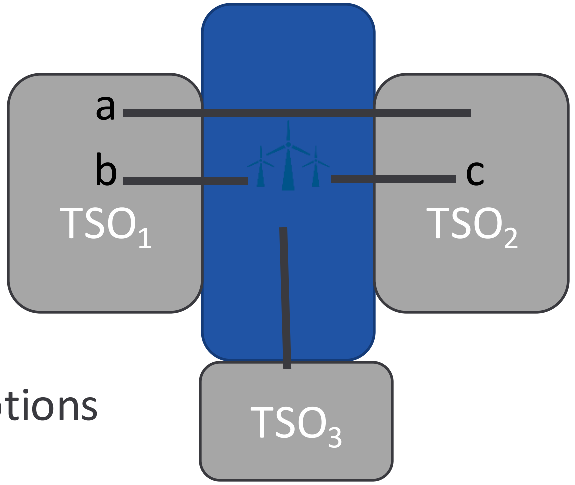
Hybrid projects (interconnector plus Offshore Wind Farm) were not. More projects or conceptual projects pop up in order to fit offshore wind ambitions.

These projects have been considered during IoSN2024.

Technical approach

The methodology was designed in order to integrate hybrid projects based on :

- Antares and Plexos optimisation tool
- **NTC reference grid of NT 2040** scenario of TYNDP 2020 with some adaptions:
  - Update of installed offshore capacities according to TYNDP 2022 NT 2040 values
  - Onshore grid NTC update according to results of IoSN 2030 of TYNDP2020 but without update on offshore borders (candidates to be examined, see map next slide)
- OWF are radially connected (based on bottom up scenario -> IoSN)
- Standard costs in order to be able to test the methodology
- Standard connection on Offshore Wind Farm
- Many candidates were given as input for optimiser
  - Direct interconnectors (IoSN)
  - Hybrid projects
  - Multiple links
  - Links between 2 offshore farms
- In order to strengthen our methodology, we did sensitivity calculations on cost assumptions

