TYNDP 2026 model assumptions and methodology for Infrastructure Gaps Identification, System Assessment and Project-specific Cost-Benefit Analysis

March 9th, 2026

ENTSOG System Development team

Brussels & online

Workshop admin

The **recording** of this session, as well as the **slides** will be published

Please use the **Q&A section** or ask live by raising a **virtual hand.**

Thank you!

Agenda

Topic	Presenter	Time
Introduction	Kacper Żeromski System Development Director	14:35 – 14:40
TYNDP context	Simona Marcu TYNDP Project Manager	14:40 – 14:50
Annex D1 - Implementation Guidelines for project-specific cost-benefit analyses of hydrogen projects	Maria Castro Subject Manager Investment Isabell Kolonko Investment Advisor	14:50 – 15:35
Annex D2 - Hydrogen Infrastructure Gaps Identification methodology	Rafail Tsalikoglou Investment Adviser	15:35 – 16:00
Annex D3 - Hydrogen and Natural Gas System Assessment methodology	Diana Fathelbajanova Modelling Subject Manager Isabell Kolonko Investment Advisor	16:00 – 16:25
Closing	Simona Marcu TYNDP Project Manager	16:25 – 16:30

Each session includes Q&A → please use the Ms. Teams Q&A section

TYNDP acronyms


Picture courtesy of Gaz System

CBAM – Cost-Benefit Analysis Methodology
CD – Curtailed Demand
CDF –2 Week Cold Dunkelflaute
CODH – Cost of Disrupted Hydrogen
DC – Disruption Case
DGM – Dual Gas Model (H_2-NG)
DHEM – Dual Hydrogen Electricity Model
GLE – Gas LNG Europe
GSE – Gas Storage Europe
HDC – Hydrogen Disruption Case
IG – Implementation Guidelines
IGI – Infrastructure Gaps Identification
IL – Infrastructure Level
LICD - LNG and Interconnection Capacity Diversification
MASD - Minimum Annual Supply Dependence
PCI – Project of Common Interest
PMI – Project of Mutual Interest
PS-CBA – Project-Specific Cost-Benefit Analysis
SA – System Assessment
SCN – Scenario(s)
SMR – Steam Methane Reformer
SLID – Single Largest Infrastructure Disruption
SSO – Storage System Operator
TSO – Transmission System Operator
WGV – Working Gas Volume
WTP – Willingness To Pay


Picture courtesy of Gaz System

What is being consulted?

TYNDP 2026 ANNEX D1 - IMPLEMENTATION GUIDELINES FOR PROJECT-SPECIFIC COST-BENEFIT ANALYSIS OF HYDROGEN PROJECTS

Draft version for public consultation

→ Art. 11 of TEN-E Reg.*

TYNDP 2026 ANNEX D2 – HYDROGEN INFRASTRUCTURE GAPS IDENTIFICATION METHODOLOGY

Draft version for public consultation

→ Art. 13 of TEN-E Reg.

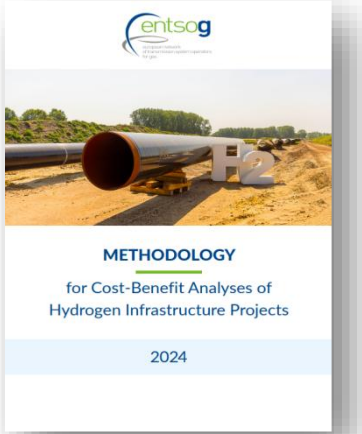
TYNDP 2026 ANNEX D3 – HYDROGEN AND NATURAL GAS SYSTEM ASSESSMENT METHODOLOGY

Draft version for public consultation

→ Art. 26, 32 of Reg. 2024/1789 (methane)
→ Art. 59, 60 of Reg. 2024/1789 (hydrogen)

Complementing:

+



Stakeholder consultation between 9-31 March 2026

Approved by the EC in February 2025

*Reg. EU 2022/869

TYNDP 2026 cycle-specific

cross-cycle

Guidance documents under consultation between 9-31 March

The documents are available on the ENTSOG website:

ENTSOG TEN-YEAR NETWORK DEVELOPMENT PLAN 2026

- Public consultation on draft Annex D
  - Draft Annex D - Guidance documents
    - Draft TYNDP 2026 Annex D1 - Implementation Guidelines
    - Draft TYNDP 2026 Annex D2 - Infrastructure Gaps Identification methodology
    - Draft TYNDP 2026 Annex D3 - System Assessment methodology

Two stakeholder events support the consultation:

- **9 March**: webinar, 14:30-16:30 CEST (hybrid)
- **23 March**: live Q&A, 13:00-14:00 CEST (online)

Please reply to the consultation by filling-in this online form. The questionnaire coves:

- **Annex D1 - Implementation Guidelines** for project-specific cost-benefit analyses (PS-CBA) of hydrogen projects
  → 15 questions: infrastructure levels, benefit indicators, sensitivities, weather scenarios, etc.
- **Annex D2 - Hydrogen Infrastructure Gaps Identification** methodology
  → 7 questions: target years, weather scenarios, assumptions for IGI indicators, etc.
- **Annex D3 - Hydrogen and Natural Gas System Assessment** methodology
  → 5 questions: infrastructure levels, repurposing indicators, etc.

See the Guidance Documents stakeholder events page and stakeholder consultation press release.

TYNDP Context

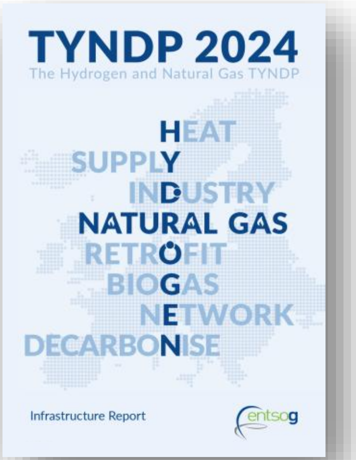
What is the TYNDP in practice?

In line with the previous cycle, TYNDP 2026 consists of:

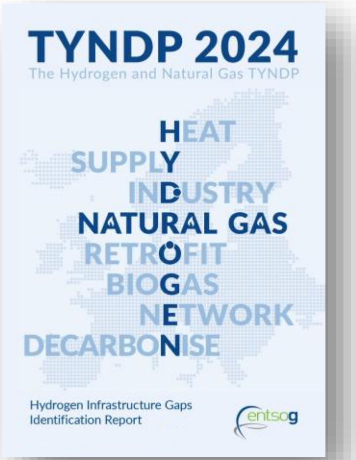
- 4 main reports*:

Annex D – perimeter of application:

