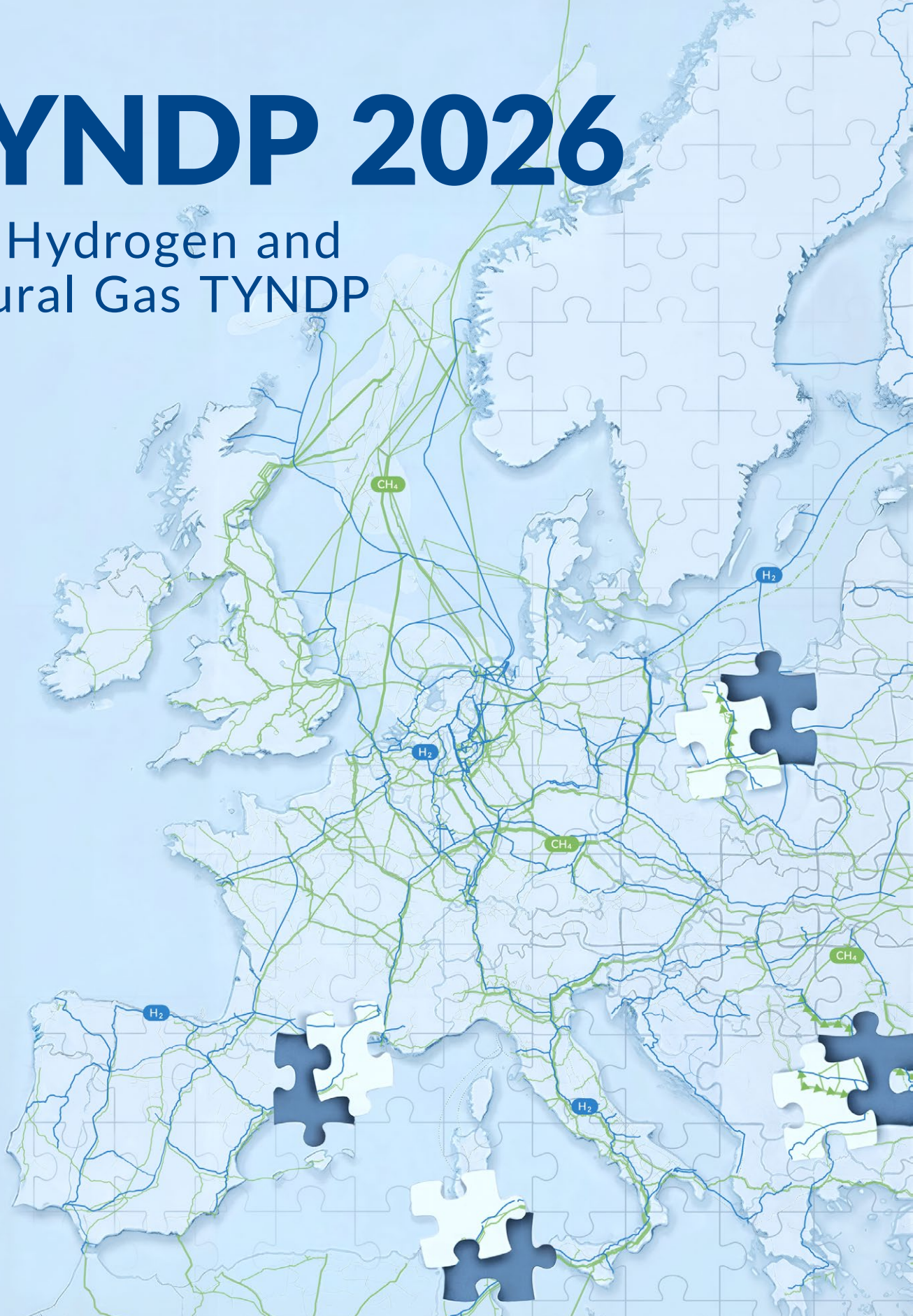


TYNDP 2026

The Hydrogen and Natural Gas TYNDP



Hydrogen Infrastructure Gaps Identification Report

DRAFT for public consultation



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Abbreviations

ACER	European Union Agency for the Cooperation of Energy Regulators
Annex C2	TYNDP 2026 Hydrogen Infrastructure Capacities
Annex D1	TYNDP 2026 Implementation Guidelines
Annex D2	TYNDP 2026 Hydrogen Infrastructure Gaps Identification methodology
CBA	Cost-Benefit Analysis
CCGT	Combined-Cycle Gas Turbine
CR	Curtailment Rate
DGM	Dual Gas Model
DHEM	Dual Hydrogen-Electricity Model
DRES	Dedicated Renewable Energy Sources
EC	European Commission
ENTSO-E	European Network of Transmission System Operators for Electricity
ENTSOG	European Network of Transmission System Operators for Gas
ETS	European Union Emissions Trading System
EU	European Union
EU-27	The 27 Member States of the European Union
FEED	Front-End Engineering Design
FID	Final Investment Decision
GCV	Gross Calorific Value (Higher Heating Value)
GWh	Gigawatt-hour
GWh/d	Gigawatt-hours per day
H ₂	Hydrogen
HCR	Hydrogen Demand Curtailment Rate
IGI	Infrastructure Gaps Identification
IL	Infrastructure Level
IGI indicator 1	Hydrogen Infrastructure Gaps Identification indicator for hydrogen demand curtailment in DHEM
IGI indicator 2	Hydrogen Infrastructure Gaps Identification indicator for hydrogen market clearing price spreads in DHEM
IoSN	Identification of System Needs
LH ₂	Liquid Hydrogen
MW	Megawatt
MWh	Megawatt-hour
NCV	Net Calorific Value (Lower Heating Value)
NT+	National Trends+ Scenario
P2X	Power-to-X (electrolytic hydrogen production)
PCI	Project of Common Interest
PMI	Project of Mutual Interest
RES	Renewable Energy Source(s)

SMR	Steam Methane Reforming
SRES	Shared Renewable Energy Sources
TEN-E	Trans-European Networks for Energy
TWh	Terawatt-hour
TWh/y	Terawatt-hours per year
TYNDP	Ten-Year Network Development Plan
UI	Unlimited Imports
UK	United Kingdom
UP	Unlimited Pipelines
UPS	Unlimited Pipelines and Storage
UPSI	Unlimited Pipelines, Storage and Imports
US	Unlimited Storage
VoLL	Value of Lost Load
WTPH ₂	Willingness to Pay for Hydrogen
y	Year

Country codes (ISO)

AT	Austria
BE	Belgium
BG	Bulgaria
CH	Switzerland
CZ	Czechia
DE	Germany
DK	Denmark
DZ	Algeria
EE	Estonia
ES	Spain
FI	Finland
FR	France
GR	Greece
HR	Croatia
HU	Hungary
IE	Ireland
IT	Italy
LT	Lithuania
LU	Luxembourg
LV	Latvia
MT	Malta
NL	Netherlands
PL	Poland

PT	Portugal
RO	Romania
SE	Sweden
SI	Slovenia
SK	Slovakia
UA	Ukraine
UK	United Kingdom

1. Introduction

The Hydrogen Infrastructure Gaps Identification (IGI) report, a core part of ENTSOG's TYNDP, is intended to inform European institutions, infrastructure developers and other stakeholders of where the EU hydrogen infrastructure may not sufficiently connect expected demand centres to supply sources, under the TYNDP 2026 National Trends+ scenario.

Potential regional infrastructure gaps are assessed for clearly identified sets of hydrogen infrastructure, assumed to be in place in a given target-year, in the future. Such sets of infrastructure are called 'hydrogen infrastructure levels'. The report does not identify individual investment obligations. Instead, it provides a regional, model-based view, with specific metrics (IGI indicators).

This document is established in line with Article 13 of the TEN-E Regulation. Further details about its legal background, assumptions, modelling tools, and methodologies are provided in the TYNDP 2026 IGI methodology (Annex D2)¹ which refers to the TYNDP 2026 Implementation Guidelines (Annex D1) as well as to the [TYNDP 2026 scenarios](#). Annexes D1 and D2 were subject to an extensive public stakeholder consultation between 9 March and 10 April 2026.

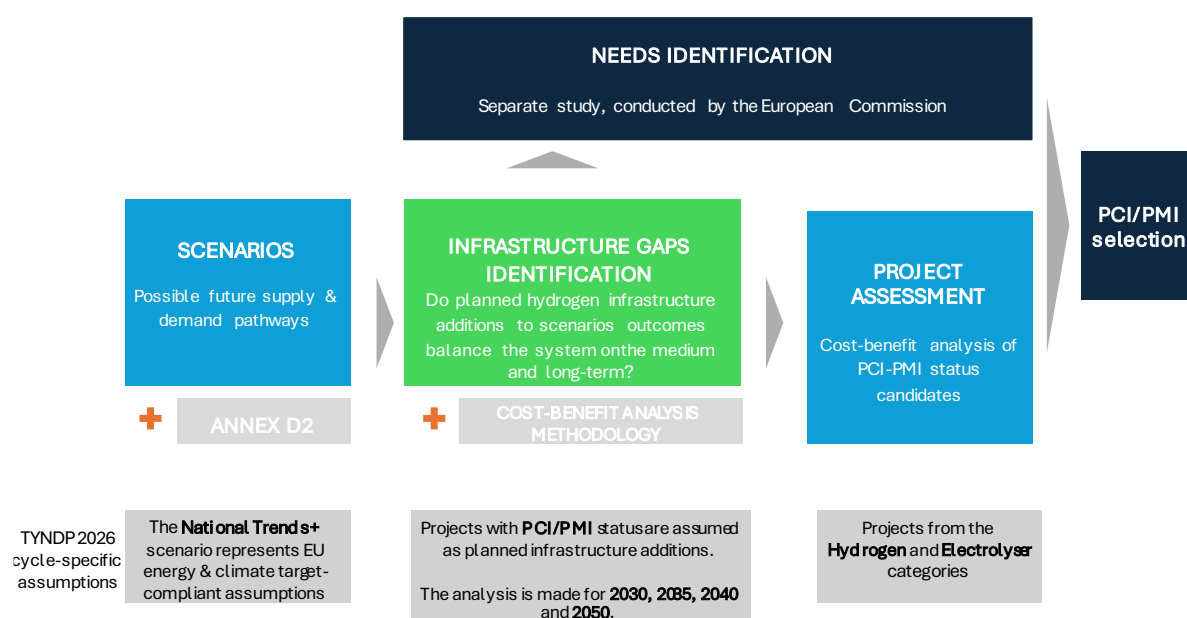


Figure 1 – The hydrogen IGI in the wider TYNDP process

This draft version of the Hydrogen IGI report is for stakeholder consultation. Any feedback received will be taken into account by ENTSOG in the preparation of an updated draft. This shall be submitted first to ACER and then to the EC for their opinions, in line with Article 11 (3) of the TEN-E Regulation. The final

¹ The TYNDP 2026 Annexes D1 and D2 are available in the [TYNDP 2026 section](#) of the ENTSOG website

draft will be updated by ENTSOG taking into account ACER's and EC's opinions. As a last step, the report will be submitted to ACER as part of the Draft TYNDP 2026 set of documents, and adapted in light of the feedback received, for publication in its final form.

Infrastructure gaps identified in ENTSOG's hydrogen-related TYNDP 2026 IGI report may in some cases also be addressed by energy infrastructure solutions in other sectors like the electricity sector or the natural gas sector. This is the case for any infrastructure gaps identification that is focused on a specific energy vector. For electricity, ENTSO-E prepares the Identification of System Needs (IoSN) report, which is the equivalent to ENTSOG's Hydrogen IGI report. For increased cross-sector perspective, the two reports should be read as complementing each other.

From Hydrogen IGI 2024 to 2026: what changed?

Between the TYNDP 2024 Hydrogen Infrastructure Gaps Identification report and the TYNDP 2026 assessment, several methodological changes have been introduced. While the 2024 IGI assessed only the years 2030 and 2040, the 2026 IGI adopts a longer-term perspective by evaluating the hydrogen system in 2030, 2035, 2040 and 2050. In addition, whereas the 2024 IGI assessed both the PCI/PMI and Advanced infrastructure levels, the 2026 IGI focuses exclusively on the PCI/PMI infrastructure level, thereby concentrating on more mature hydrogen projects, based on a recommendation received from ACER. Furthermore, as recommended by both ACER and the EC, the 2026 assessment no longer includes an evaluation under a stress weather year scenario, resulting in the removal of IGI Indicator 2.2 relating to hydrogen demand curtailment under stressful climatic conditions.

A comparison between the TYNDP 2024 and TYNDP 2026 Hydrogen IGI assessments shows a significant reduction in hydrogen demand and hydrogen demand curtailment at EU level. While the 2024 IGI assessed demand levels of approximately 620 TWh/y in 2030 and 1,929 TWh/y in 2040, the 2026 IGI assumes considerably lower demand levels of around 335 TWh/y and 1,296 TWh/y, respectively. These lower demand levels reduce overall stress on the hydrogen system, leading to lower demand curtailment and better market-clearing price spreads. In 2030, curtailed hydrogen demand decreases from 52 TWh/y in TYNDP 2024 to 36 TWh/y in TYNDP 2026. In 2040, the reduction is even more significant, with curtailed hydrogen demand decreasing from 294 TWh/y to 62 TWh/y. This reduction implies a substantial improvement in the ability of the assessed infrastructure to supply hydrogen demand across Europe. However, it should be noted that the two assessments are based on different project collections, scenario and infrastructure assumptions.