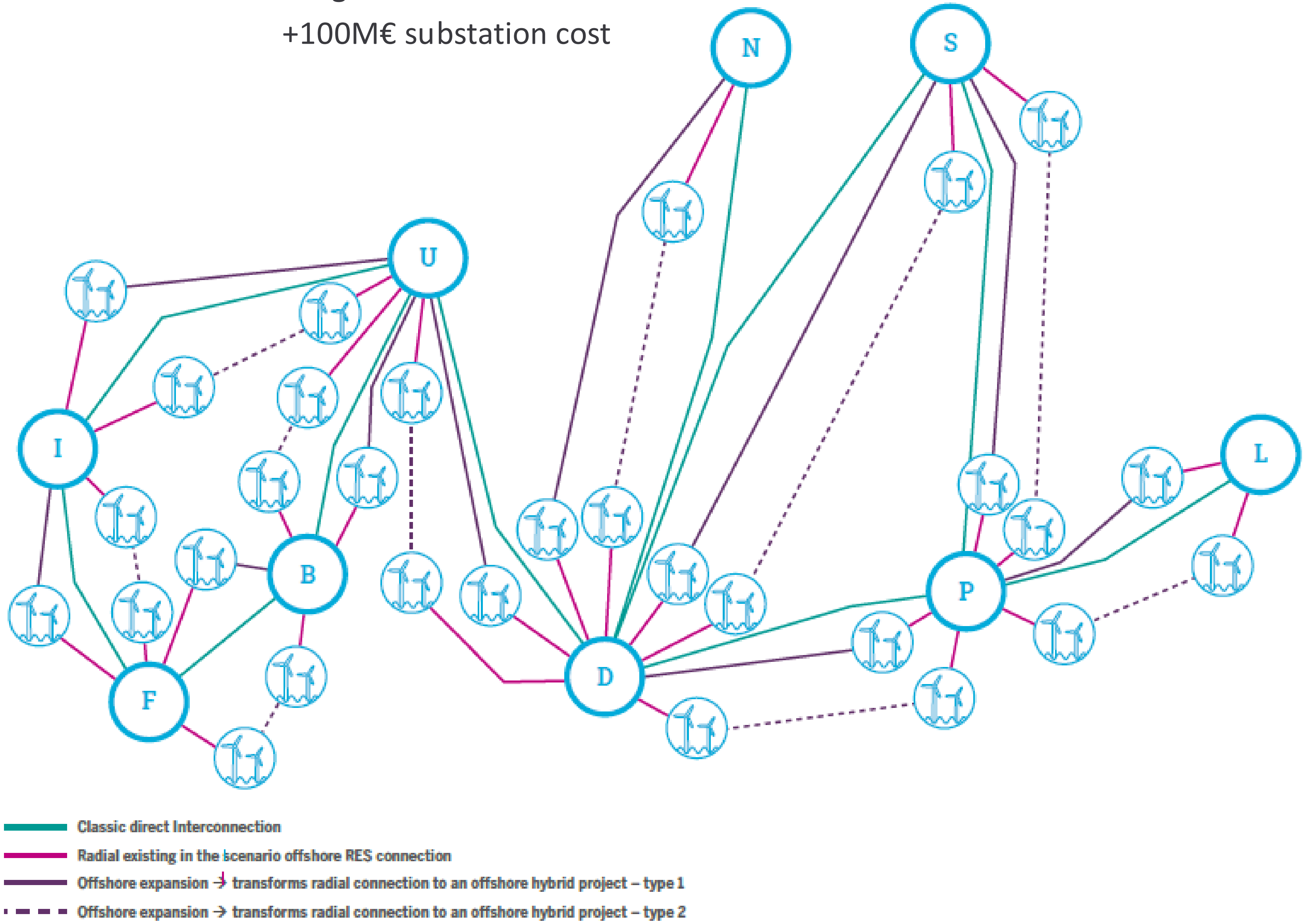


Candidates selection

Standard Candidates

- 2 GW
- 4 M€/km
- Length x 1.2 + 2 x 20km for onshore route
- +100M€ substation cost