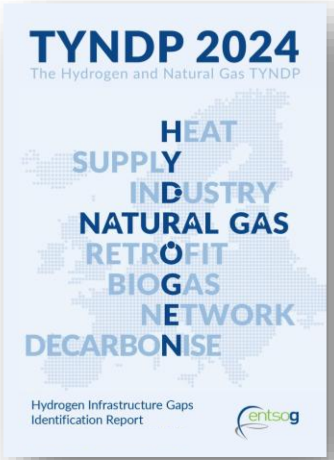
(1). Scenarios



(2). Infrastructure



(3). Infrastructure Gaps identification H_2



(4). System Assessment H_2 and NG

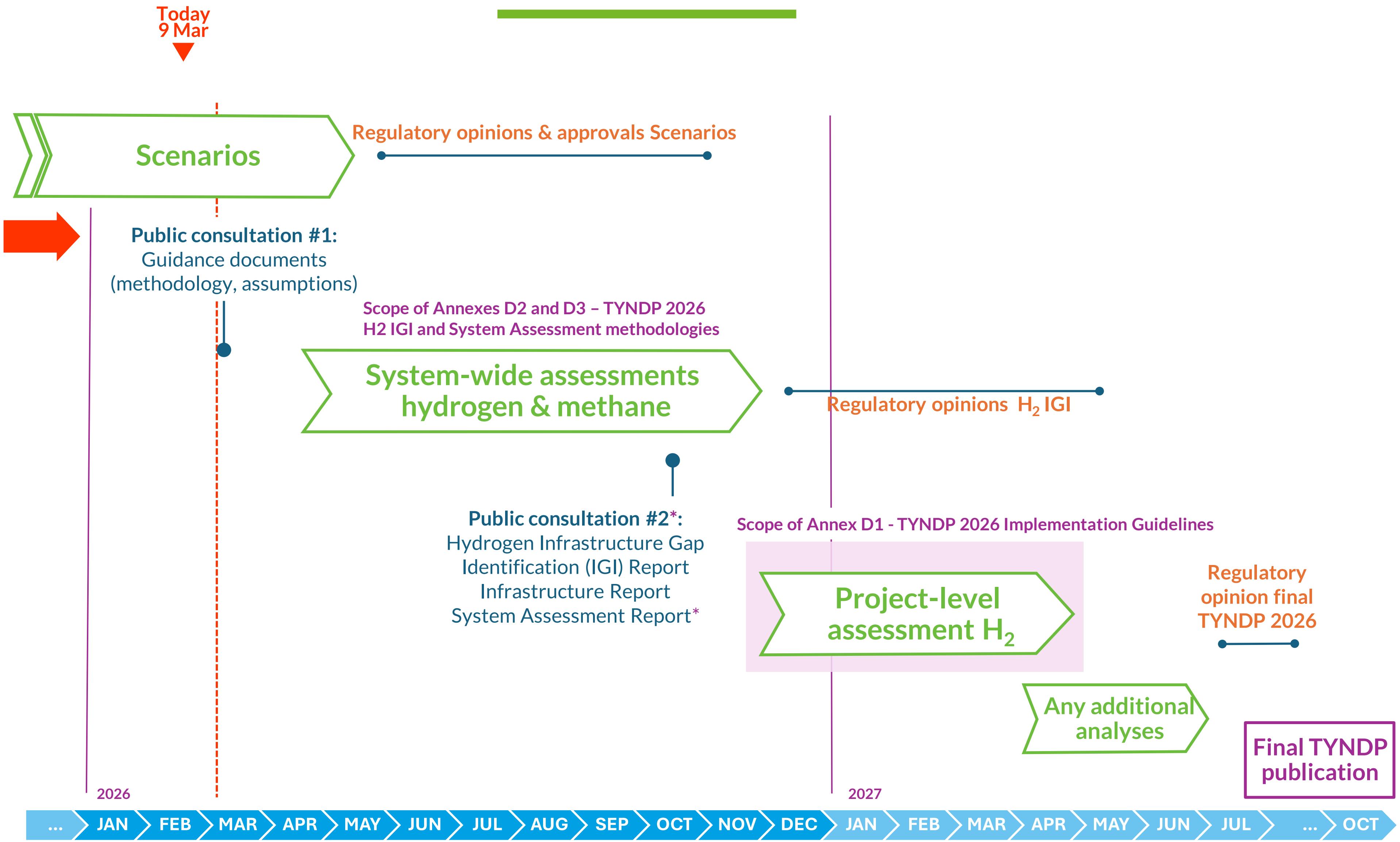
+ Project-specific CBA

- 5 annexes:
  - **Annex A** – Project details
  - **Annex B** – Infrastructure Maps
  - **Annex C** – Topology & Capacities
  - **Annex D** – Methodologies
  - **Annex E** – Analysis tables
- A visualization platform

*Representation illustrative - most recent available reports

Follow www.entsog.eu/tyndp and www.entsog.eu/scenarios

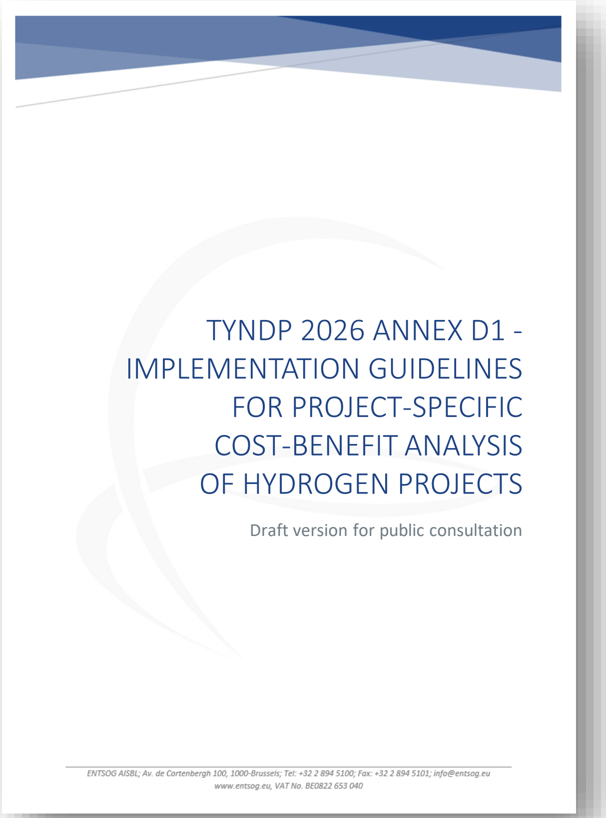
Annex D in ENTSOG's TYNDP 2026 timeline



*The System Assessment report may be consulted together with or separately from the other reports.

Annex D1 - Implementation Guidelines for project-specific cost-benefit analyses of hydrogen projects

Annex D1: Overview


TYNDP 2026 ANNEX D1 - IMPLEMENTATION GUIDELINES FOR PROJECT-SPECIFIC COST-BENEFIT ANALYSIS OF HYDROGEN PROJECTS

Draft version for public consultation

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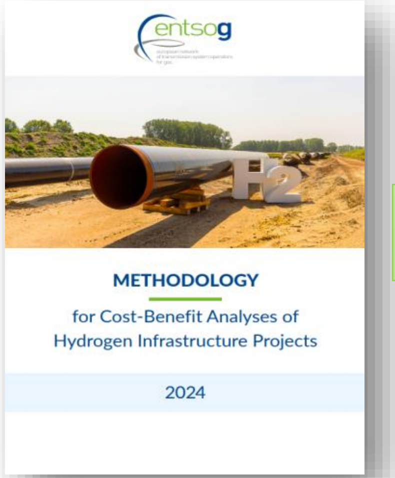
1. **Introduction**
2. **Modelling** (Model description, Hydrogen Infrastructure Level(s), Target Years, Weather Years, Market Assumptions)
3. **Project assessment**
   - ✓ Project grouping
   - ✓ PS-CBA general principles
   - ✓ Benefit indicators
   - ✓ Other elements (environmental impact, climate adaptation measures)
   - ✓ Project costs
4. **Economic performance indicators**
5. **Sensitivity analysis**
6. **Annexes** (Detailed description of the hydrogen ILs, detail of assumptions (e.g., emission factors, supply potentials, conversion factors, etc.)

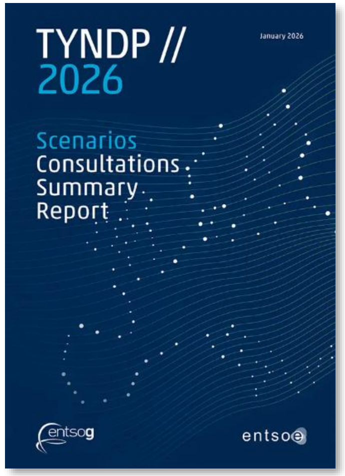
PS-CBA: Interlinkage with other TYNDP/ENTSOG reports

Approved by the EC in February 2025



Single-sector H2 CBAM

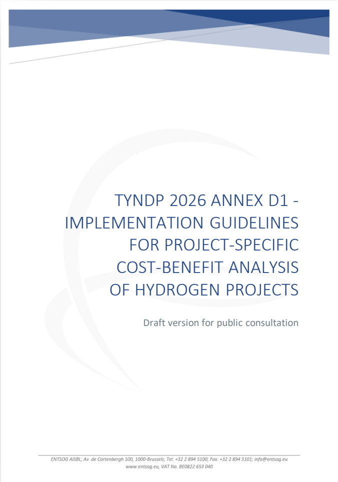
Under development



Draft TYNDP 2026 Scenario Report (Q2 2026)

Scenario Methodology (July 2025)

Currently consulted

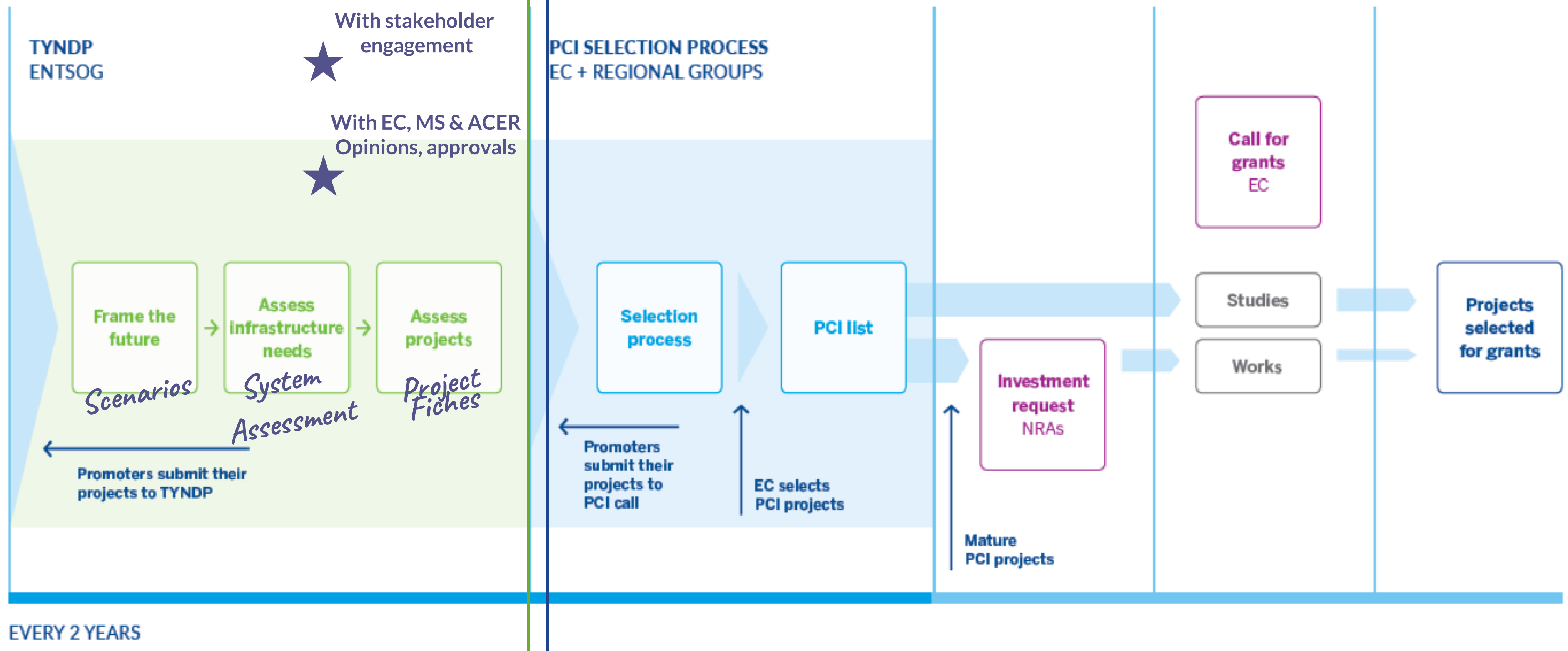


Annex D1:

Hydrogen PS-CBA Implementation Guidelines for TYNDP 2026

Project Specific Cost-Benefit Analysis

The TYNDP process in the wider TEN-E framework



Every two years ENTSOG & ENTSO-E **plan, assess and test** the infrastructure against **possible futures**

The **EC and regional groups attribute PCI or PMI status** to a list of candidate projects, considering their **contributions to covering the system needs** identified in the TYNDP.