Despite these methodological and scenario differences, the comparison confirms several consistent structural findings regarding the future European hydrogen market. Germany continues to emerge as the main hydrogen demand and transit hub, while the Iberian corridor, the Nordic corridor and import routes from North Africa and Ukraine remain key sources of hydrogen supply. Moreover, both

assessments repeatedly identify specific regions, particularly parts of Central and South-Eastern Europe, including the Balkans, as structurally vulnerable to infrastructure constraints.

Overall, the 2026 IGI reiterates some of the conclusions already highlighted in the 2024 assessment. Mainly, insufficient transmission capacity and limited market connections remain the primary drivers of hydrogen demand curtailment and market-clearing price spreads across the EU. At the same time, the results indicate that, beyond 2040, expansion of cross-border pipeline network alongside storages and/or imports are necessary to eliminate remaining infrastructure gaps.

2. Executive Summary

The IGI assesses the evolution of hydrogen infrastructure needs under the PCI/PMI hydrogen infrastructure level through two indicators: hydrogen demand curtailment and hydrogen market clearing price spreads between countries, under the National Trends+ scenario demand assumptions.

The European hydrogen system progressively integrates, reaches several large, interconnected market zones, with regional shortages persisting in South-East Europe and certain isolated markets through 2050.

2030: Limited infrastructure development and high infrastructure needs across Europe

In 2030, the IGI assessment shows that most European countries rely primarily on domestic hydrogen production, mainly electrolytic production, to satisfy their demand.

The limited development of the PCI/PMI infrastructure level in 2030 leads to 12% of European hydrogen demand being unsatisfied, with nine countries experiencing severe curtailment rates ranging from 70% to full disruption. Infrastructure scarcity limits cross-border flows, while access to liquid or pipeline imports remains very limited or non-existent.

In this context, significant price spreads between European countries reflect a fragmented hydrogen market, insufficient infrastructure development and a low degree of cross-border market integration.

2035: PCI/PMI infrastructure expansion reduces curtailment and improves market convergence

By 2035, the expansion of PCI/PMI transmission infrastructure, storage facilities and import routes, together with increased national electrolytic production, improves the integration of national hydrogen markets. This leads to a significant reduction in the unsatisfied hydrogen demand at EU level, from 12% in 2030 to 3% on average, and allows remaining hydrogen demand to materialise across Europe.

The development of the PCI/PMI infrastructure level enables cross-border flows that connect supply-rich areas such as the Iberian Peninsula, Nordic region, North Africa and Ukraine with hydrogen demand hubs concentrated in central and North-West Europe through several transport corridors. As a result, the model results show lower and more convergent market clearing prices, indicating reduced infrastructure needs across Europe.

However, infrastructure development remains uneven across Europe. In particular, a number of countries in Southern Europe remain isolated and exposed to high shortage rates and/or elevated and dispersed hydrogen market clearing prices.

2040: Infrastructure needs increasingly driven by demand growth

By 2040, the European hydrogen market becomes more interconnected through the continued expansion of the PCI/PMI infrastructure level, including additional cross-border and storage capacities

and new connections to extra-EU supplies mainly from the United Kingdom. Despite these developments and a significant increase in hydrogen supply, including up to 67% growth in electrolytic production on average (highest producers include Germany and Spain), hydrogen demand rises sharply compared with 2035, by around 60%, leading to an increase of curtailment from 3% to 5% at EU level and to the re-emergence of market clearing price differences in several regions.

While most interconnected countries benefit from diversified supply sources and aligned market clearing prices, some isolated or weakly connected markets, particularly in South-Eastern Europe, continue to experience high curtailment rates and elevated prices, indicating persistent infrastructure and supply constraints.

2050: Similar trends to 2040, with higher demand further increasing system stress

The overall picture in 2050 remains similar to 2040: despite further infrastructure expansion, higher production and additional imports, continued demand growth –of around 65% compared with 2040 – maintains unsatisfied hydrogen demand at 5% at EU level and sustains regional price differences, highlighting persistent needs for supply, flexibility and market integration in some regions.

The IGI assessment includes additional sensitivities that allow the exploration of alternative infrastructure and supply configurations in sections 6.4 and 6.5.

3. The PCI/PMI hydrogen infrastructure level

The PCI/PMI hydrogen infrastructure level contains existing hydrogen infrastructure, FID hydrogen projects, and hydrogen projects on the Union list², modified by requests of the European Commission concerning import corridors. The projects included in the PCI/PMI hydrogen infrastructure level are shown in Figure 2 and listed in Annex I of this report, as well as in the TYNDP 2026 Annex D1³.

This IGI report focuses the analysis on four assessed simulation years (i.e., 2030, 2035, 2040 and 2050). Not all projects included in the PCI/PMI hydrogen infrastructure level will be fully implemented in all timeframes. Project implementation is often carried out in phases, with each phase having a different commissioning year. If the commissioning year of a project or phases is 2030 or later, for instance, it will not be considered in the 2030 assessment⁴. The same principle applies for 2035 and 2040. However, in the 2050 assessment, full deployment of PCIs and PMIs is assumed.

Regarding intra-EU transmission infrastructure, several southern European countries are not connected to the European network under the PCI/PMI hydrogen infrastructure level, as shown in Figure 1. In particular, the Greek and Bulgarian hydrogen systems are connected to each other through PCIs but remain isolated from other neighbouring countries. Under this hydrogen infrastructure level, the countries and regions without cross-border hydrogen infrastructure are Romania, Slovenia, Croatia, Ireland, Cyprus, Malta.

Regarding storage infrastructure in the PCI/PMI hydrogen infrastructure level, only Denmark, Germany, the Netherlands, France, and Spain have hydrogen storage capacities (see Table 1).

Table 1: Hydrogen storage capacities considered in the PCI/PMI hydrogen infrastructure level for the assessed years (unit: GWh/d for injection and withdrawal and GWh for working gas volume).

Storage capacities	Direction	2030	2035	2040	2050
Denmark	Injection	0,00	4,00	4,00	4,00
Denmark	Withdraw	0,00	11,00	11,00	11,00
Denmark	Working Gas Volume	0,00	118,00	118,00	118,00

² 7th Union list of Projects of Common Interest (PCI) and Projects of Mutual Interest (PMI) (i.e., 2nd Union list under the revised TEN-E Regulation) as detailed in section B of Annex VII to the TEN-E Regulation.

³ Available in the [TYNDP 2026 section](#) of the ENTSOG website

⁴ Hydrogen infrastructure capacities of the PCI/PMI hydrogen infrastructure level for 2030, 2035, 2040 and 2050 are published as part of the TYNDP 2026 Annex C2, available in the [TYNDP 2026 section](#) of the ENTSOG website

France	Injection	0,00	29,20	29,20	29,20
France	Withdraw	0,00	28,40	28,40	28,40
France	Working Gas Volume	0,00	1130,00	1130,00	1130,00
Germany	Injection	21,00	184,10	264,80	290,30
Germany	Withdraw	21,00	184,10	264,80	290,30
Germany	Working Gas Volume	1066,00	6752,00	8442,00	8442,00
Italy ⁵	Injection	0,00	6,00	6,00	6,00
Italy	Withdraw	0,00	16,00	6,00	6,00
Italy	Working Gas Volume	0,00	345,00	345,00	345,00
Netherlands	Injection	0,00	13,20	13,20	13,20
Netherlands	Withdraw	0,00	13,20	13,20	13,20
Netherlands	Working Gas Volume	0,00	975,00	975,00	975,00
Spain	Injection	41,00	61,50	102,50	123,00
Spain	Withdraw	41,00	102,50	143,50	164,00
Spain	Working Gas Volume	272,00	980,00	1800,00	2456,00
Total	Injection	62,00	292,00	413,70	459,70
Total	Withdraw	62,00	339,20	460,90	506,90
Total	Working Gas Volume	1338,00	9955,00	12 465,00	13121,00

Regarding extra-EU supplies, the PCI/PMI hydrogen infrastructure level has limited access to extra-EU supply potential. Two import corridors are considered in the PCI/PMI infrastructure, and five countries have access to liquid imports:

- Regarding pipeline imports from extra-EU sources (see Table 2): PCIs and PMIs are considered to unlock North African, Ukrainian supply potential from 2035.

⁵ As the connection to the Italian storage is not part of the 2nd PCI list, the storage is not connected to the Italian and European Network in the simulations

- > Regarding hydrogen import terminals (see Table 3): In 2030, extra-EU imports will be limited to the PCI import terminals in Belgium and the Netherlands. Thereafter, higher capacity of PCI import terminals will be considered in these countries due to the planned full implementation of the multiple phases of the PCIs and other projects. From 2035, additional PCI import terminals located in Greece and Germany will be considered, and in France from 2040.

Table 2: Extra-EU import capacities via pipelines considered in the PCI/PMI hydrogen infrastructure level (unit: GWh/d).

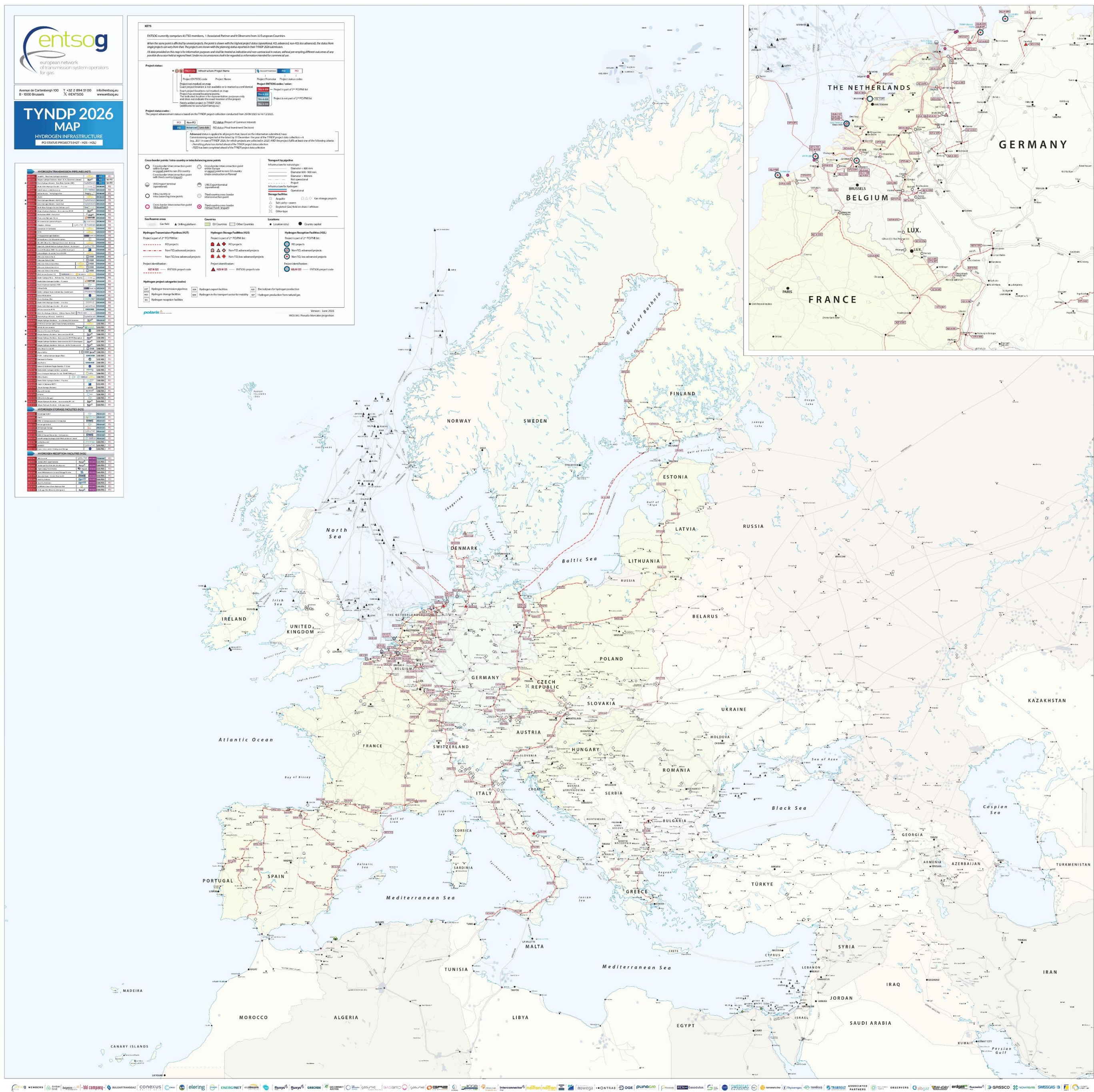
From Country	To Country	Hydrogen import capacity			
		2030	2035	2040	2050
Algeria	Italy	0,00	448,00	448,00	448,00
Ukraine	Slovakia	0,00	144,00	144,00	144,00
United Kingdom	Belgium	0,00	0,00	96,00	240,00

Table 3: Extra-EU import capacities via terminals considered in the PCI/PMI hydrogen infrastructure level and extra-EU supply potential by ship for the assessed years (unit: GWh/d).