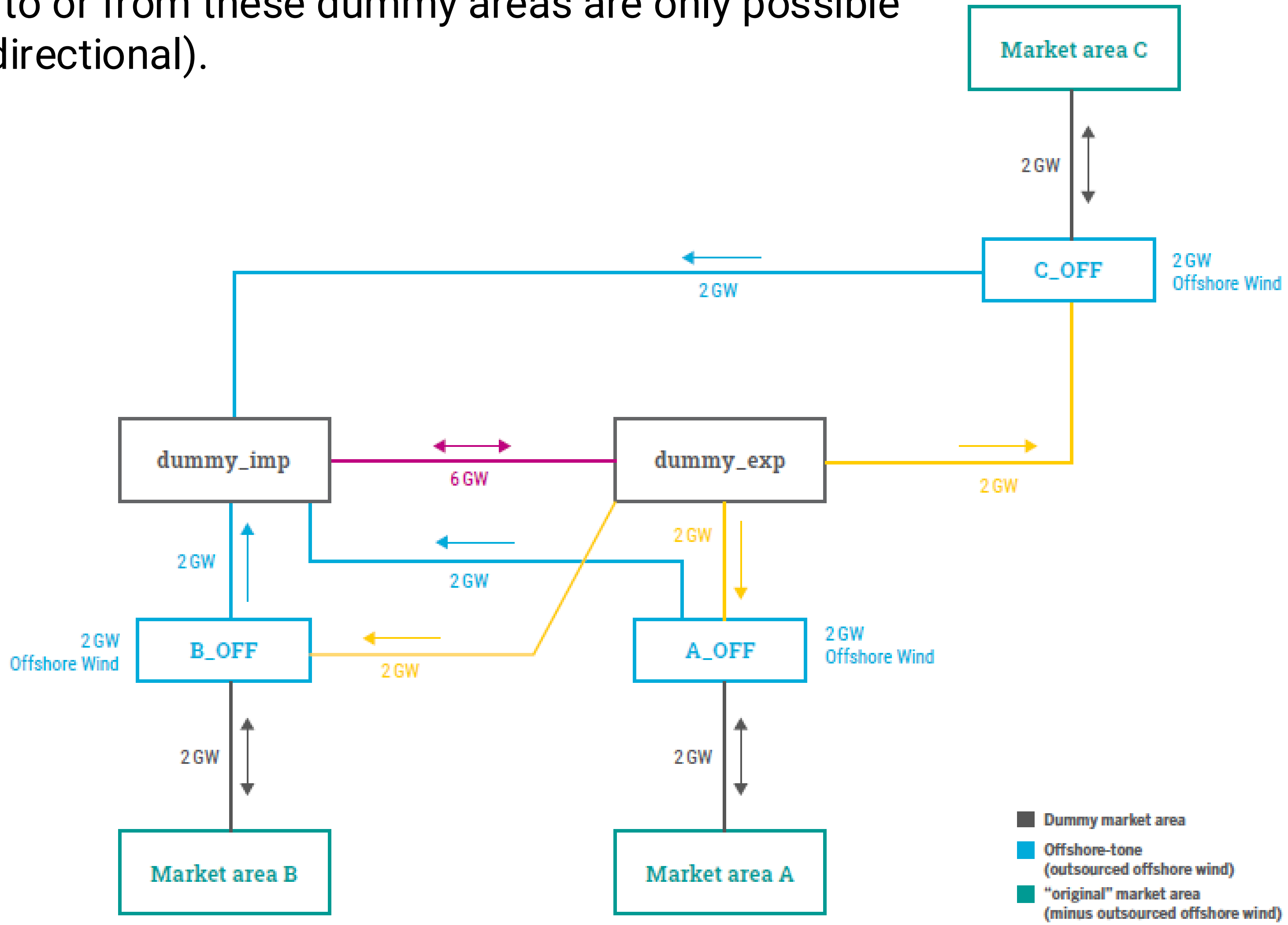
It is assumed that for hybrid projects, the **offshore RES is already radially connected** to one market area in the reference case (red lines). To assess the benefits of hybrid infrastructure compared to point-to-point interconnectors (green lines), an alternative connection candidate between the offshore RES and the second market area (purple line) is defined for each border.



What to do if I want to include a hub but I don't know through which configuration?

Two dummy market node areas are created: "dummy_imp" and "dummy_exp", which have zero load and zero generation capacity. Flows to or from these dummy areas are only possible in one direction (blue and yellow lines are uni-directional).

The bi-directional red line between the two dummy areas represents the single candidate for the whole project. By adding the purple line, **flows between the three market areas A, B and C become possible**. Without the red line, each offshore zone can only feed in its respective "home country", and flows between the different market areas are not possible. In the example shown, the overall capacity of the offshore hub is 6 GW (3 x 2 GW).



Calculations and sensitivities

Components of CAPEX	value
Sea cable line [M€/km]	4
Land cable line [M€/km]	4
Offshore AC/DC converter station [M€]	1000
Onshore AC/DC converter station [M€]	600
Expanding the platform per single new cable connection [M€]	100

The result of the optimisation is a list of candidates to be invested in that minimises the overall generation costs. Looking at each border, different results are possible. Either only the interconnector project or only the hybrid project were selected by the optimiser, or both were selected or none of them.