Inputs to the analysis: Scenario

- Proposed scenario for PS-CBA assessment is National Trends+ 2035 and National Trends+ 2040 as described in ENTSOG's and ENTSO-E's joint draft TYNDP 2026 scenario documents
  - Contains data on capacities, costs, efficiencies, electricity generation assets, hydrogen production assets, energy storages, demand, extra-EU hydrogen supply potentials etc.

Market Assumptions in the DHEM

Table 1: Summary of the market assumptions considered by DHEM for TYNDP 2026 PS-CBA process.

Market assumption		2030	2035[17]	2040	Description
Assumed ETS price (unit: €/t $CO_{2\,eq}$)		97.5	197.5	297.5	Costs for covered GHG emissions under the ETS.
Fuel prices (unit: €/GJ)	Nuclear	**0.6**	0.6	**0.6**	EU-price per fuel
	Natural gas	**9.2**	9.8	**10.4**	
	Blended gas	**9.6**	9.4	**11.8**	
	Light oil	**18.3**	19.5	**20.7**	
	Heavy oil	**15.0**	16.0	**17.0**	
	Hard coal	**4.1**	4.0	**3.9**	
	Lignite (G1[18])	**1.9**	1.9	**1.9**	Lignite price per region
	Lignite (G2[19])	**2.4**	2.4	**2.4**	
	Lignite (G3[20])	**3.1**	3.2	**3.1**	
	Lignite (G4[21])	**4.1**	4.1	**4.1**	
Hydrogen Supply Potentials (unit: TWh/y (GCV))	Algeria	0.000	29.146	57.938	The maximum extra-EU hydrogen supply potentials to Europe in the NT+ scenario
	Ukraine	25.134	25.134	38.350	
	Tunesia	61.832	69.974	78.116	
	Ammonia	76.110	137.588	243.906	
	Morocco	0.000	0.000	31.388	
	Total	163.08	261.84	449.70	

Based on Market Assumptions for DHEM in the draft Annex D1, p. 16

Pending values for Market Assumptions:

- Hydrogen import prices (unit: €/MWh*H2*)
- Hydrogen production prices (unit: €/MWh*H2*)
- $CODH_{H2}$ (unit: €/MWh_{H2})

Q19: Do you support to use the ***market assumptions*** *listed in the draft TYNDP 2026 Implementation Guidelines (section 2.7 of Annex D1, for the DHEM)?*

Target years for PS-CBA

– Given the projects’ characteristics derived from the TYNDP 2026 project collection, the target years for PS-CBA will be **2035** and **2040**

Simulation cases overview – ENTSOG’s proposal

IGI & SA: for standard and stressful climate scenarios:

IGI								
Target-year/ Scenario & IL	NT+ PCI/PMI	NT+ Adv	NT+ PCI/PMI Unlimited (4 cases*)	NT+ Adv Unlimited (4 cases*)	HE scenario PCI/PMI	HE scenario Adv	LE scenario PCI/PMI	LE scenario Adv
2030	Yes	Yes	Yes	Yes	-	-	-	-
2035	Yes	Yes	Yes	Yes	TBD	TBD	TBD	TBD
2040	Yes	Yes	Yes	Yes	TBD	TBD	TBD	TBD
2050	TBD	TBD	TBD	TBD	-	-	-	[illegible]

SA: 2 Scenarios: Russia minimised and No Russia

* Unlimited pipeline[illegible]torage, import capacities + combi[illegible]n

SA**												
Target-year/ Scenario & IL	NT+ PCI/PMI H2 Low NG	NT+ PCI/PMI H2 Adv NG	NT+ Adv H2 Low NG	NT+ Adv H2 Adv NG	HE PCI/PMI Low NG	HE PCI/PMI H2 Adv NG	HE Adv H2 Low NG	HE Adv H2 Adv NG	LE PCI/PMI Low NG	LE PCI/PMI H2 Adv NG	LE Adv H2 Low NG	LE Ad[illegible]2 Ad[illegible]NG
2030	Yes	Yes	Yes	Yes	-	-	-	-	-	-	-	-
2035	Yes	Yes	Yes	Yes	TBD	TBD	TBD	TBD	TBD	TBD	TBD	T[illegible]
2040	Yes	Yes	Yes	Yes	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TB[illegible]
2050	TBD	TBD	TBD	TBD	-	-	-	-	-	-	-	-

PS-CBA (2 yrs max)	
Target-year/ Scenario & IL	NT+ PCI/PMI
2030	-
2035	Yes
2040	Yes
2050	-

**For each selecte[illegible]ase: 1 DC, 1 2WDF and 32 DC SLID simulations

H2 IGI - Hydrogen Infrastructure Gaps Identification
HE, LE – High / Low economic variant
IGI – (Hydrogen) Infrastructure Gaps Identification
NT+ – National Trends+
SA – System Assessment

Attention to multiplication of cases vs time available

PS-CBA (2 yrs max)	
Target-year/ Scenario & IL	NT+ PCI/PMI
2030	-
2035	Yes
2040	Yes
2050	-

Q10: The methodology covers the two **planning horizons.** Do you consider the choice of target years as appropriate and relevant?

Weather Scenario (SCN 2026)

- Combines **historical weather datasets** with **future climate projections** from Coupled Model Intercomparison Project (CMIP6) from the Copernicus database.
- Ensures long-term energy system assessments reflect climate-driven impacts on renewables and temperature-sensitive demand.

Data sources

- Weather years drawn from PECD 4.2, using:
  - Climate pathway SSP2-4.5
  - Three climate models: CMR5, ECE3, MEHR
- Produces **30 candidate climate years per target year** (10-year window × 3 models).

30 candidate climate-year series → filtered to **3 representatives** through a multi-stage statistical filtering

Weather Scenario (ENTSOG PS-CBA)

Purpose & outcome

- Provides a **robust climate basis** for TYNDP 2026.
- Ensures scenarios reflect a **realistic range** of future weather conditions and uncertainty.

Weather scenarios (in PS-CBA) per target year

- Base case: **least stressful climate scenario**
- Stressful case: **most stressful climate scenario**

Target Year	Base Case	Stressful Case
2035	WS059	WS037
2040	WS065	WS077

Q11: Do you consider the ranges defined by the "base" and "stressful" weather scenarios as sufficient to capture the range of climatic uncertainty relevant to long-term infrastructure planning?

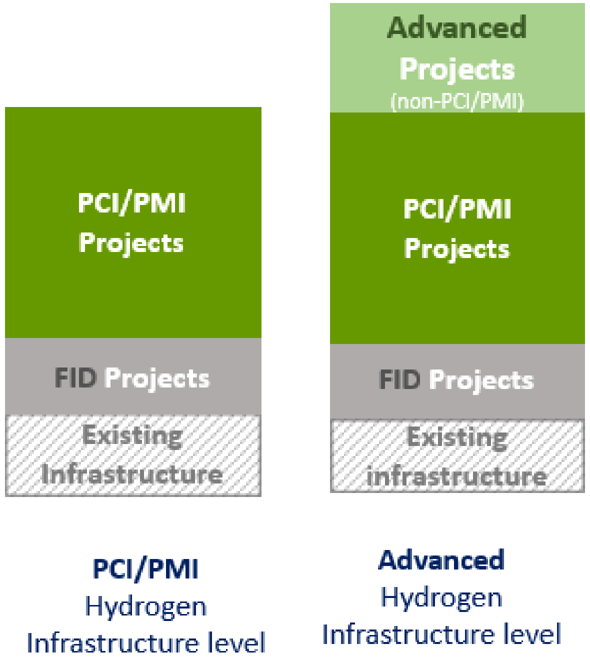
Inputs for PS-CBA: Infrastructure levels

Hydrogen infrastructure for DHEM contains a subset of the projects submitted by project promoters during the TYNDP 2026 Project collection, published in the **TYNDP 2026 Annex D implementations Guidelines (Annex I)**

Such a subset is called **infrastructure level** and is defined by the following criteria:

- **PCI/PMI Hydrogen infrastructure level:**
  - contains existing infrastructure, FID projects and projects that are part of the 7th PCI/PMI Union list(*) as detailed in section B of the Annex VII to the TEN-E Regulation.
- **Advanced Hydrogen infrastructure level:**
  - Contains PCI/ PMI Hydrogen infrastructure level plus advanced projects (Advanced maturity status for hydrogen projects is defined in the TYNDP 2026 Guidelines for project inclusion)