Import capacities by ship To Country	2030	2035	2040	2050
Belgium	28,33	59,77	107,77	107,77
France	0,00	0,00	48,00	48,00
Germany	0,00	31,20	31,20	31,20
Netherlands	13,33	28,57	28,57	28,57
Total	41,66	169,54	265,54	265,54
Effective hydrogen import potential				

Effective hydrogen import potential

Figure 2: Representation of the PCI/PMI hydrogen infrastructure level.



4. Infrastructure Gaps Identification (IGI) indicators

The analysis is performed for 2030, 2035, 2040 and 2050 as simulation target-years for the TYNDP 2026 National Trends+ scenario. It covers the PCI/PMI hydrogen infrastructure level. Two indicators are therefore used to identify regional hydrogen infrastructure gaps, measuring curtailment and price spreads under the assessment assumptions. Both IGI indicator 1 and IGI indicator 2 are quantified assuming the base weather scenario. How the IGI indicators are calculated is explained in the following paragraphs. Additional justifications and examples are available in section 5 of TYNDP 2026 Annex D2.

The IGI indicators identify the existence of an infrastructure gap through the existence of effects of such infrastructure gap, such as curtailment or persistent price spreads. Such effects are assumed to occur under infrastructure constraints or limited supply access. The non-identification of a certain infrastructure gap may be related to the infrastructure considered in the infrastructure level of the energy sectors considered in the models. The effect of this infrastructure gap is either expressed at a country for IGI indicator 1 (curtailment) or at a border for IGI indicator 2 (price spreads).

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. As a limited cooperation mode is used among countries in situations of hydrogen scarcity (see section 3.2.4 of the TYNDP 2026 Annex D1), the dominant infrastructure bottleneck is not necessarily located at a border of the country through which the IGI indicators demonstrated the existence of an infrastructure gap (see examples in section 5 of TYNDP 2026 Annex D2). Also, besides the dominant bottleneck, non-dominant bottlenecks may exist at other locations that only become apparent once the dominant bottleneck is addressed.

Additionally, an infrastructure bottleneck can in principle be addressed by different projects and via different routes. Therefore, the potential solution to cover infrastructure gaps identified by the IGI indicators is not limited to the country of IGI indicator 1 or the border of IGI indicator 2. Several combinations of production, import, storage and transmission infrastructure may address the same regional need.

4.1. IGI indicator 1: Curtailed hydrogen demand in DHEM

This IGI indicator identifies infrastructure gaps by measuring the hydrogen demand curtailment at individual nodes during the base weather scenario, and without infrastructure or source disruptions.

To define which hydrogen demand curtailments are a significant indication of a hydrogen infrastructure gap, the following threshold must be passed:

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

If hydrogen demand curtailment is above the threshold, this indicates an infrastructure gap for the given assumptions. As there is only a limited cooperation mode considered for hydrogen in the DHEM (see section 2.6 of the TYNDP 2026 Implementation Guidelines), the infrastructure bottleneck causing the hydrogen demand curtailment rate to be above the threshold (defined above) in a certain country is not necessarily located at the border between this country and its direct neighbours.

4.2. IGI indicator 2: Market clearing price spreads in DHEM

This IGI indicator 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. Zone 2 nodes are areas of hydrogen production and/or storage and/or consumption within a country, that are connected to the national hydrogen backbone. The hydrogen market clearing price spread is thereby based on the hourly hydrogen market clearing prices in the DHEM. It is calculated for each combination of simulation year and hydrogen infrastructure level.

The hydrogen prices and flows in the DHEM are linked to the merit order of hydrogen supply options as well as hydrogen demand associated with end users' willingness to pay for hydrogen (i.e., WTP_{H_2} as defined in TYNDP 2026 Annex D1). The merit order of hydrogen production has the following elements:

- > **Electrolytic hydrogen production** costs are linked to the price of the used electricity and the water price in the respective country as well as the process efficiency;
- > **Hydrogen production from natural gas** within the EU is based on the TYNDP 2026 NT+ scenario and depends on the natural gas price, operating and maintenance costs, process efficiency, and Emissions Trading System (ETS) costs (thereby being differentiated between low-carbon and unabated hydrogen production from natural gas).
- > **Hydrogen imports** have specific costs as defined in the TYNDP 2026 NT+ scenario;

Especially the electrolytic hydrogen production thereby depends on the availability of RES and nuclear energy. Electrolysers that are connected to an electricity bidding zone or dedicated RES may be limited in their load factor by this availability. Also, the electricity price is subject to a merit order of electricity production as well as the end users' willingness to pay for electricity (e.g., VoLL). The electricity price is thereby influencing the cost of electrolytic hydrogen production.

As the DHEM aims at maximising the joint market rents in the electricity sector and in the hydrogen sector, it dispatches the European electricity and hydrogen supply options in an optimised way while respecting hard constraints like production and transport capacities. Thereby, the most expensive hydrogen supply source is usually defining the hydrogen market clearing price in a perfectly interconnected area. However, in case of hydrogen undersupply, the end users are competing for this supply up to their willingness to pay for hydrogen, thereby setting the hydrogen market clearing price at this level. From this dispatch of production options result hydrogen (and electricity) flows.

If countries are well connected, they share the same hydrogen market clearing price. If countries are not connected at all, the interdependency of their hydrogen market clearing prices is limited as these prices then rely on their own hydrogen supply options and hydrogen demand. A certain correlation may still be observed, e.g., due to one or several of the following reasons:

- > The price and availability of electricity used for electrolytic hydrogen production may be correlated (e.g., due to similar weather conditions in these countries and/or sufficient cross-border capacity in the electricity system).
- > The reliance on the same means of hydrogen production from natural gas may be correlated.
- > The frequency of hydrogen demand curtailment may be correlated.

When countries are connected but the sum of connections between them is a bottleneck during certain periods of time, the hydrogen market clearing price is the same during periods of time when the interconnection is not acting as a bottleneck and is detached when the interconnection is acting as a bottleneck. Then, a limited price correlation can be observed. The less often the bottleneck is observed and the lower the resulting price spread during these periods of detachment is, the lower is the average price spread.

To define which hydrogen market clearing price spreads are a significant indication of a hydrogen infrastructure gap, one of the following thresholds must be passed:

- > Threshold 1: This refers to a hydrogen market clearing price difference. It is calculated as the yearly average of the absolute hourly price differences between two Zone 2 nodes. The threshold is exceeded if this average difference is greater than 2 €/MWh.
- > Threshold 2: A hydrogen market clearing price spread as the absolute average daily hydrogen market clearing price spread between two Zone 2 nodes of different countries of more than 20 €/MWh for more than 40 days per year.

If there is a hydrogen market clearing price spread above one of the thresholds, this indicates an infrastructure gap for the given assumptions.

More details are provided in TYNDP 2026 Annex D1 and TYNDP 2026 Annex D2.

5. Disclaimers

The results of the TYNDP 2026 IGI report are related to the assessed scenario (i.e., NT+) and years (i.e., 2030, 2035, 2040 and 2050).

The lines depicted in the grid flow maps are derived from simulations used to identify infrastructure gaps within the assessed infrastructure levels and assessed years. These indicative lines do not reflect ENTSG's expectations on how the European network will evolve during the simulated years. The report's primary objective is to identify gaps, not to predict either the development of European infrastructure or future flows. Additionally, many projects included in the TYNDP are not part of the analysed infrastructure levels. Their commissioning could complement network flows compared to those presented in the report and potentially address some of the identified infrastructure gaps.

The term "*bottleneck*" in this report refers to situations where two conditions are met: (1) the capacity is being utilised to its maximum potential, and (2) no alternative routes are available. When a capacity is identified as a bottleneck, it signals the need for potential enhancements to that capacity along the specific fully utilised route and/or the development of new projects following other interconnections.

No generic hydrogen infrastructure projects are used in this TYNDP 2026 IGI report. Instead, only real projects that were submitted by project promoters are considered.

The representation of grid flows in the maps of this report is based on a schematic representation from capital to capital.

All values that refer to the energy content of molecules (e.g., GWh/d, €/MWh or TWh/y) are stated in terms of their Gross Calorific Value (GCV) in this IGI report. For hydrogen, the conversion factor from NCV to GCV is 1.176. The reference temperatures used for the NCV calculation are 25°C/0°C.

6. Assessment of PCI/PMI infrastructure level

This section describes the evolution of the IGI indicators for the base weather scenario for the analysed PCI/PMI infrastructure levels and for all simulation years.

All results from the TYNDP 2026 IGI assessment are available in the following link: [Microsoft Power BI IGI 2026 Results](#)

6.1. Development of hydrogen supply and demand over the assessment period

Overview: supply-demand balance, supply distribution per country and type, average flows and maximum utilisation

In 2030, the development of the PCI/PMI infrastructure level is rather limited and only a few countries in Northwest Europe (namely Belgium, the Netherlands, Denmark and Germany) and the Nordic region (Finland and Sweden) are interconnected. Hydrogen PCI/PMI storage infrastructure is only available in Spain and Germany and regarding hydrogen imports, only import terminals to Belgium and the Netherlands are considered for this assessment year. In this context, hydrogen demand is met solely through indigenous production, mainly electrolytic production, and to a lesser extent, through hydrogen production using natural gas or methane. Available hydrogen supplies are insufficient to satisfy all projected demand, thereby leading to hydrogen curtailment.

By 2035, hydrogen demand more than doubles. Simultaneously, the European hydrogen transmission and storage infrastructure part of the PCI/PMI infrastructure level developed considerably, many European countries are interconnected, and storage and terminal infrastructure develops across Europe. In addition, import infrastructure via pipeline emerges in 2035, connecting European hydrogen network with Ukraine and North Africa (Algerian imports via Tunisia). In 2035, the available supplies are not enough to satisfy demand all year long, however, level of curtailment is now lower because of the development of PCI/PMI hydrogen infrastructure as well as the supply growth.

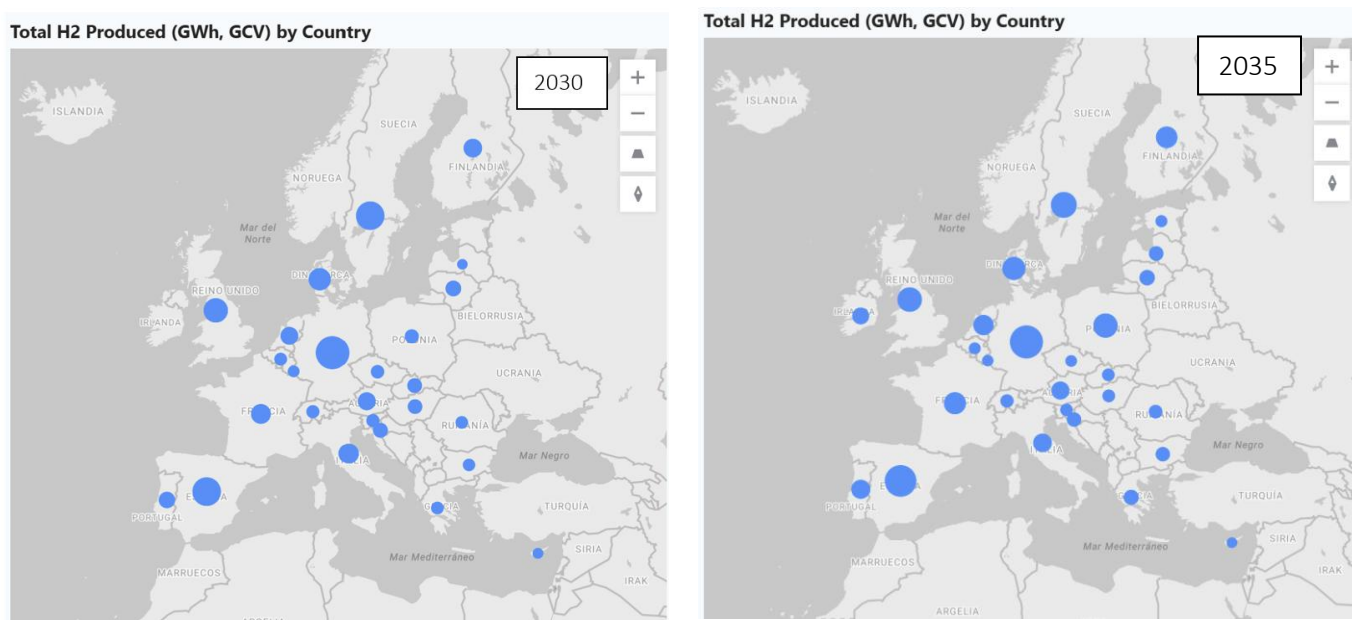
Hydrogen demand continues to rise in the long term (i.e., 2040 and 2050), driven mostly by industrial decarbonisation and the growing penetration of hydrogen in the transport and power sectors. In line with such demand growth, all hydrogen supply sources increased significantly. Electrolytic hydrogen production covers the largest share of demand, accounting for nearly 80% of European hydrogen demand. Regarding hydrogen infrastructure, from 2040, there is an increase in the import capacities, particularly a new interconnection with the United Kingdom and the development of new liquid import capacities, as well as development of storage capacities.