Case	Description
Base Case	**4M€/km** **+ 100 M€** additional cost for hybrid projects to be "multi-terminal-ready" (equal to 10% of substation cost)
Cost Sensitivity 1	**1.8 M€/km** for subsea cable (instead of 4 MEUR/km) - based on ACER report,
Cost Sensitivity 2	assuming **+20% of cost offshore converter** (**200 M€**) for hybrid asset, instead of 10% (100 M€)
Cost Sensitivity 2a	assuming **+30% of offshore converter cost** (**300 M€**) for hybrid asset, instead of 10% (100 M€)
Cost Sensitivity 3	**-10%** decrease of overall cost = capex
Cost Sensitivity 4	**+10%** on the overall cost = capex

The common core is still the same; the needs remain regardless of the fluctuations in prices. The results of the optimiser are stable, whatever the price.

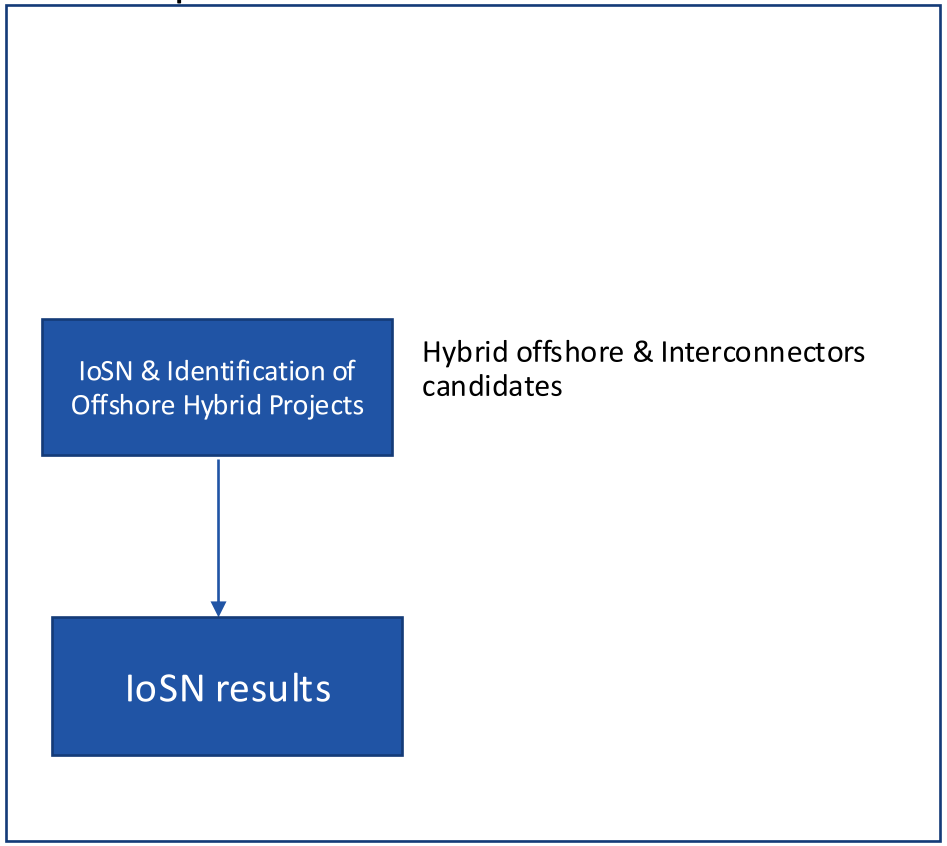
Components of CAPEX	CAPEX sensitivity					
Scenario	base	sens1	sens2	sens2a	sens3	sens4
Sea cable line [M€/km]	4	1.8	4	4	−10 %	+10 %
Land cable line [M€/km]	4	1.8	4	4		
Offshore AC/DC converter station [M€]	1000	1000	1000	1000		
Onshore AC/DC converter station [M€]	600	600	600	600		
Expanding the platform per single new cable connection [M€]	100	100	200	300		

Base case is equal to case 4, case 2 and case 2a. Therefore, we can conclude that an increase of 10 % of CAPEX or + 20 % / 30 % additional converter cost had no effect. Moreover, case 3 and case 1 provide one more project compared to base case. Therefore, a decrease of 10 % allows one more project