- The PS-CBA can be based on **one** out of two defined infrastructure levels
- Selected Infrastructure level will be defined based on the outcome of the public consultation and EC feedback



(*) Currently adopted as delegated act

Grouping: General principles

PS-CBA groups will be drafted by ENTSOG with following grouping principles:

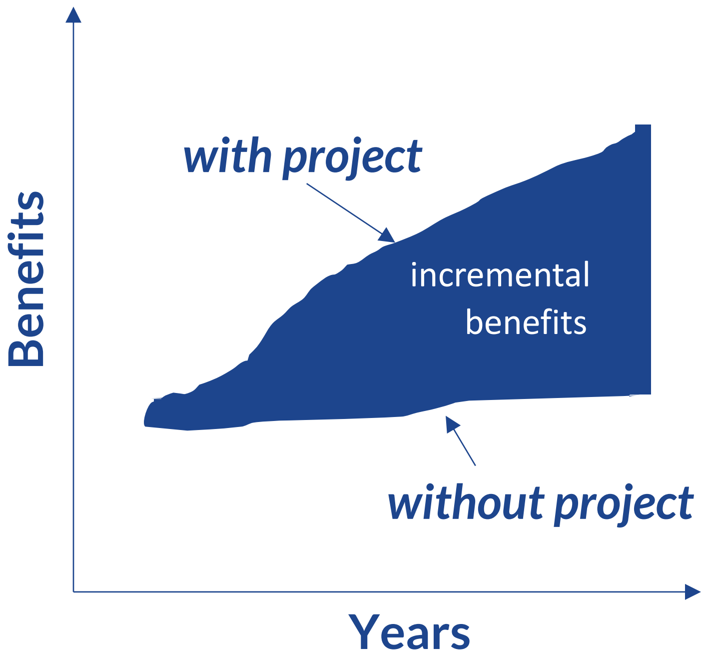
- At minimum, the transmission projects on both sides of a boarder that jointly form an interconnector must be grouped together
- At minimum, a hydrogen reception terminal and its connecting pipeline to the hydrogen grid must be grouped together
- At minimum, a hydrogen storage and its connecting pipeline to the hydrogen grid must be grouped together.
- Enabled projects to be grouped together with its enabling project
- Enhancer projects to be grouped with the enhanced project (separate groups to capture incremental benefit)
- Competing project to be grouped separately and as many groups as competing projects identified
- Maximum 5 years difference between commissioning years
- Maximum one stage of advancement apart(*)

Final project groups will be shared with project promoters after validation by EC and ACER

(*) Except for enabling and enabled projects under consideration (only grouped within same advancement level)

Incremental approach

- PS-CBA estimates benefits associated with the project by **comparing** two situations: **“WITH the project”** vs. **“WITHOUT the project”** based on the infrastructure level



Legal background

- *TEN-E Regulation*: PCIs‘ and PMIs‘ potential overall benefits must outweigh costs in accordance with specific criteria
  - Specific criteria to meet: **Sustainability** at least one other criterion out of:

    Competition **Market integration** **Security of supply**

  - This requirement is tested with **PS-CBA**
  - PS-CBA results in the form of project fiches will feed into the PCI/PMI selection process

PS-CBA assessment: benefit indicators

Benefit indicators:

B1: GHG emissions variation
CO_2 eq. emissions (Unit: t CO_2 eq/ y)

B2: non-GHG emissions variation
Non-GHG emissions (Unit: t non-GHG emission/ y)

B3.1: Integration of renewable electricity generation
Renewable energy curtailment (Unit: GWh/ y)

B3.2: Integration of renewable and low-carbon H_2
Hydrogen supply (Unit: GWh/y)

B4: Increase of market rents
Market rents (Unit: €/y)

B5: Reduction in exposure to curtailed hydrogen demand
Curtailed H_2 demand (Unit: GWh/y)

TEN-E Criterion
- Sustainability
- Competition
- Market integration
- Security of supply

B1: GHG emissions variations

- Measures the variation of GHG emissions as a result of the implementating a group of projects.
- Considers the change of GHG emissions as a result of:
  - Changing the generation mix in the **electricity sector**
  - Supply sources to meet hydrogen demand in the **hydrogen sector**
  - Reduction of the energy curtailment from the **electricity and hydrogen sector**
- Calculates the GHG emissions by multiplying the usage of electricity generation type, hydrogen production type, hydrogen import options
- Calculated for the reference climate years
- Proposed emissions factors consider direct GHG emissions (at least CO_2, CH_4, N_2O) from stationary combustion
- Emissions factors are included in the Annex III of the document

Q14: Do you consider the European Investment Bank values for the ***societal cost of carbon*** *appropriate for the calculation of the* ***GHG emissions variations indicator (B1)*** *in the TYNDP 2026 PS-CBA as proposed in the draft TYNDP 2026 Implementation Guidelines?*

B1: GHG emissions variations

$$\Delta GHG\ emissions\ enabled\ by\ (group\ of)project(s)$$
$$= \Big(\sum_i^n (power\ generation_{i,with\ (group\ of)project(s)} * CO_{2-eq} emission\ factor_i) + \sum_j^m (hydrogen\ production_{j,with\ (group\ of)project(s)}$$
$$* CO_{2-eq} emission\ factor_j) + \sum_l^r (hydrogen\ import\ from\ supply\ potential_{l,with\ (group\ of)project(s)} * CO_{2-eq} emission\ factor_l)$$
$$+ \sum_i^s (Curtailed\ energy_{i,with\ (group\ of)project(s)} * CO_{2-eq} emission\ factor_i)\Big)$$
$$- \Big(\sum_i^n (power\ generation_{i,without\ (group\ of)project(s)} * CO_{2-eq} emission\ factor_i) + \sum_j^m (hydrogen\ production_{j,without\ (group\ of)project(s)}$$
$$* CO_{2-eq} emission\ factor_j) + \sum_l^r (hydrogen\ import\ from\ supply\ potential_{l,without\ (group\ of)project(s)} * CO_{2-eq} emission\ factor_l)$$
$$+ \sum_i^s (Curtailed\ energy_{i,without\ (group\ of)project(s)} * CO_{2-eq} emission\ factor_i)\Big)$$

This benefit indicator (B1) is monetized as follows:

$$B1_{monetised} = (Societal\ Cost\ of\ Carbon * GHG\ emissions\ variations\ enabled\ by\ (group\ of)project(s)) - total\ GHG\ emission\ costs\ monetised\ in\ B4$$

- Primary output: savings of **tCO_2eq/year**
- Monetised using the Social Cost of Carbon, excluding the GHG emission costs already captured in the B4 indicator (i.e., reflected in the ETS price): **Δ €/year.**

B2: Non-GHG emissions variations

- Captures how the implementation of projects changes the non-GHG emissions
- Considers the change of non-GHG emissions as a result of:
  - Changing the generation mix in the **electricity sector**
  - Supply sources to meet hydrogen demand in the **hydrogen sector**
  - Reduction of the energy curtailment from the **electricity and hydrogen sector**
- Only based on main simulation run of reference weather year in DHEM
- Measures non-GHG emissions (NOx, SO_2, NH_3, PM2.5, PM10 , NMVOC) from electricity generation, hydrogen production, imports Proposed non-GHG emissions factors are included in the Annex IV of the document.
  - Primary output: savings of **tPollutantX/year**
  - Can be monetised with pollutant-specific damage costs: **delta €/year**

Q15: Do you agree that the non-GHG emissions variations indicator (B2) should be monetised? If yes, do you support the usage of the European Environment Agency values for the VOLY cost or the VSL cost to be used for the monetisation?

B2: Non-GHG emissions variations

$$\Delta Non - GHG\ emissions\ enabled\ by\ (group\ of)project(s)_y$$
$$= \Big(\sum_i^n (power\ generation_{i,with\ (group\ of)project(s)} \cdot Non$$
$$- GHG\ ef_{i,y}) + \sum_j^m (hydrogen\ production_{j,with\ (group\ of)project(s)}$$
$$\cdot Non - GHG\ emission\ factor_{j,y}) + \sum_l^r (hydrogen\ import\ from\ supply\ potential_{l,with\ (group\ of)project(s)}$$
$$\cdot Non - GHG\ emission\ factor_{l,y})$$
$$+ \sum_i^s (Curtailed\ energy_{i,with\ (group\ of)project(s)} * Non$$
$$- GHG\ ef_{i,y})\Big)$$
$$- \Big(\sum_i^n (power\ generation_{i,without\ (group\ of)project(s)} \cdot Non$$
$$- GHG\ ef_{i,y}) + \sum_j^m (hydrogen\ production_{j,without\ (group\ of)project(s)}$$
$$\cdot Non - GHG\ emission\ factor_{j,y}) + \sum_l^r (hydrogen\ import\ from\ supply\ potential_{l,without\ (group\ of)project(s)}$$
$$\cdot Non$$
$$- GHG\ emission\ factor_{l,y}) + \sum_i^s (Curtailed\ energy_{i,without\ (group\ of)project(s)}$$
$$* Non - GHG\ emission\ factor_{i,y})\Big)$$

B3.1: Integration of renewable electricity generation

- Captures how the implementation of projects changes the uncurtailed renewable electricity generation
- Only based on main simulation run of base case weather year
- Output: **Energy/year**
  - Not monetised in this indicator

Example

- Case: The hydrogen storage project allows increased usage of renewable electricity production by providing a storage option for renewable energy in the form of hydrogen.
- Non-monetised results of this benefit indicator (B3.1):
  - Variation of renewable electricity generation: +1 TWh/year

B3.2: Integration of renewable and low-carbon hydrogen

- Captures how the implementation of projects changes the integration of renewable and low-carbon hydrogen
- Only based on main simulation run of base case weather year in DHEM
- Considers the sum of electrolytic hydrogen production (considered renewable or low-carbon), blue hydrogen production (considered low-carbon), renewable hydrogen imports (e.g., ammonia, North Africa, etc.),
- Output: **Energy/year**
  - Not monetised in this indicator

Example

- Case: Country A's domestic hydrogen market is already is fully satisfied. As it is not connected to other countries, this is limiting further usage of electrolytic hydrogen production. Country B's hydrogen demand is satisfied with unabated hydrogen production from natural gas. The hydrogen transmission project allows for exports from country A to country B. Thereby, it allows for increased usage of electrolytic hydrogen production in country A. In the importing country B, this reduces the usage of unabated (grey) hydrogen production from natural gas.
- Non-monetised results of this benefit indicator (B3.2):
  - Variation of relevant hydrogen production: +10 TWh/year

B4: Increase of Market Rents

Definition

- Captures changes in market rents resulting from implementing a project or group of projects.