Table 4: Supply and demand balance expressed in TWh/y (GCV terms) for the PCI/PMI infrastructure level and all years.

Yearly hydrogen supply-demand balance	PCI/PMI IL	PCI/PMI IL	PCI/PMI IL	PCI/PMI IL
	2030	2035	2040	2050
H ₂ produced via electrolysis	204	593	1005	1698
H ₂ produced using natural gas	95	116	107	152

Yearly hydrogen supply-demand balance	PCI/PMI IL	PCI/PMI IL	PCI/PMI IL	PCI/PMI IL
	2030	2035	2040	2050
H ₂ shipped imports	0	0,37	14,88	22,84
H ₂ pipeline imports	0	62	107	115
H ₂ injection fuel	0,08	0,45	0,51	0,58
Demand CCGT H ₂	0,8	27	85	59
Curtailed H ₂ native demand	36	22	62	98
Total native H ₂ demand	334	766	1210	2027
% CR on native demand EU27	11%	3%	5%	5%
Total H ₂ demand	335	793	1296	2087
Total H ₂ supplied	299	771	1234	1988

Figure 3. Distribution of hydrogen electrolytic production in Europe in the IGI 2026



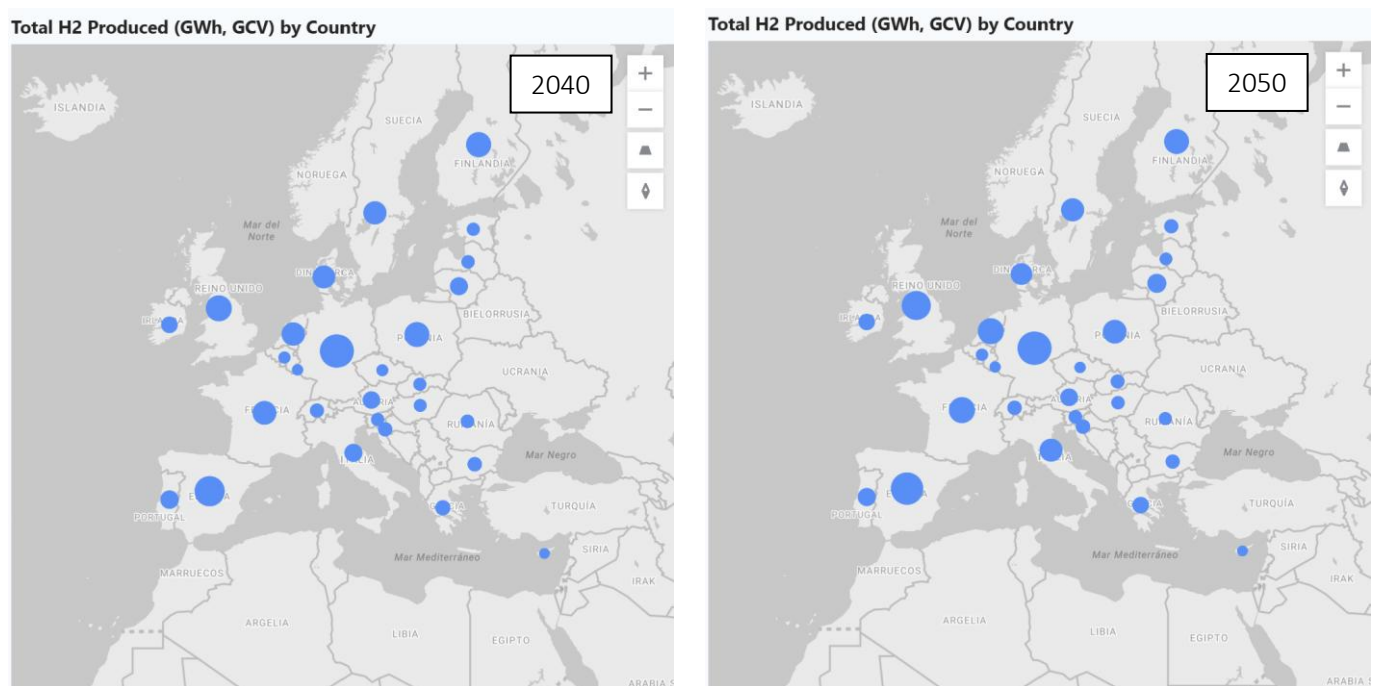


Figure 5 above shows hydrogen electrolytic production across the European countries for the PCI/PMI hydrogen infrastructure level assessment from 2030 to 2050. European countries progressively develop electrolytic hydrogen production over the assessment period. Although expected production levels vary significantly across EU-27 countries, all Member States develop electrolytic production to a greater or lesser extent. The countries with the highest levels of electrolytic hydrogen production are Germany, Spain, Finland, Poland, France and Sweden.

Some countries have more than one source of electrolytic hydrogen production. This is related to the intra-country assumptions, which can be summarised as follows:

- Consideration of electrolytic hydrogen production from dedicated RES in Poland and Greece and offshore RES in Germany.
- Consideration of electrolytic production from shared RES in Spain, Portugal, Germany and Croatia.

Figure 4.: Distribution and quantification of hydrogen production from natural gas in the IGI 2026

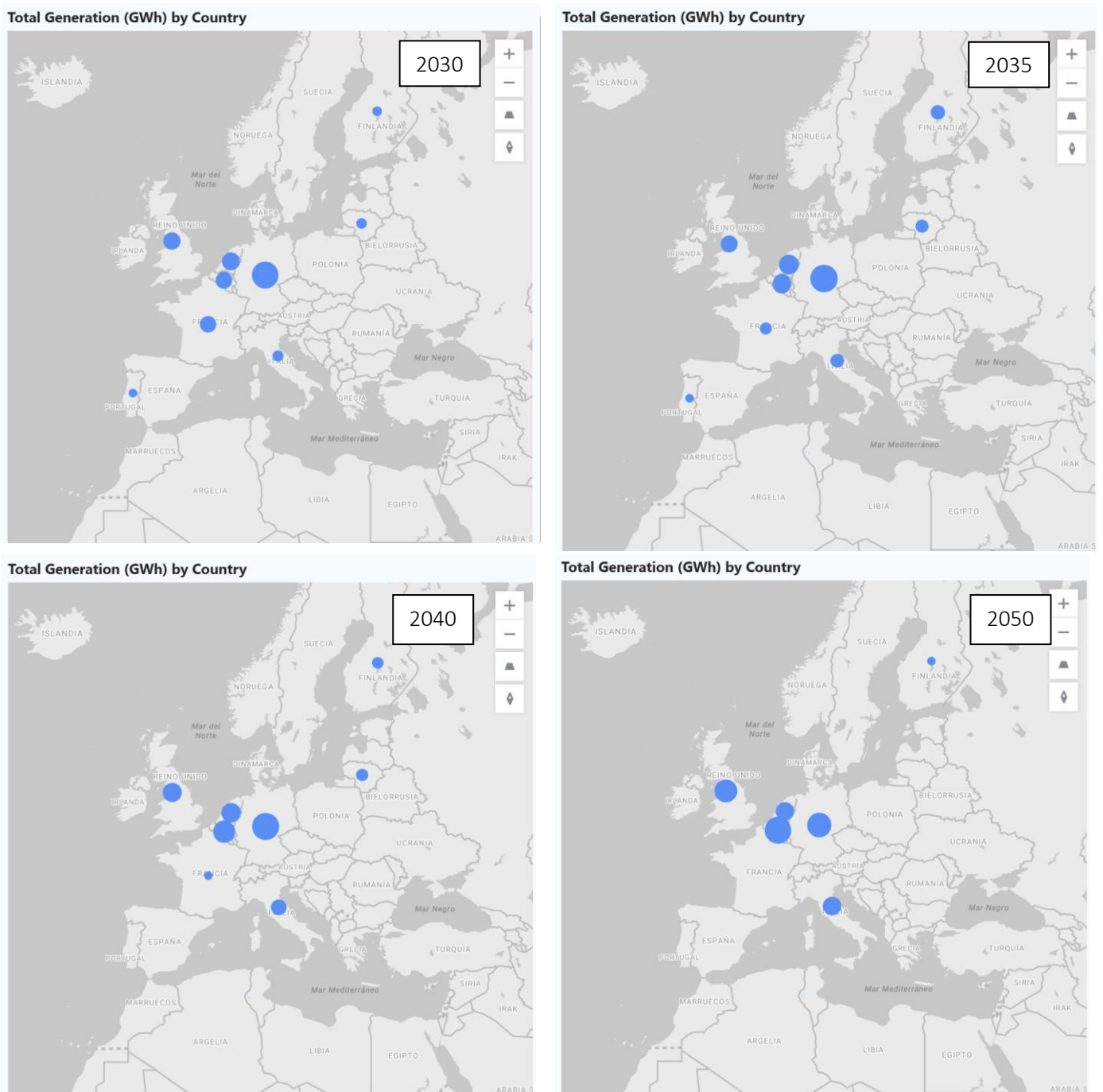


Figure 4 above present the hydrogen generation from natural gas across the European countries for the PCI/PMI hydrogen infrastructure level assessment from 2030 to 2050. Unlike electrolytic production, hydrogen production from natural gas is foreseen in only a limited number of European countries and, in most cases, remains significantly lower than electrolytic production.

Figure 5. Representation of the PCI/PMI IL in GCV cross-border and import capacity per assessed year (2030, 2035, 2040 and 2050)