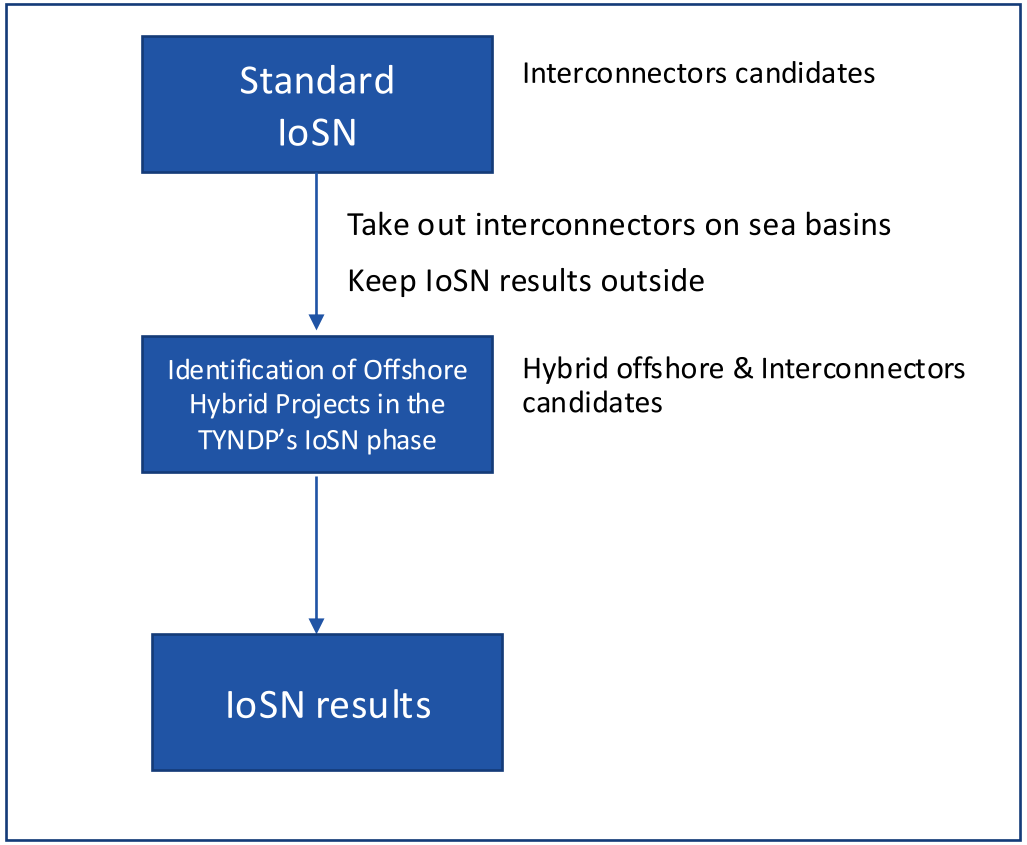
Built candidate	Type	Sensitivity scenario						Number of occurrences
		base	sens 1	sens 2	sens 2a	sens 3	sens4	
OFF_Doff – S_Off	HA.3	1	1	1	1	1	1	6
OFF_Doff – U_Off	HA.3	1	1	1	1	1	1	6
OFF_D-N	HA.1	1	1	1	1	1	1	6
OFF_I-U	HA.1	1	0	1	1	1	1	5
OFF_K-N	HA.1	0	1	0	0	0	0	1
OFF_F-S	HA.1	0	1	0	0	1	0	2

How to include the methodology in the IoSN?

Option 1



Option 2



Currently not possible to know if option 1 is doable. Further tests are needed.

Simpler approach, but the analysis is not fully integrated

Offshore infrastructure candidates: what to consider?

ONDP is mandated to consider the needs for radials, hybrid, interconnectors hybrid and reinforcements. And H2…

The target of the methodology is to provide a configuration of the system including the optimal mix of offshore assets.