Indicator Calculation

- Sum of short-run economic surpluses for:
    - Consumers
    - Producers
    - TSOs/ congestion rent beneficiaries (TSOs for electricity; producers/consumers/shippers for hydrogen depending on market rules)
    - Cross-sectoral beneficiaries (e.g., electrolysers)
- Covers both **electricity** and **hydrogen** sectors.
- Expressed in **monetized terms (€/year).**

Model Used

- Dual Hydrogen/Electricity Model (DHEM)

*Q16: Do you support that the **increase of market rents indicator (B4)** covers both the electricity sector and the hydrogen sector in the TYNDP 2026 PS-CBA and is thereby aligned with the approach taken by ENTSO-E for the PS-CBA of electricity projects?*

B4: Increase of Market Rents

$$\text{Maximise}(\text{Market rents})$$
$$= \text{Maximise}(R_{el} + R_{H2})$$
$$= \text{Maximise}(R^{el,H2}_{Producer} + R^{el,H2}_{Consumer} + R^{el,H2}_{Grid\ congestion} + R^{el,H2}_{Cross-sector})$$

Producer rent (for electricity or hydrogen)

= Sum of hourly differences between cost of generating or withdrawing energy and the market clearing price multiplied by the quantity of energy produced by a certain production type.

Consumer rent (for electricity or hydrogen

= Sum of hourly differences between price consumers are willing to pay and the market clearing price multiplied by the quantity of energy consumed by a certain consumer type.

Congestion rent (for electricity or hydrogen)

= Sum of hourly differences between market clearing prices at both sides of an interconnection point multiplied by the quantity of energy transported across this IP.

Cross-sector rent (between electricity and hydrogen)

= Sum of hourly differences between (1) market clearing price in one energy system multiplied by the quantity of transferred energy and (2) market clearing price in another energy system multiplied by the quantity of transferred energy after conversion efficiency.

*Q17: When calculating **benefit indicator B4** (i.e., **increase of market rents**), do you support the consideration of cost of hydrogen disruption equal to WTP_{H2}?*

B5: Reduction in exposure to curtailed hydrogen demand

Definition

- Measures the **reduction in curtailed hydrogen demand** (HDC) in a given area due to the implementation of a project or group of projects.

Indicator Calculation

- Calculated using a **more stressful weather year** than the one applied for other benefit indicators.
  - Step 1: DHEM computes HDC (MWh) under the stressful weather year.
  - Step 2: DHEM computes HDC (MWh) under the reference weather year.
  - Step 3: Reference-year HDC is subtracted from the stressful-year HDC to avoid double counting with indicators based on the reference year.
- Can be monetised (€/year) using:
  - Assumptions on the **Cost of Disrupted Hydrogen Demand (CODH)**
  - Assumed **frequency** of stressful weather year occurrence.

Model Used

- Dual Hydrogen/Electricity Model (DHEM)

B5: Reduction in exposure to curtailed hydrogen demand

$$DHDC_{DHEM,reference\ year} = (HDC_{DHEM,European\ Union,reference\ year,with\ (group\ of)\ project(s)} - HDC_{DHEM,European\ Union,reference\ year,without\ (group\ of)\ project(s)})$$

The none-monetised benefit indicator is therefore defined as follows:

$$DHDC_{B5} = MAX(DHDC_{DHEM,stress\ year}) - DHDC_{DHEM,reference\ year}$$

This benefit indicator can then be monetised as follows:

$$B5_{monetised} = CODH * DHDC_{B5} * Probability\ of\ occurence$$

- CODH should reflect the economic damage avoided by preventing hydrogen supply disruptions (distinct from Willingness to Pay, which allows producer surplus).
- For TYNDP 2026, ENTSOG proposes using the maximum 2022 daily electricity price as a provisional CODH; final value will depend on Public Consultation results.

Q20: Do you support that the reduction in exposure to curtailed hydrogen demand indicator (B5) is calculated based on the stressful weather scenario?

PS-CBA assessment: monetisation of benefits

Benefit indicators:

B1: GHG emissions variation
CO_2 eq. emissions (Unit: t CO_2 eq/ y)

B2: non-GHG emissions variation
Non-GHG emissions (Unit: t non-GHG emission/ y)

B3.1: Integration of renewable electricity generation
Renewable energy curtailment (Unit: GWh or % CD)

B3.2: Integration of renewable and low-carbon H_2
Hydrogen supply (Unit: GWh/)

B4: Increase of market rents
Unit: Directly expressed in monetized terms (M€/y)

B5: Reduction in exposure to CD under stress-case Climatic year
Curtailed H_2 demand (Unit: GWh or % CD)

Monetized elements to be considered in the EPI of each PS-CBA group

Monetisation factor:

B1: Shadow cost of carbon(*)
Source: EIB Granularity: Assessed years

B2: Non-GHG emission cost
Source: EEA Granularity: Assessed years

Already monetised as part of B4 indicator

Already monetised as part of B4 indicator

B4: Increase of market rents
Unit: M€/y Source: ENTSOG (IG)

B5: CODH
Source: ENTSOG Granularity: assessed years

(*) Monetization of GHG (B1) **should not consider** the GHG **emissions costs already monetized as part of B4 (avoid double counting)**

Criterion
- Sustainability
- Competition
- Market integration
- Security of supply

Q21: Do you consider the list of ***benefit indicators*** *in the draft TYNDP 2026 Implementation Guidelines as* ***complete and satisfactory?***

PS-CBA assessment: monetisation of benefits

Monetisation factor:

B1: Shadow cost of carbon(*)
Source: EIB Granularity: Assessed years

B2: Non-GHG emission cost
Source: EEA/ENTSO-E Granularity: Assessed years

Already monetised as part of B4 indicator

Already monetised as part of B4 indicator

B4: Increase of market rents
Unit: M€/y Source: ENTSOG (IG)

B5: CODH
Source: ENTSOG Granularity: assessed years

Table 2: Proposed societal cost of carbon for TYNDP 2026 PS-CBA process for simulated years (source: EIB[32]).

Monetization factor (B1)[33]	2035	2040
Proposed societal cost of carbon (published 2024 by EIB) (unit: € /t CO_2-eq)	387.5	525
Proposed societal cost of carbon (factored by Eurostat inflation index 2025)[34] (unit: € /t CO_2-eq)	394.86	534.98

Table 3: Average EU damage cost per tonne of pollutant (source: European Environment Agency[37]).

Pollutant	Average EU damage cost (unit: € (2025)/t pollutant)	
	VOLY	VSL
NO_x	19.09	53.40
SO_2	20.15	47.67
PM 10	64.00	175.46
PM 2.5	107.52	294.78
NH_3	23.61	64.98
NMVOC	2.29	5.57

CODH *(monetization of B5 indicator)*	
Proposed CODH (€)	To be defined after the consultation

Q12: *Do you agree that the non-GHG emissions variations indicator (B2) should be monetised? If yes, do you support the usage of the European Environment Agency values for the VOLY cost or the VSL cost to be used for the monetisation?*

EPI - Economic Performance Indicators

Monetisation factor:

B1: Shadow cost of carbon
Source: EIB — Granularity: Yearly value

B2: Non-GHG emission cost
Source: EEA/ENTSO-E Granularity: Yearly value

B4: Increase of market rents
Source: ENTSOG (IG) — Granularity: 10-years

B5 CODH
Source: tbd (IG) — Granularity: tbd (IG)

Monetised indicators

Costs:

(source: Project promoters)

CAPEX — Unit: M €

OPEX — Unit: M €/ y

Replacement costs — Unit: M €

Costs

Inputs to the EPI

Economic Performance Indicators (EPI)

ENPV – Economic Net Present Value — Unit: M €

EB/C ratio – Economic Benefit/Cost ratio — Unit: n.a.