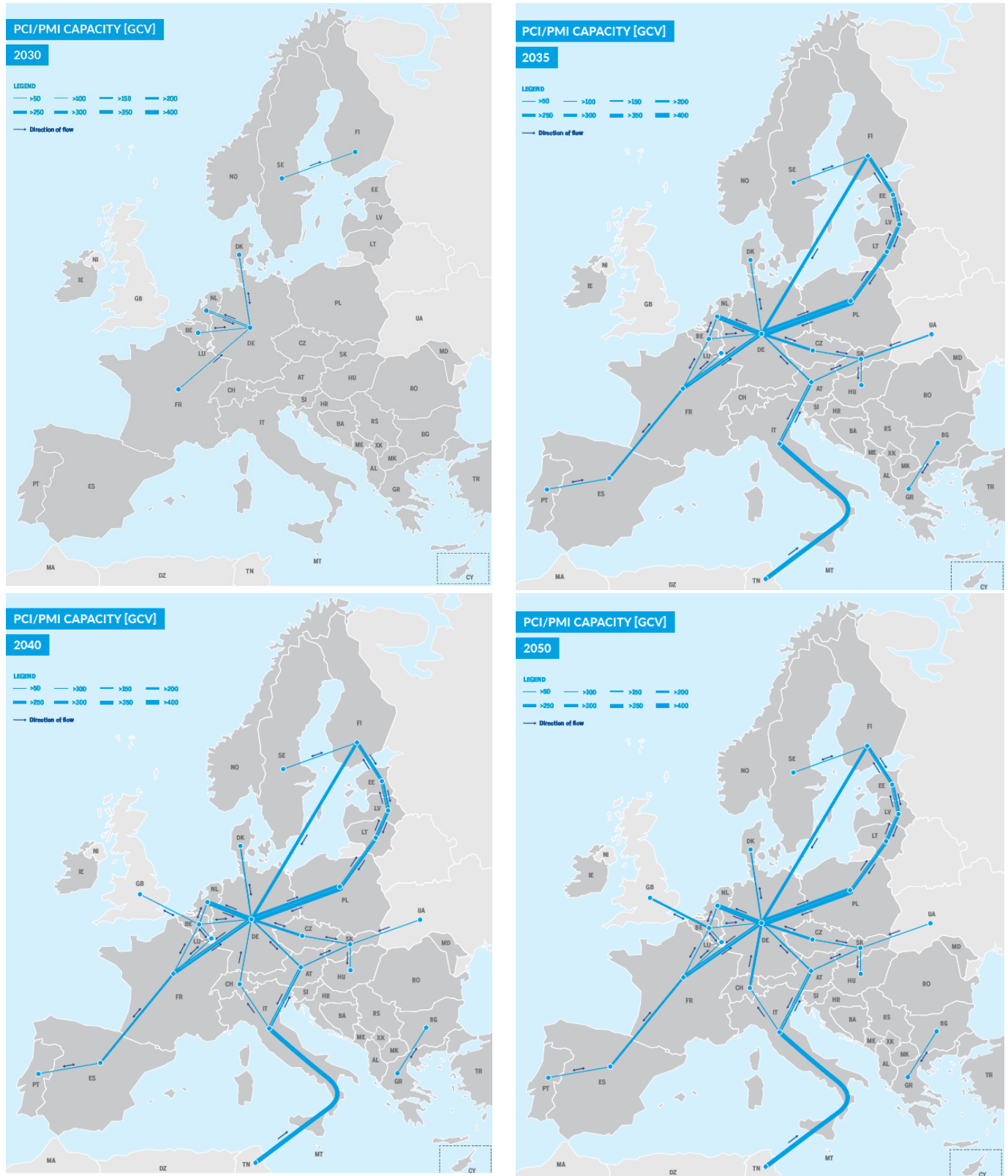
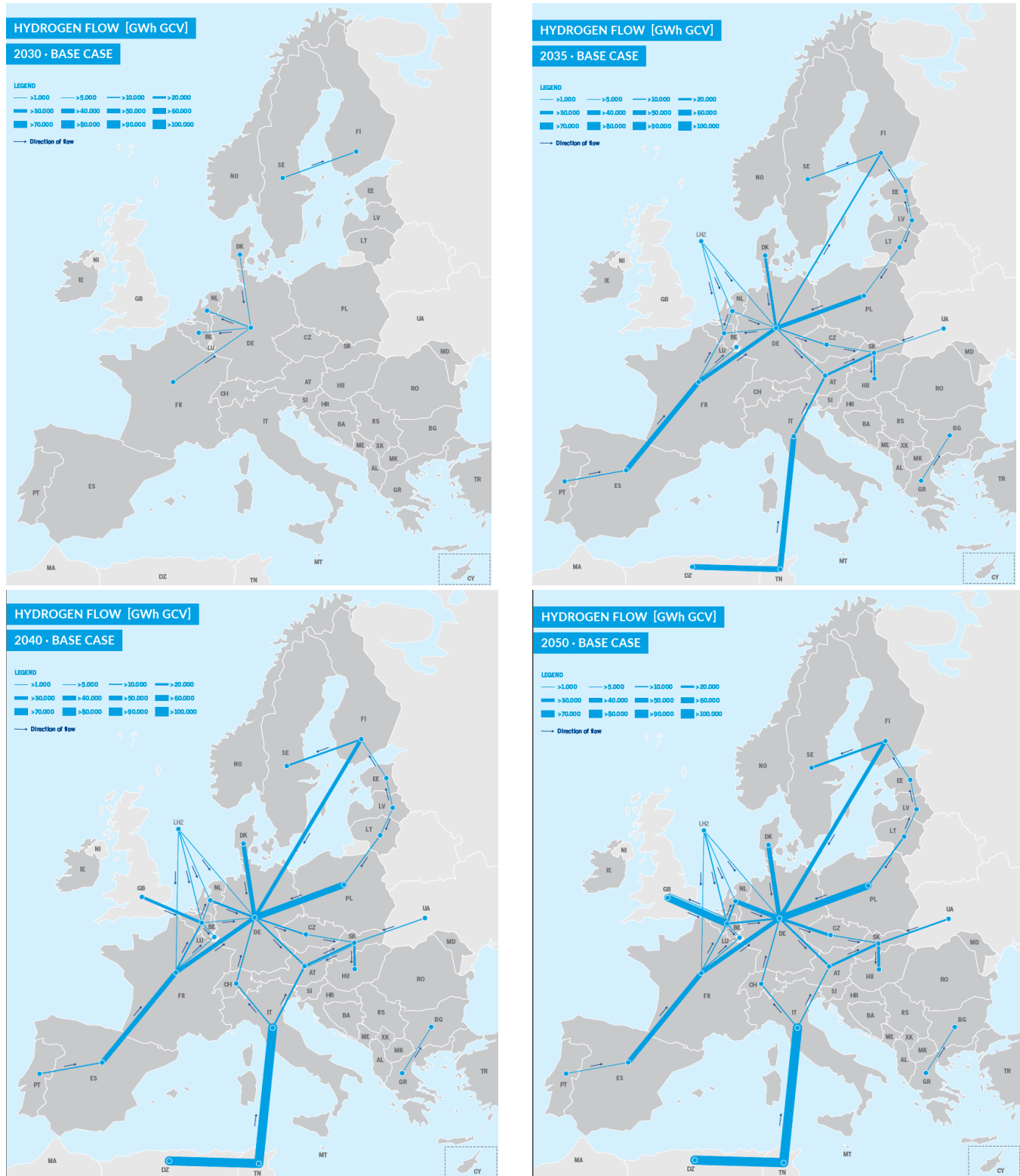


Figure 6. Hydrogen flows through the different assessment years in the IGI 2026



In 2030, intra-EU cross-border flows are fairly limited, and most European countries satisfy their hydrogen demand with their domestic production. From 2035 onwards, intra-EU cross-border flows become more relevant, increasingly connecting supply with demand and progressively expanding in line with demand growth towards 2050.

In 2035, the main transport corridors identified in the IGI assessment for the PCI/PMI infrastructure level are:

- A transport corridor connecting electrolytic hydrogen production from the Iberian Peninsula to Germany through France.
- The Ukrainian import corridor, transporting Ukrainian supplies to Slovakia, Czechia and Hungary.
- A transport corridor connecting Nordic electrolytic hydrogen production with Germany.
- An import corridor connecting North African hydrogen supplies with Austria and Germany through Italy.

In addition to the transport corridors identified in 2035, the following developments emerge from 2040 onwards:

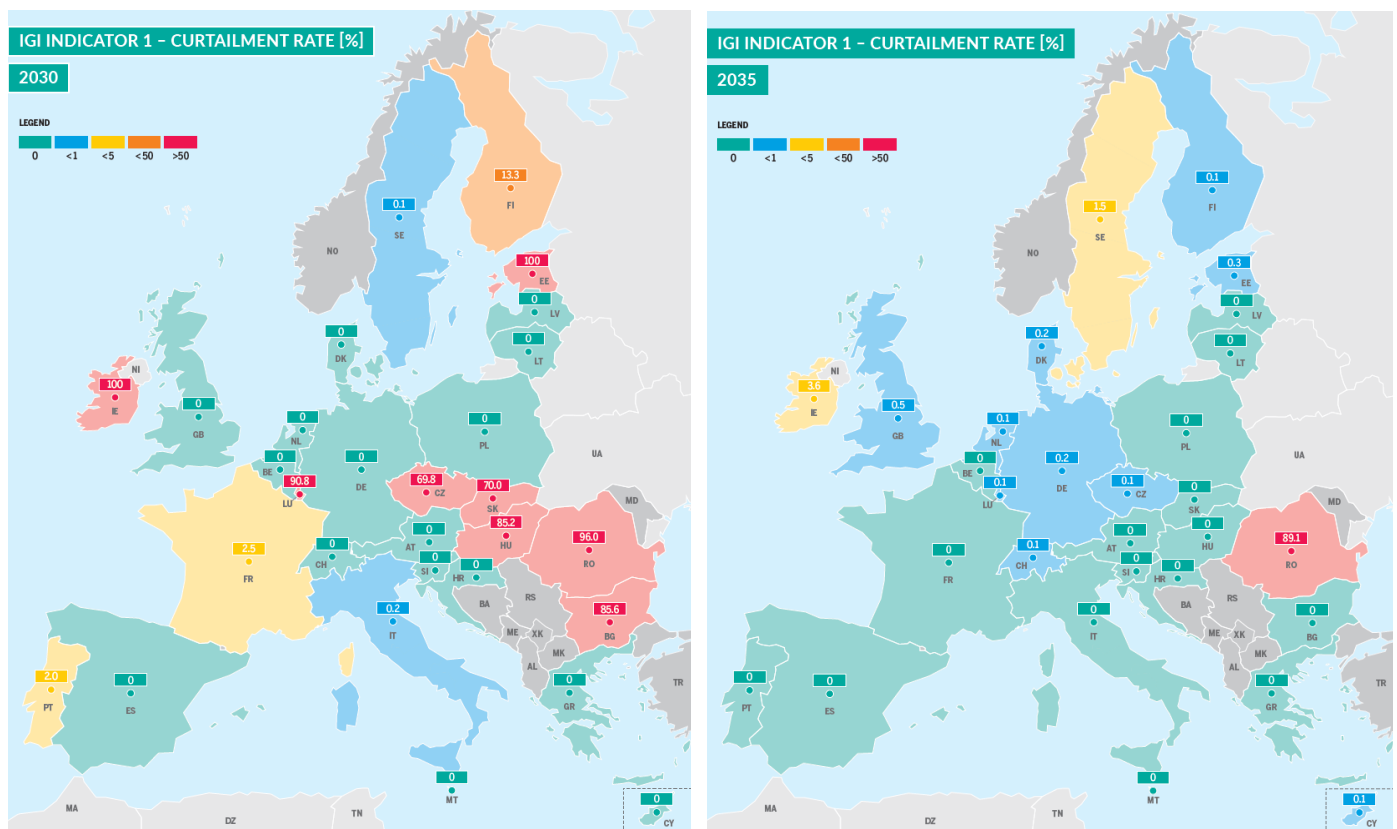
- The North African hydrogen corridor develops an additional route, connecting North African supplies to Germany through Switzerland.
- An interconnection between Belgium and the United Kingdom enables UK electrolytic hydrogen production to be transported to continental Europe through Belgium.

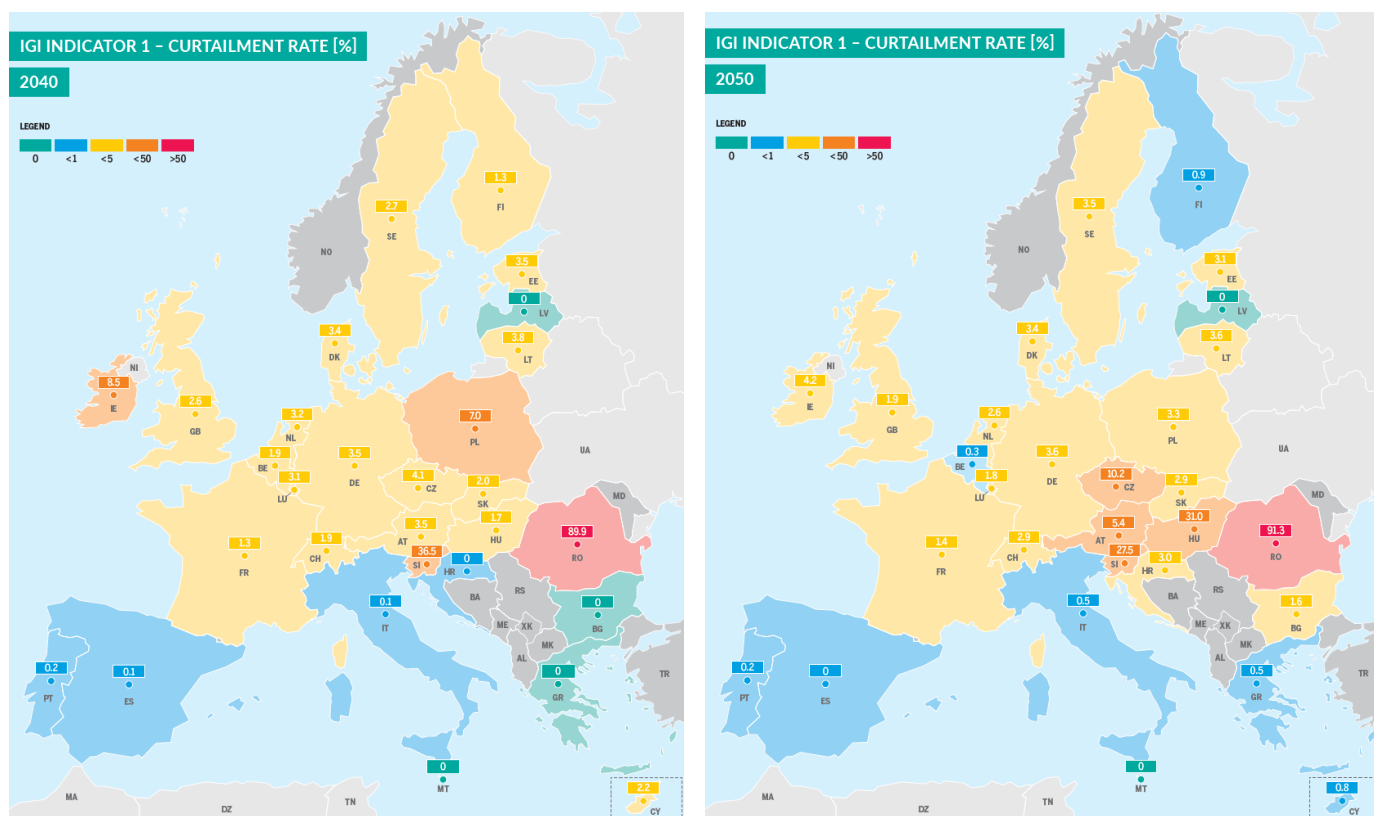
6.2. IGI indicator 1: Curtailed hydrogen demand in DHEM

As explained in section 1, this IGI indicator assesses infrastructure gaps by quantifying hydrogen demand curtailments at individual nodes during the base weather scenario, assuming no disruption to infrastructure or supply sources. The assessment is performed for the PCI/PMI hydrogen infrastructure level and all the assessed years.

Figure 7 shows yearly average curtailment rates of hydrogen demand in the Zone 2 nodes of different countries. The yearly average hydrogen curtailment rates are thereby colour-coded in the table to indicate levels relative to the set threshold: red signifies curtailment above the 0% threshold, while green represents no curtailment.

Figure 7. Yearly average hydrogen demand curtailment rate at country level in the PCI/PMI hydrogen infrastructure level for base weather scenario and check of the threshold of IGI indicator 1 (unit: %).





The number of countries experiencing hydrogen demand curtailment increases across the assessment years. Curtailment occurs in 13 of 27 countries in 2030, 14 in 2035, 23 in 2040 and 25 in 2050. Differences in curtailment rates across countries reflect variations in infrastructure development, demand levels and supply availability.

In comparison with IGI indicator 2, this IGI indicator focusses on supply availability. As explained in the description of the PCI/PMI hydrogen infrastructure level (see section 3 and Figure 2), with limited availability of extra-EU supplies, hydrogen demand is satisfied mainly with electrolytic hydrogen production (P2X) and hydrogen production from natural gas – predominantly through Steam Methane Reforming (SMR). Countries with higher availability of supply from those sources or from imports show lower curtailment rates.

Table 5 presents a country-level analysis based on the hydrogen supply-demand and pipeline flow for the assessment years.

Table 5. Country-level assessment of hydrogen demand curtailment based on demand, supply and pipeline flows

COUNTRY	2030	2035	2040	2050
AT	P2X production is equal to demand.	P2X production is equal to demand.	Most demand is met by domestic P2X production.	Most demand is met by domestic P2X production.
BE	Demand is mainly met by SMR, with limited P2X production and minor inflows from DE.	Production mainly SMR, with limited P2X. DE/NL flows and liquid imports.	Production mainly SMR, with limited P2X, flows with DE, NL and the UK, plus liquid imports.	Production mainly SMR, with limited P2X, flows with DE, NL and the UK, plus liquid imports.

COUNTRY	2030	2035	2040	2050
BG	Low production. Country is isolated.	P2X increases. Connection with GR.	Most demand met by domestic P2X and GR connection.	Most demand met by domestic P2X and GR connection.
CY	Demand fully met by domestic P2X.	Production below demand. Country remains isolated.	Production below demand. Country remains isolated.	Production below demand. Country remains isolated.
CZ	Low P2X production. Country is isolated.	Low production. Import from UA through SK	Low production. Imports from UA through SK and flows from DE.	Low production. Imports from UA through SK and flows from DE.
DE	P2X and SMR production. Flows from FR and DK. Flows mainly to NL.	Demand is supported by domestic P2X and lower SMR production. Inflows mainly from FR, DK, FI and PL.	Demand is supported by domestic P2X and lower SMR production. Flows mainly from FR, DK, FI, NL and PL.	Demand is supported by domestic P2X and lower SMR production. Flows mainly from FR, DK, FI, NL and PL.
DK	Demand fully met by domestic P2X. Exports to DE.	Demand fully met by domestic P2X. Exports to DE.	Demand fully met by domestic P2X. Exports to DE.	Demand fully met by domestic P2X. Exports to DE.
EE	No production. Country is isolated.	Low P2X production. Flows from LV.	P2X production higher than own demand. Flows from LV to FI.	P2X production higher than own demand. Flows from LV to FI.
ES	Demand is fully met by domestic P2X production. Country is isolated.	Demand is fully met by domestic P2X production. Flows from PT and to FR.	Demand is fully met by domestic P2X production. Flows from PT and to FR.	Demand is fully met by domestic P2X production. Exports to FR and from/to PT.
FI	Low P2X and SMR production compared to demand. Flows from SE.	Low P2X and SMR production compared to demand. Flows from/to SE and DE.	P2X and SMR production higher than demand. Flows mainly from/to DE and SE.	P2X and SMR production higher than demand. Flows mainly from EE and from/to DE.
FR	P2X and SMR production are low. Limited exports to DE.	Demand is met by domestic P2X and SMR production. Flows mainly from/to ES and DE.	Demand is met by domestic P2X and SMR production. Flows mainly from/to ES, BE and DE.	Demand is met by domestic P2X only. Flows mainly from/to ES, BE and DE.
GR	Demand is fully met by domestic P2X production.	Demand is fully met by domestic P2X production. Connection with BG.	Demand is fully met by domestic P2X production. Connection with BG.	Demand is fully met by domestic P2X production. Connection with BG.
HR	Demand is fully met by domestic P2X production. Country is isolated.	Demand is fully met by domestic P2X production. Country is isolated.	Demand is fully met by domestic P2X production. Country is isolated.	Demand is fully met by domestic P2X production. Country is isolated.
HU	Very low P2X production compared to demand. Country is isolated.	Very low P2X production compared to demand. Flows from SK. Imports from UA through SK.	Very low P2X production compared to demand. Import from UA through SK.	Very low P2X production compared to demand. Import from UA through SK.
IE	No production. Country is isolated.	Demand is fully met by domestic P2X production. Country is isolated.	Demand is fully met by domestic P2X production. Country is isolated.	Demand is fully met by domestic P2X production. Country is isolated.
IT	Demand is fully met by domestic P2X and SMR production.	Production is based on P2X and SMR. Imports from DZ and flows to AT and CH.	Production is based on P2X and SMR. Imports from DZ and flows to AT and CH.	Production is based on P2X and SMR. Imports from DZ and flows to AT and CH.

COUNTRY	2030	2035	2040	2050
		from DZ and flows to AT.		from DZ and flows to AT and CH.
LT	Demand is fully met by domestic P2X and SMR production.	Demand is fully met by domestic P2X and SMR production. Flows to PL.	P2X and SMR production higher than demand. Flows from/to PL and LV.	P2X production higher than demand. Flows from/to PL and LV.
LU	Very low P2X production. Country is isolated.	Very low P2X production. Country is isolated.	Very low P2X production. Flows from FR.	Very low P2X production. Flows from FR.
LV	No hydrogen demand and no production.	No hydrogen demand. P2X production is exported to LT and EE.	No hydrogen demand. P2X production is exported to LT and EE.	No hydrogen demand. P2X production is exported to LT and EE.
MT	No hydrogen demand and no production.	No hydrogen demand and no production.	No hydrogen demand and no production.	No hydrogen demand and no production.
NL	Demand is mostly met by SMR, with a smaller contribution from P2X production. No flows.	Demand is met by P2X and SMR production. Exports from/to BE and DE.	Demand is mostly met by P2X production, with some SMR. Exports from/to BE and DE.	Demand is mostly met by P2X production, with some SMR. Exports mainly from/to BE and DE. Lower liquid imports.
PL	Demand is fully met by domestic P2X production. Country is isolated.	Higher P2X production than demand. Flows to DE and LT/Baltics.	Higher P2X production than demand. Flows from/to DE and LT/Baltics.	Higher P2X production than demand. Flows from/to DE and LT/Baltics.
PT	Demand is fully met by domestic P2X production. Country is isolated.	Demand is met by domestic P2X with some SMR production. Exports to ES.	Demand is met by domestic P2X production. Exports to ES.	Demand is met by domestic P2X production. Flows from/to ES.
RO	Very low P2X production compared to demand. Country is isolated.	Very low P2X production compared to demand. Country is isolated.	Very low P2X production compared to demand. Country is isolated.	Very low P2X production compared to demand. Country is isolated.
SE	Demand equals domestic P2X production. Flows to FI north.	Demand equals domestic P2X production. Flows from/to FI north.	Demand slightly higher than domestic P2X production. Flows from/to FI north.	Lower P2X production compared to demand. Flows from FI north.
SI	Demand is fully met by domestic P2X production. Country is isolated.	Demand is fully met by domestic P2X production. Country is isolated.	P2X production is less than demand. Country is isolated.	P2X production is less than demand. Country is isolated.
SK	P2X production is lower than demand. Country is isolated.	P2X production is lower than demand. Flows mainly from AT. Flows to HU.	P2X production is lower than demand. Flows mainly from AT, CZ and UA. Flows to HU.	P2X production is lower than demand. Flows mainly from AT, CZ and UA. Flows to HU.

The country-level analysis shows that in 2030, several countries rely predominantly on domestic P2X production, while those with limited domestic production and weak or no interconnections are more exposed to curtailment. Isolated countries, such as Cyprus, Slovenia, Romania, Croatia and Ireland remain particularly dependent on their own production profiles, whereas countries like Latvia and Malta appear less exposed because demand is absent.

As the PCI/PMI infrastructure level develops over time, cross-border flows become important. Already by 2035, Germany emerges as a central demand and transit hub, supported by domestic P2X and SMR production, as well as

inflows from France, Denmark, Finland, the Netherlands and Poland. The Iberian Peninsula and Denmark consistently act as strong P2X suppliers, exporting to France and Germany, respectively. Italy plays an important role for the North African import corridor, supplying Austria. The Bulgaria-Greece interconnection benefits both countries, although they remain isolated from their other neighbours. Finally, the Ukrainian interconnection helps Czechia and Hungary reduce their exposure to curtailment.

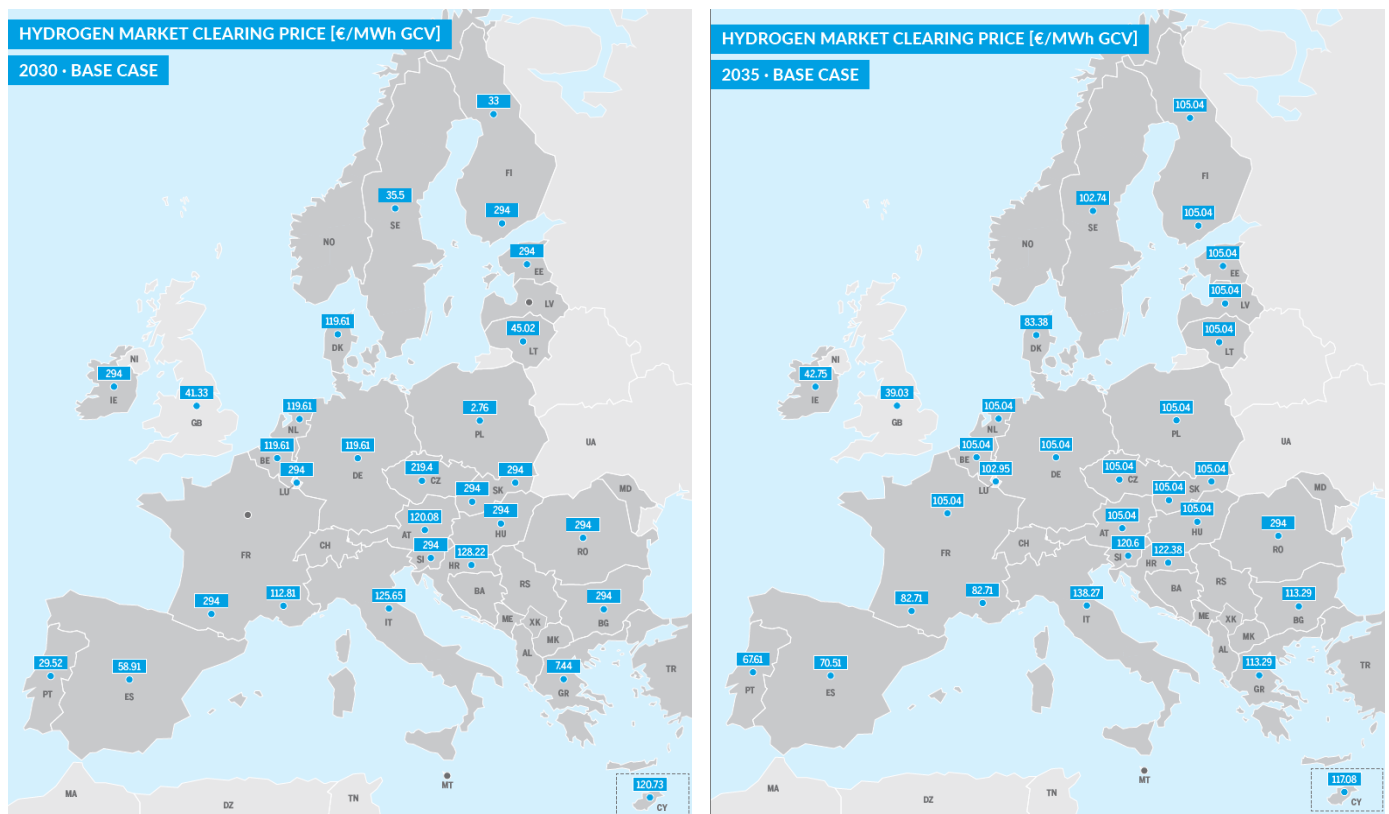
In 2040, total hydrogen demand increases sharply compared with previous years, leading to a higher number of countries experiencing curtailment of hydrogen demand, as shown in Table 5. Infrastructure continues to expand, connecting more countries and enabling surplus production to reach demand centres. Shipped imports increase from 0,37 TWh/y to 15 TWh/y providing more flows to Belgium, France, Germany and the Netherlands. Pipeline imports almost doubled between 2035 and 2040. Notable developments include the UK interconnector, which injects hydrogen into the European backbone through Belgium, and North African imports routed through Italy and Switzerland. Balkans remain isolated, while Czechia and Hungary remain dependent on inflows from Ukraine via Slovakia because of their comparatively low domestic production.