Assumptions:

- EPI are calculated considering **constant (real) prices**
- Before/After first/last simulated year: **benefits equal to 1st / last simulated year**
- Between simulated years: **linear interpolation**

Economic parameters:

- Basis year for Social Discount Rate: **2025**
- Social Discount Rate: **4%**
- Assessment period: **25 years**
- Residual value: **Not considered**
- Simulated years: **2035** and **2040**

Annex D2 - Hydrogen Infrastructure Gaps Identification methodology

Legal background

- *Regulation on the internal markets for renewable gas, natural gas and hydrogen and TEN-E Regulation: Hydrogen TYNDP shall identify cross-border hydrogen infrastructure gaps to implement the TEN-E priority corridors for hydrogen and electrolysers on the basis of the TYNDP scenarios*
- *Priority corridors:*

Interlinkage between Annex D1 & D2

- Annex D2 - IGI methodology **provides guidance** on the different elements of relevance for the IGI report
- **Cross-references** between Annex D1 - Implementation Guidelines and Annex D2 – IGI methodology

Elements already defined in TYNDP 2026 Implementation Guidelines (Annex D1)

- ✓ General modelling concepts
- ✓ Simulation tools and models to be used
- ✓ TYNDP scenario(s) to be used
- ✓ Infrastructure level serving as counterfactual for gap assessment

Elements not defined in the TYNDP 2026 Implementation Guidelines (Annex D1)

- ✗ Indicators for Identifying infrastructure gaps (Section 5)
- ✗ Threshold values for IGI indicators to determine presence of gaps (Section 5)
- ✗ Methodology to compare results across hydrogen infrastructure levels (Section 6)

Elements defined and not defined in Annex D1, also applicable to Annex D2

Simulation cases in IGI

- **Main differences from TYNDP 2026 Annex D1 – Implementation Guidelines:**
  - Annex D1 models 2035 and 2040 → IGI expands model horizons to include 2030 and 2050*
  - Annex D1 assesses only PCI/PMI H_2 IL, while both hydrogen infrastructure levels (i.e., PCI/PMI H_2 IL and Advanced H_2 IL) are assessed within the TYNDP 2026 IGI report.

*Simulation of 2050 target year is subject to time constraints for TYNDP 2026 process.

Target-year/ Scenario & IL	NT+ PCI/PMI IL	NT+ Advanced IL	NT+ PCI/PMI IL Sensitivity (Unl.)	NT+ Advanced IL Sensitivity (Unl.)
2030	✓	✓	✓	✓
2035	✓	✓	✓	✓
2040	✓	✓	✓	✓
2050*	🔍✓	🔍✓	🔍✓	🔍✓

Consultation question 23: Do you consider this choice of target years appropriate and relevant?

IGI Indicator 1

IGI indicator 1: Hydrogen market clearing price spreads in DHEM

- This indicator is based on:
  - The NT+ scenario
  - The base weather case
  - The objective function of the DHEM

The DHEM produces **hourly hydrogen market clearing prices per hydrogen node.**

The **hourly spread** is the difference between hourly hydrogen market clearing prices of different hydrogen nodes in absolute value.

IGI Indicator 1 thresholds

- **Proposed thresholds for public consultation:**

Threshold 1: A hydrogen market clearing price spread between two Zone 2 nodes of different countries of more than 4 €/MWh_{H2}; OR

Threshold 2: A hydrogen market clearing price spread between two Zone 2 nodes of different countries of more than 20 €/MWh_{H2} for more than 40 days per year.

If one of the two thresholds is passed, an infrastructure gap is identified.

Consultation question 24: Do you support the definition of the IGI indicator 1 as well as the concept and values of its thresholds?

IGI Indicator 2 and thresholds

IGI indicator 2: Curtailed hydrogen demand in DHEM

This indicator is based on:

- The NT+ scenario
- The base weather case
- The objective function of the DHEM

⇨ DHEM measures the **unsatisfied demand** at each individual node

- **Proposed thresholds for public consultation:**

  Threshold: A yearly average hydrogen demand curtailment rate of more than 0 %.

If there is a hydrogen demand curtailment above the threshold, an infrastructure gap is identified.

Consultation question 25: Do you support the definition of the IGI indicator 2 as well as the concept and values of its thresholds?

Presentation of the IGI results

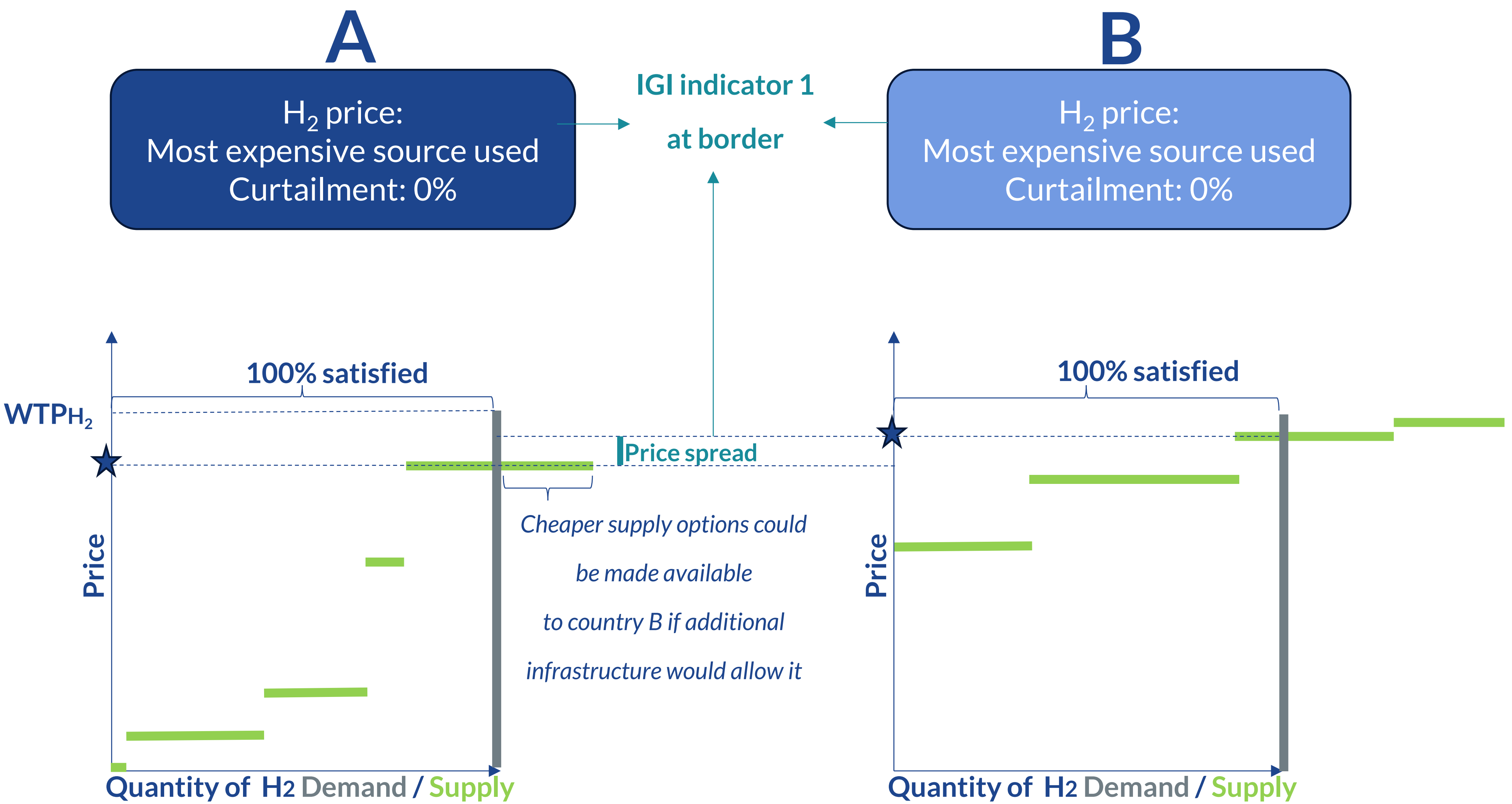
→ The TYNDP 2026 IGI report presents each relevant IGI indicator on a map and/or in a table.

The following information is provided:

- the calculated value of relevance for the thresholds (i.e., hydrogen market clearing price spread for IGI indicator 1 and hydrogen demand curtailment rate for IGI indicator 2;
- the information if the threshold was reached or not.
- average and maximum yearly volumes.
- the amount of time that the maximum utilisation of IP capacity is reached.

Implementation of IGI indicators – Example 1

– *Case: No curtailments, but different prices in country A and country B (interconnected)*



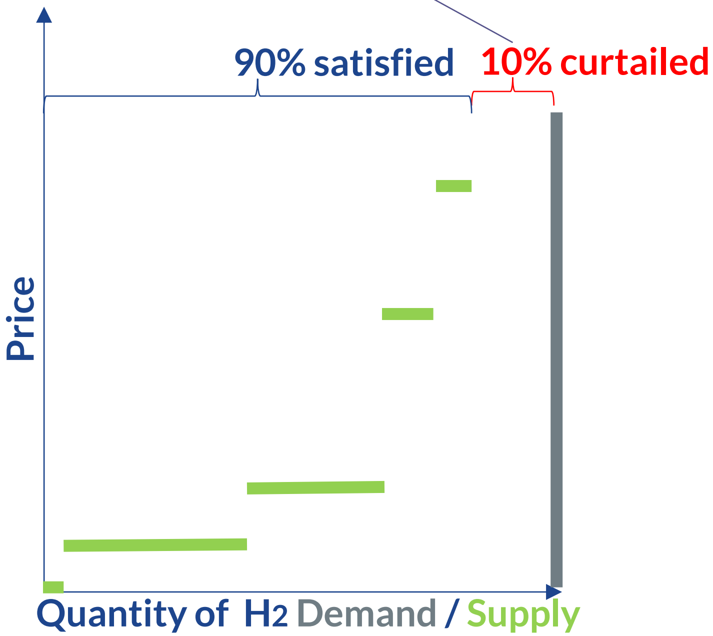
Implementation of IGI indicators – Example 2

– *Case: Curtailment in country C but not in country D (interconnected)*

C

H_2 price:
WTPH2
Curtailment: 10%

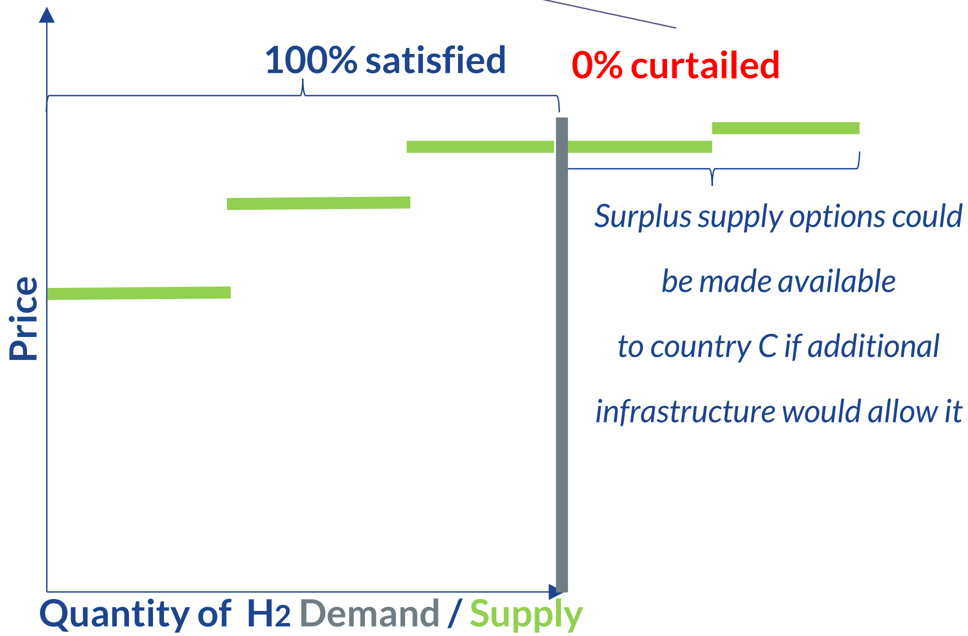
IGI indicator 2 at country-level



D

H_2 price:
Most expensive source used
Curtailment: 0%

IGI indicator 2 at country-level



Implementation of IGI indicators – Example 3

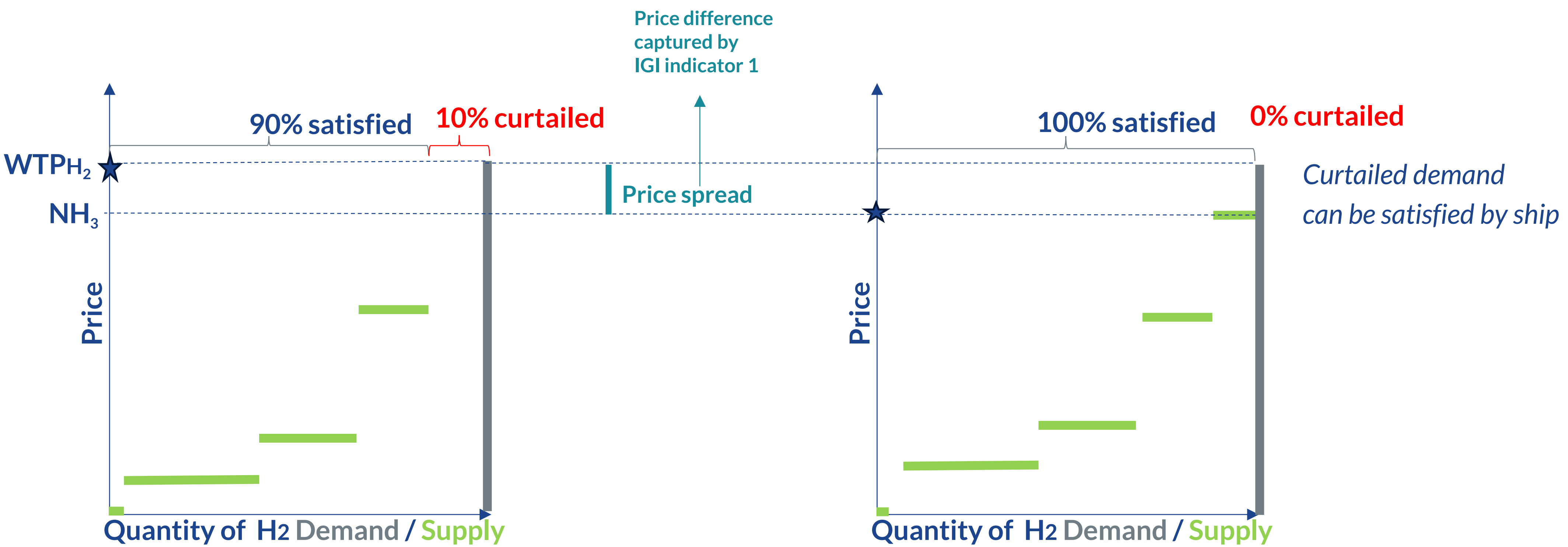
– *Case: Curtailments and different prices in isolated country G*

G

H_2 price:
$WTPH_2$
Curtailment: 10%

G

H_2 price:
NH_3
Curtailment: 0%



Comparison of the indicator results

Is an infrastructure gap of the PCI/PMI H_2IL mitigated or solved in the Advanced H_2IL?

An infrastructure gap was solved:
Additional project(s) addressing bottleneck(s) are one possible solution to solve infrastructure gap

An infrastructure gap was only mitigated:
Additional project(s) addressing bottleneck(s) are helping but are not sufficient to fully solve infrastructure gap

"Unlimited infrastructure" exercise

- To provide additional and in-depth information on the bottlenecks linked to transport and storage capacities, **a sensitivity analysis exercise** is proposed to identify infrastructure gaps caused by restrictions on the supply side (i.e., structural undersupply) and/or import capacities directly connected to the import potential.

Unlimited Pipes (UP) → Unlimited Storage (US) → Unlimited Pipes + Storages (UPS) → Unlimited Imports (UI)

Consultation question 26: Do you support the inclusion of the proposed sensitivity regarding unlimited infrastructure and/or supply?

Sensitive Analysis for unlimited infrastructure
a multi-step approach

Pipeline Bottlenecks

Step 1 - Identification of stressed interconnections

-> *Max interconnection usage and disconnected country groups across* PCI/PMI IL vs Advanced IL, weather scenarios, years 2030, 2040, 2045 & 2050.

Total transport Bottlenecks

Step 2 – Curtailment caused by limited transport capacity

-> *H2 demand curtailment is caused by limited intra-EU H2 transport capacity (unlimited transport capacity)*

->*Identify the additional hydrogen import and hydrogen electrolytic supply that was unused due to the limited intra-EU transport (optimisation)*

Storage Bottlenecks

Step 3 - Curtailment caused by limited storage capacity

-> *H2 demand curtailment is caused by limited intra-EU H2 storage capacity (unlimited storage)*

-> *Identify the structural undersupply that could only be solved by unlimited imports*

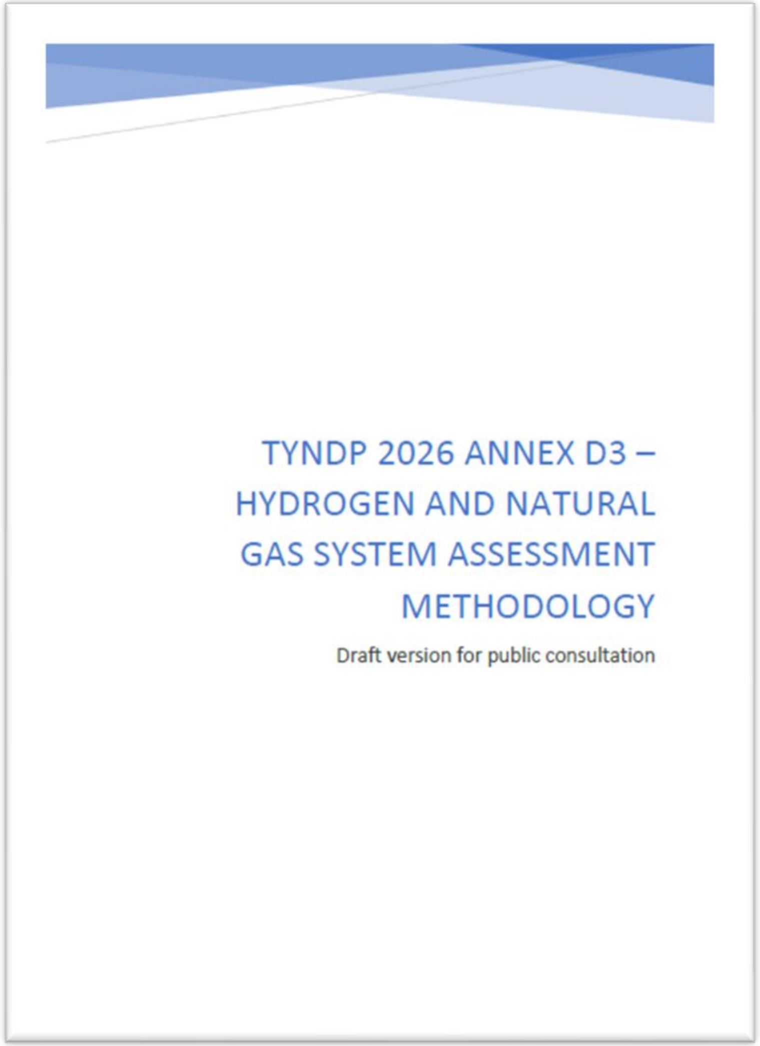
Attribution & outcomes

Step 4 – Identify fully/partially solved gaps.