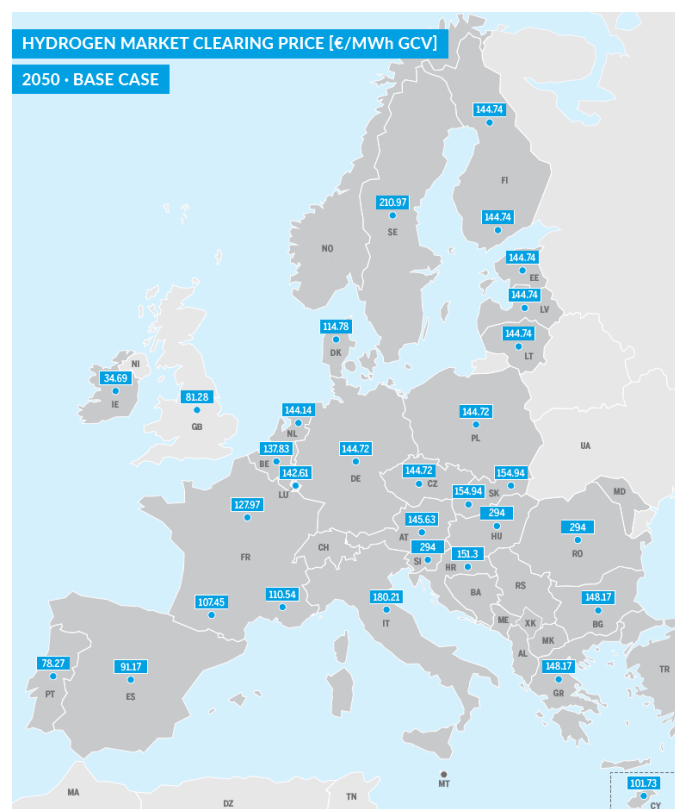
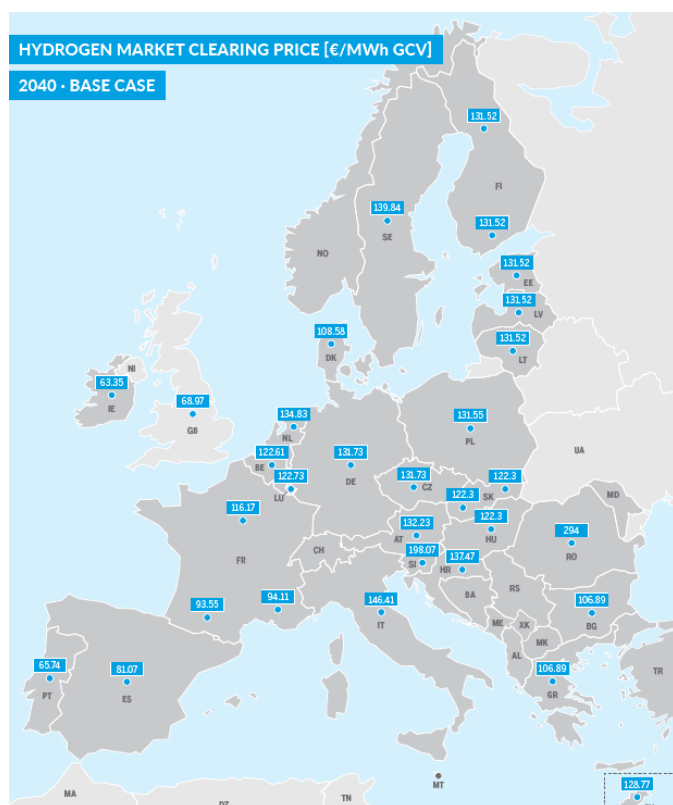
In 2050, the overall picture remains similar to 2040. Total hydrogen demand increases substantially, reaching 2087 TWh/y, compared to 1296 TWh/y in 2040. A similar pattern is observed on the supply side, with growth in domestic hydrogen production, shipped imports and pipeline imports. Importantly, pipeline imports from the UK double relatively to 2040, while shipped imports increase by around 50%. The main import corridors from North Africa and Ukraine also expand. However, several countries remain vulnerable, particularly the ones where domestic production is insufficient and cross-border flows are limited, resulting in higher curtailment levels than in the previous assessment year. Hungary records an almost 30% increase in curtailment between 2040 and 2050. This is mainly driven by a doubling of hydrogen demand over the period, while the country remains largely dependent on Ukrainian imports through Slovakia due to its low domestic production.

6.3. IGI indicator 2: Market clearing price spreads in DHEM

Overview: Hydrogen market clearing prices per country

Figure 8: Average hourly hydrogen market clearing prices by country under the PCI/PMI hydrogen infrastructure level in 2030, 2035, 2040 and 2050 (€/MWh).





The evolution of average hourly hydrogen market clearing prices appears to reflect the combined effect of supply adequacy, infrastructure availability and the level of hydrogen demand curtailment. In 2030, the PCI/PMI infrastructure level remains relatively limited, with only a few interconnected countries and restricted access to extra-EU hydrogen imports (only liquid imports). As a result, many countries rely mainly on domestic electrolytic or natural gas-based production. Where domestic supply is insufficient and interconnections are weak or absent, curtailment rates are high, which pushes market clearing prices upward, potentially towards the assumed cost of disruption for hydrogen.

2030 – high and dispersed prices driven by limited market integration

In 2030, average hourly hydrogen market clearing prices are expected to be relatively high and strongly differentiated across countries. This reflects the early stage of PCI/PMI infrastructure development, where only a limited number of countries are interconnected and access to extra-EU imports is restricted. As a result, prices are mainly determined by local supply conditions, including the availability and cost of domestic electrolytic production and hydrogen production from natural gas. Countries with limited domestic production or no connection to neighbouring systems are more exposed to scarcity pricing —for example Bulgaria, Czechia, Estonia, Hungary, Ireland, Luxembourg, Romania and Slovakia. Whereas countries with access to domestic supply, storage or import terminals show more moderate prices —for example Belgium, the Netherlands, Sweden and Spain.

2035 – lower and more convergent prices as infrastructure expands

By 2035, the expansion of PCI/PMI transmission infrastructure, storage and import routes improves the integration of national hydrogen markets as hydrogen can be transported more efficiently from supply-rich areas or import entry points towards demand centres. Average hourly market clearing prices are therefore expected to become more aligned as reflected by the convergence of many values around 105 €/MWh. The emergence of pipeline imports from North Africa and Ukraine, together with additional terminal and storage capacities, increases the available supply mix and reduces the reliance on higher cost local balancing options. Compared with 2030, price differences between countries should therefore narrow, particularly along the main emerging corridors linking the Iberian Peninsula, France, Germany, the Nordic region, Italy and Central Europe.

2040 – clearing price increase and wider price differentiation in constrained areas

In 2040, average hourly hydrogen market clearing prices increase again in several regions, despite further growth in supply and infrastructure. This reflects the strong increase in hydrogen demand (more than 60% compared to 2035), which raises the need for additional supply, imports and cross-border flows. In countries that are well connected to large production zones, import corridors or storage assets, prices remain more closely aligned with neighbouring markets - Germany, Czechia, Sweden, Finland and the Baltics. However, where infrastructure bottlenecks persist or where domestic production remains insufficient – Austria, Belgium, Italy, Slovenia, Croatia – prices may detach from the wider European price level during constrained hours. This leads to renewed price differentiation between well-integrated market areas and countries or regions with limited access to flexible supply sources.

2050 – persistent price pressure in parts of the system despite larger supply volumes

By 2050, the hydrogen system reaches a much larger scale, with higher electrolytic production, increased imports and more extensive transmission infrastructure. Nevertheless, average hourly market clearing prices remain elevated in some countries because demand growth also reaches its highest level (2097 TWh/y in 2050, compared to 1296 TWh/y in 2040). In well-integrated regions, prices reflect a broader European supply level, supported by imports, domestic production and cross-border flexibility. In contrast, countries with limited interconnection, low domestic production or constrained access to imports may continue to experience higher average prices – Sweden, Slovenia, Croatia, Romania, Bulgaria and Greece. The persistence of price differences in 2050 therefore indicates that, even with larger infrastructure and supply volumes, some regional bottlenecks continue to affect market integration – Italy, Slovakia, Austria.

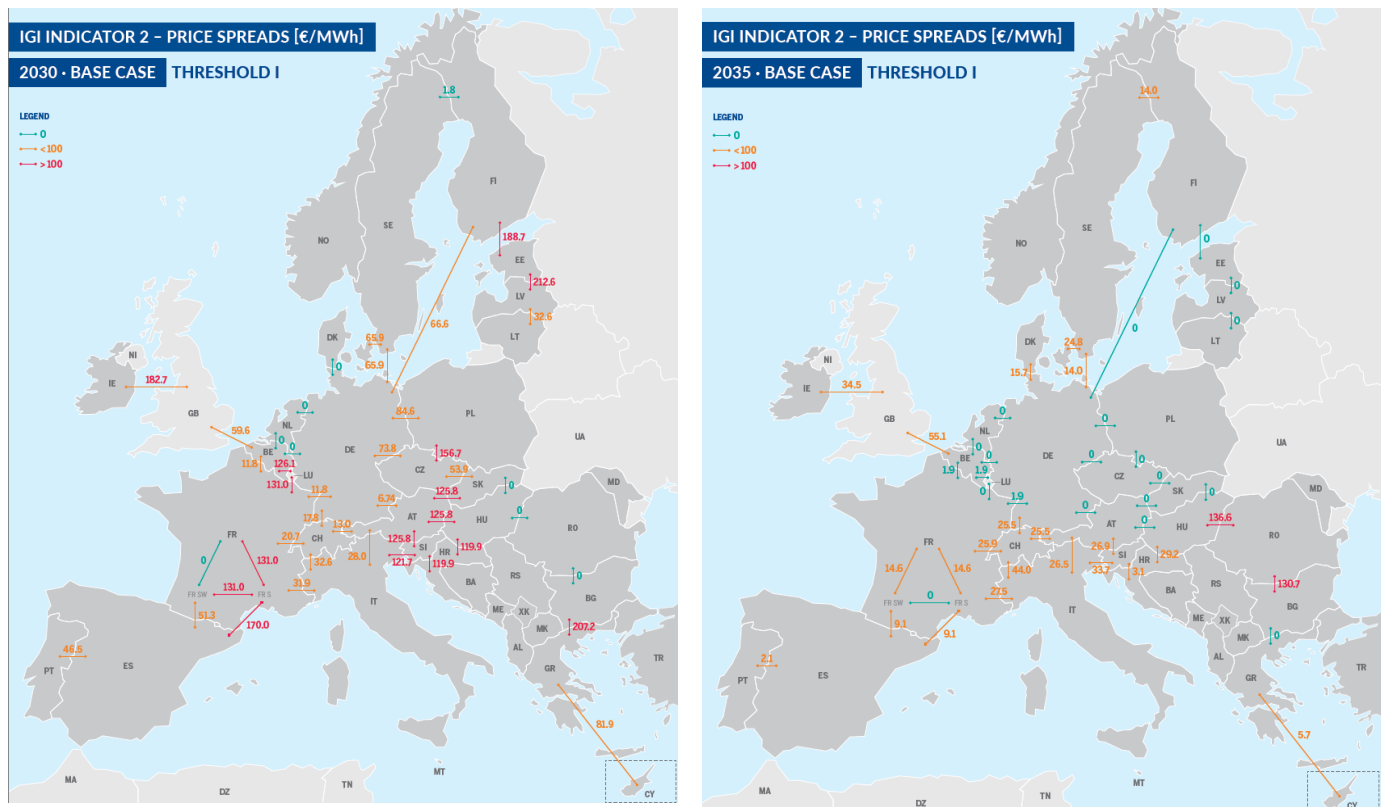
Price differences do not necessarily imply an infrastructure gap. For identification of infrastructure gaps, the thresholds of IGI indicator 2 are used.