-> *Overview of infrastructure gaps that could be fully and/or partially solved by the advanced infra level projects.*
Fully solved gaps (threshold exceeded in PCI/PMI, not exceeded in Advanced)

Annex D3 - Hydrogen and Natural Gas System Assessment methodology

Annex D3: overview


TYNDP 2026 ANNEX D3 – HYDROGEN AND NATURAL GAS SYSTEM ASSESSMENT METHODOLOGY

Draft version for public consultation

The TYNDP 2026 System Assessment (SA) methodology contains analyses :

1. the SA approach of the gas (Natural gas and Hydrogen) sector, including natural gas infrastructure repurposing principles
2. the Supply Adequacy Outlook including a biomethane progress report

Inputs to the analysis

- The TYNDP 2026 System Assessment methodology is focusing on the Dual Hydrogen/Natural Gas Model (Dual Gas Model, DGM).
  - The Dual Hydrogen/Electricity Model (DHEM) is only relevant to provide certain input data (detailed in the methodology).
- National Trends+ (NT+) scenario and 2030, 2035 and 2040 as simulation years
- Both natural gas infrastructure levels (i.e., Low natural gas infrastructure level and Advanced natural gas infrastructure level), and both hydrogen infrastructure levels (i.e., PCI/PMI hydrogen infrastructure level and Advanced hydrogen infrastructure level).
- Focus on various stress cases (climatic stress conditions, infrastructure stress conditions, repurposing, etc.) expressed through the different indicators

Indicator: Demand curtailment and Curtailment Rate

- Demand curtailment (in energetic terms) is an output of the DGM simulation
- Curtailment rate (in relative terms) is then given by the following formula:

$$Curtailment\ rate = \frac{Demand\ curtailment}{Demand}$$

The indicators are interpreted by identifying infrastructure bottlenecks by assessing which demand curtailments are caused by full usage of relevant infrastructure. Also, different infrastructure levels can be compared.

- The indicators are measured in several simulations:
  - Base case (normal year),
  - Stressful case (derived from Scenario),
  - Climatic stress conditions (Peak Demand & 2-week Cold Dunkelflaute),
  - Supply stress conditions as import source dependency (S-1) - *in line with the Regulation of the European Parliament and Council phasing out Russian natural gas imports by November 2027, the TYNDP 2026 System Assessment assumes no Russian natural gas imports. Consequently, the S-1 stress condition for Russian supply is applied in all assessed cases.*
  - Disruption cases (SLID)

Disruption cases: SLID for CH_4

This case intends to investigate the impact of the disruption of the single largest natural gas infrastructure entering a given country of the different countries to measure the impact of such disruptions at a European level

- SLI stands for "Single Largest Infrastructure"
  - It is the largest infrastructure entering a given country, excluding storage and national production but including import capacity from outside the EU.
  - SLI capacities will be reviewed and adjusted where necessary, with the next largest relevant infrastructure identified as the SLI when the single largest infrastructure serves as a transit route for Russian gas.

- SLID is the "Single Largest Infrastructure Disruption"
  - It is computed on a peak demand situation, with the associated supply and national production in this configuration, and all storages being filled at 35%.

Indicators for repurposing principles. Background

- Based on the conclusions of the 2024 Copenhagen Forum, ENTSOG and ENNOH were to develop a joint Repurposing Report
- In the 2025 Copenhagen Forum the conclusions stated that the repurposing principles, which were presented in said forum should be integrated in the TYNDP 2026

- requests ENTSOG and pre-ENNOH to conduct consultations with all relevant stakeholders before the final publication of the draft repurposing principles document in November 2025. It also calls on ENTSOG and pre-ENNOH to apply the final repurposing principles in the upcoming TYNDP 2026.

Defining indicators for repurposing principles: LICD

- LNG and Interconnection Capacity Diversification (**LICD**) – page 27 Annex D1 TYNDP 2020 methodology
- **Purpose:**
  - Measures **diversification of gas flow paths** to a market area, not just import routes.
  - Focuses on **market integration**, not import routes.
  - Capacities are **capped by country demand** to avoid distortion.
  - LICD is referring to price pressure/market integration changes through changes in diversification
- **Indicator Type:**
  - Based on the **Herfindahl-Hirschman Index (HHI)**.
  - **Range:** 0 to 10,000
  - **Lower value = better diversification**
  - Minimum values:
    - 2 borders → LICD ≥ 5,000
    - 3 borders → LICD ≥ 3,333

Defining indicators for repurposing principles: MASD

- Minimum Annual Supply Dependence (**MASD**) – page 30 Annex D1 TYNDP 2020 methodology
  - Assess defined supply corridors/zones (see Regulation 2017/1938 Annex **I**)
  - Europe would be cooperating fully to cover curtailments.

- **Purpose:**
  - Identifies **dependence on specific supply sources**.
  - Highlights **physical bottlenecks** in infrastructure.

- **Interpretation:**
  - **Lower MASD value = lower dependence**
  - Calculated **per source** over a full year.

- **Regional Cooperation:**
  - Countries within a region **share dependence levels**, unless limited by infrastructure.
  - Promotes **joint resilience strategies**.

Defining indicators for repurposing principles: MASD/LICD

- **Assessment Structure:**

- **Demand Curtailment**
  - Assessment will be conducted at the European level, not at the individual country level
  - Provides an indicative overview of the impact of gas pipeline repurposing on the European market
  - Further detailed assessment will be based on LICD and MASD indicators

- LICD and MASD assessment basis:
  - Infrastructure Level:
    All infrastructure Levels will be assessed

  - Time Horizons:
    2030, 2035, 2040 based on the distribution of commissioned projects in the TYNDP

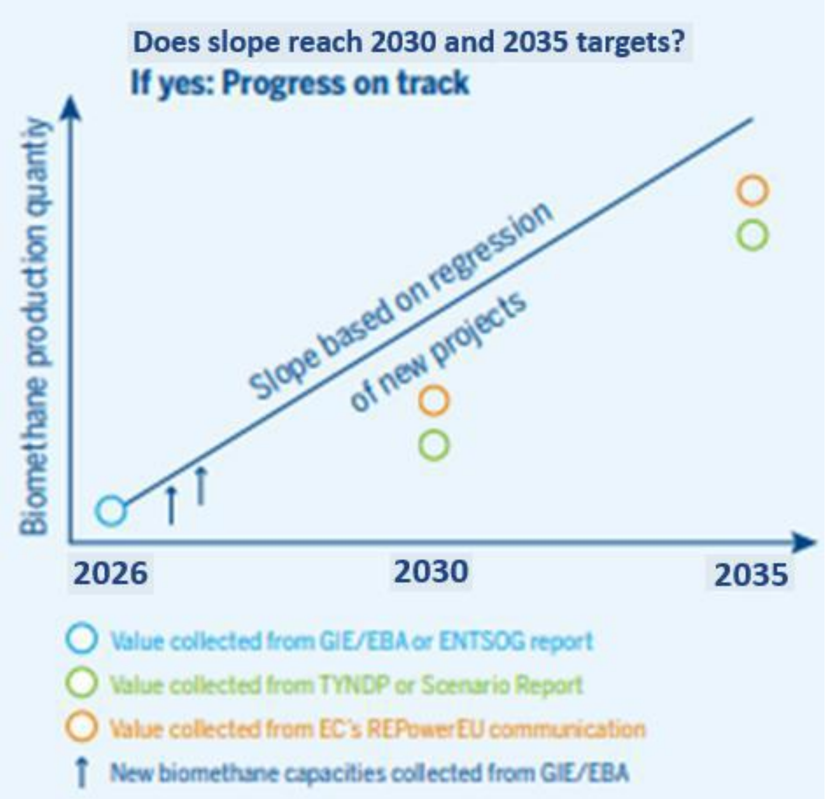
Overview of cases

Cases per combination of scenario, modelling year, and combination of natural gas and hydrogen infrastructure levels	Duration	Results	Granularity options
▪ Base case	Full year	HDC HCR NGDC NGCR	Node, Country, European Union, or Europe
▪ Stressful case			
▪ Peak Day (PD)	1 day		
▪ Peak day (PD) with SLID for natural gas for each Member State individually			
▪ 2-week Cold Dunkelflaute (CDF)	2 weeks		
▪ Increase in exposure to curtailed natural gas demand	Full year	ΔNGDC ΔNGCR	
▪ Minimum Annual Supply Dependence (MASD)	Full year	NGDC NGCR	
▪ LNG and Interconnection Capacity Diversification (LICD)	Full year	HHI	Per border between the countries

*S-1 stress condition for natural gas supply from Russia is applied across all assessed cases
**DC/CR: demand curtailment and curtailment rate
*** HHI: Herfindahl-Hirschman index, an indicator of concentration or, conversely, diversification

Supply Adequacy Outlook for natural gas

- DGM simulations described above are used to quantify import needs based on TYNDP 2026 scenarios and considering infrastructure contraints
- Biomethane progress report:



Thank you for your attention