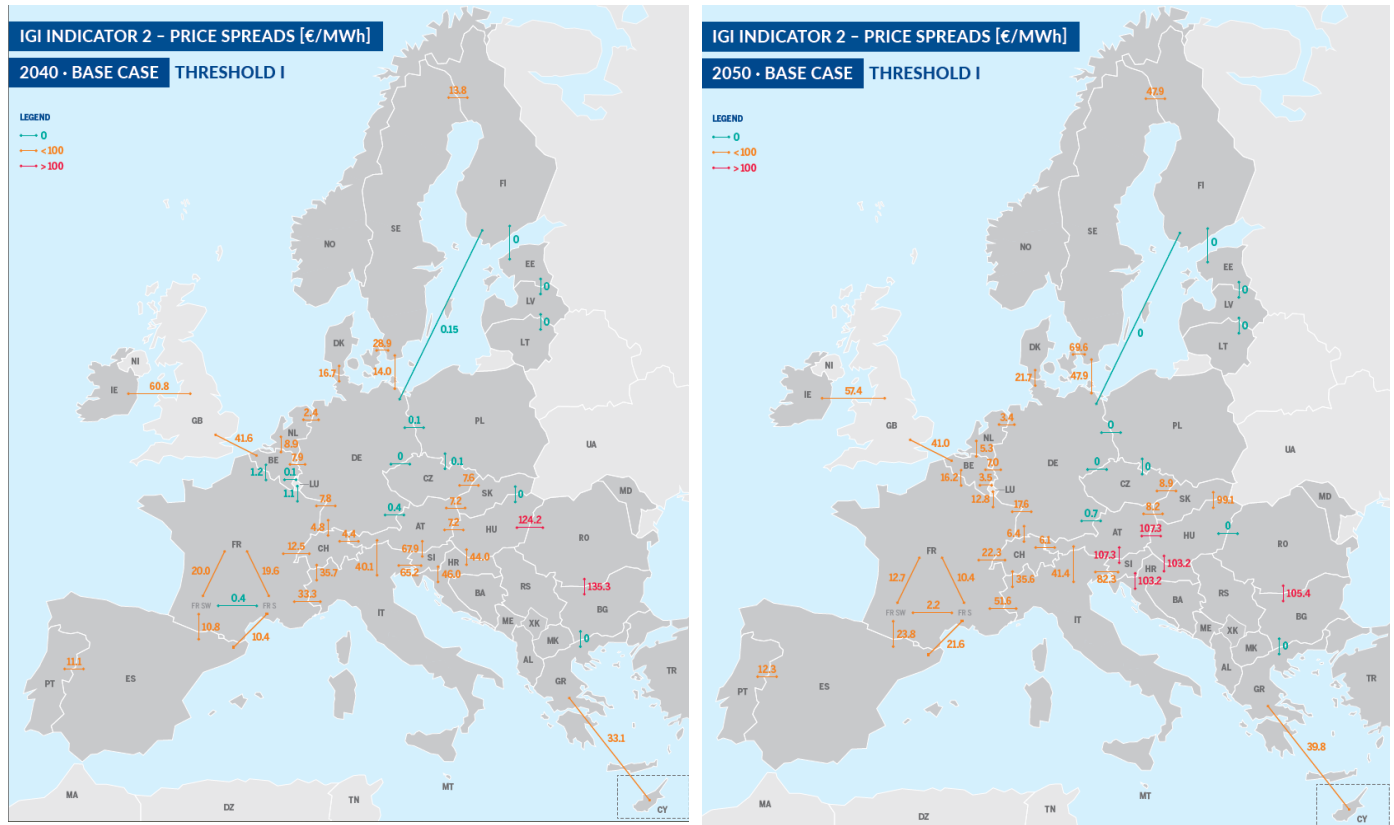
Hydrogen market clearing price spreads

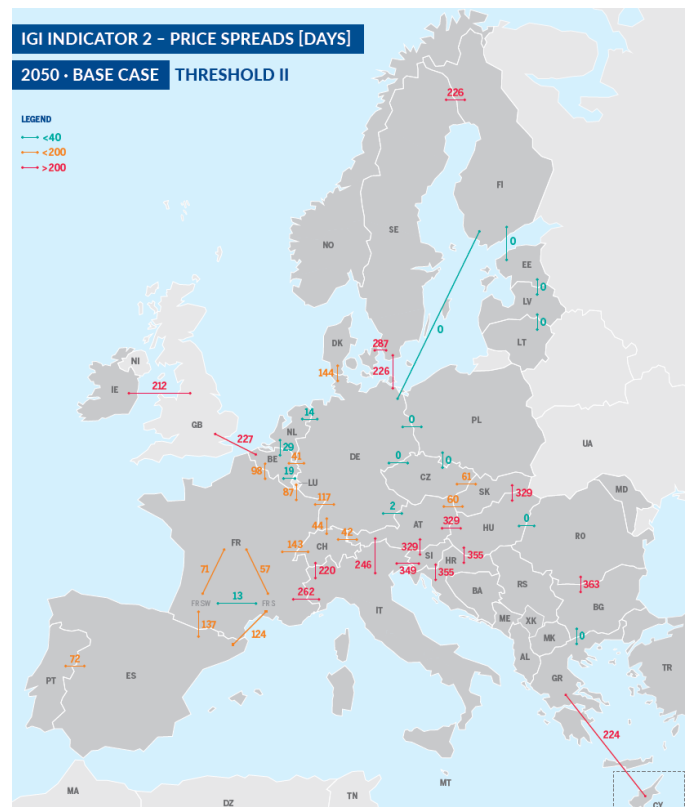
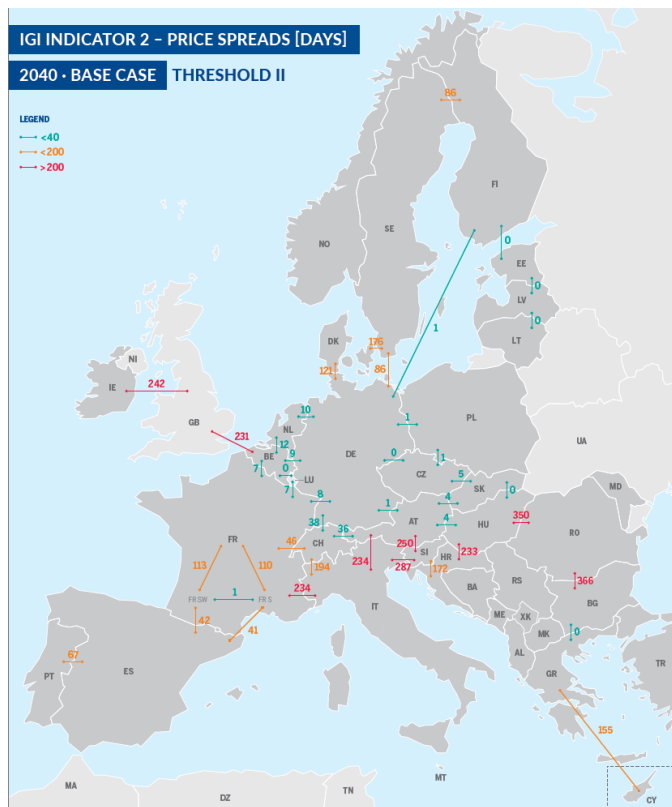
If one of the two thresholds of IGI indicator 2 is exceeded a regional hydrogen infrastructure gap is assumed to be identified (see section 4.2). Figure 9 presents the results of IGI indicator 2 and lists the borders for which Threshold 1 and/or Threshold 2 were assessed. Threshold 1 measures the yearly average of the absolute hourly hydrogen market clearing price differences between two Zone 2 nodes. It is exceeded when the annual average price difference is above 2 €/MWh. This threshold captures persistent differences in market clearing prices over the year, even when the daily price spread is not extremely high. It is aligned with the threshold value used in ENTSO-E's [draft Implementation Guidelines for TYNDP 2026](#), based on updated demand levels in the NT+ scenario, as well as on a recommendation by

ACER. Threshold 2 identifies more pronounced and recurring price separation. It is exceeded when the absolute average daily hydrogen market clearing price spread is above 20 €/MWh for more than 40 days per year. The values reported under Threshold 2 therefore represent the number of days during which significant daily price separation occurs. The values are colour-coded in the table to indicate levels relative to the set threshold: red signifies a price spread/number of days above the relevant threshold, while green represents a price spread/number of days below it.

Figure 9. IGI Indicator 2 - Average hydrogen market-clearing price spreads between countries in 2030, 2035, 2040 and 2050: Threshold 1 (€/MWh)







2030 shows the most widespread and severe price separation. Many borders have very high Threshold 1 values and Threshold 2 values close to a full year, for example:

- Bulgaria-Greece border: 207.20 and 365 days
- Estonia-Finland border: 188.73 and 365 days
- Estonia-Latvia border: 212.59 and 365 days
- Belgium-Luxembourg border: 126.10 and 365 days
- Austria-Hungary, Austria-Slovenia, Austria-Slovakia (West) borders: 125.76 and 365 days

This suggests that in 2030, several borders experience almost constant or very frequent price detachment, reflecting the limited development the PCI/PMI hydrogen infrastructure level or the prevalence of isolated networks and restricted market integration.

In contrast, connected market areas exhibit price convergence, or no material price spread. This indicates that, despite the limited scale of the market in 2030, the infrastructure between these countries is sufficient to enable hydrogen exchanges without creating transmission bottlenecks. This is observed, for example, at the Finland-Sweden, Belgium-Germany, Belgium-Netherlands, Germany-Denmark and Germany-Netherlands borders.

It should also be noted that the absence of a price spread, does not necessarily indicate an efficiently integrated market. In some isolated systems, neighbouring countries display identical hydrogen clearing prices because both markets reach the hydrogen curtailment price. Consequently, no price differential is observed despite the lack of effective integration. Examples include the Bulgaria-Romania, Hungary-Romania and Hungary-Slovakia borders.

By 2035, many spreads decline sharply or disappear, especially where additional infrastructure becomes available. Examples include:

- Austria-Germany border: from 6.74 €/MWh / 37 days in 2030 to 0 €/MWh and 0 in 2035
- Austria-Slovakia and Austria-Hungary: from 125.76 €/MWh and 365 in 2030 to 0 €/MWh and 0 in 2035
- Bulgaria-Greece border: from 207.20€/MWh 365 days in 2030 to 0 €/MWh and 0 in 2035
- Czechia-Germany border: from 73.83 €/MWh and 225 to 0 €/MWh and 0
- Estonia-Finland and Estonia-Latvia from very high values to 0 €/MWh and 0

Therefore, IGI results show major improvement in market integration for several regions.

In 2040 and 2050, price spreads reappear or increase on several borders, likely because demand growth outpaces infrastructure or supply development in some areas, leading to persistent or renewed bottlenecks. This increase is much more pronounced for countries that are weakly connected such as Hungary, or completely isolated Slovenia and Romania:

- Austria-Hungary, Slovakia-Hungary borders: increases again to 107.28/99.10 €/MWh and 329/329 days in 2050
- Croatia-Hungary border: increases again to 103.18 €/MWh and 355 days in 2050
- Austria-Slovenia and Croatia-Slovenia borders: 107.28/103.18 €/MWh and 329/355 days in 2050
- Bulgaria-Romania border remains high from 2035 onwards, reaching 105.44 €/MWh and 363 days in 2050

IGI indicator 2 results also indicate that by 2035 a substantial improvement in market integration in several regions is possible. This is reflected in the sharp reduction or complete disappearance of hydrogen market clearing price spreads on several borders. Whereas in 2030, hydrogen market-clearing prices in Northern and Western Europe converge in Germany, Denmark, The Netherlands and Belgium, with lower prices in Finland and Sweden, in 2035, a larger group of countries have alignment of prices, extending to Central Europe, including Austria, Czech Republic, Slovakia, Hungary, Poland, Luxembourg, Estonia, Latvia and Lithuania.

This improvement appears to be closely linked to the emergence of the PCI/PMI European network which enables stronger cross-border flows and availability of extra-EU imports. Both factors support a greater price convergence between previously constrained markets.

6.4. Analysis with hypothetical infrastructure approach

The main purpose of this section is the investigation of any system limitations due to the potential bottlenecks in the PCI/PMI infrastructure level, without any implications regarding the development of specific projects⁶. To explore different possibilities and limitations, five hypothetical scenarios are defined in the Annex D2 – IGI implementation guidelines:

- **Unlimited Pipelines (UP):** unlimited connections between (transmission) nodes for all nodes defined in topology;
- **Unlimited Storage (US):** unlimited storage withdrawal, injection and working gas volume in existing storage countries part of PCI/PMI infrastructure level;
- **Unlimited Imports (UI):** unlimited imports capacities for imports defined in the PCI/PMI infrastructure level;
- **Unlimited Pipelines and Storage (UPS):** unlimited connections between nodes, plus unlimited storage withdrawal, injection and working gas volume in existing storage countries part of PCI/PMI infrastructure level;
- **Unlimited Pipelines and Storages and Imports (UPSI):** unlimited connections between nodes, plus unlimited storage withdrawal, injection and working gas volume in existing storage countries part of PCI/PMI infrastructure level, plus unlimited imports capacities for imports defined the PCI/PMI infrastructure level;

The simulation results indicate two different system behaviours across the assessment years. For 2030 and 2035, hydrogen demand curtailment is fully avoided or negligible through the unlimited pipelines scenario. It can be concluded that bottlenecks are infrastructure-related and not supply-related. However, for 2040 and 2050, curtailment is only fully mitigated under the combined unlimited pipelines and storages scenario. For that reason, the last hypothetical scenario that includes the combination of Unlimited Pipelines, Storages and Imports (UPSI) was not considered necessary and is not presented.

Years 2030 and 2035:

Under the unlimited pipeline scenario, H2 curtailment in Europe is fully mitigated in 2030 and nearly eliminated by 2035. In contrast, it is not fully mitigated under the unlimited storage or unlimited imports scenarios. This suggests that Europe's system constraints are pipeline bottlenecks that limit its ability to meet demand. Supply within Europe and additional external sources are sufficient for 2030 and 2035. Indeed, in US and UI hypothetical scenarios, some countries have limited interconnection capacity or remain isolated, such as the interconnected Greek - Bulgarian systems and other countries, such as Slovenia, Croatia and Hungary.

⁶ See section 6 of Annex D2 - Hydrogen Infrastructure Gaps Identification Methodology, available in the [TYNDP 2026 section](#) of the ENTSG website

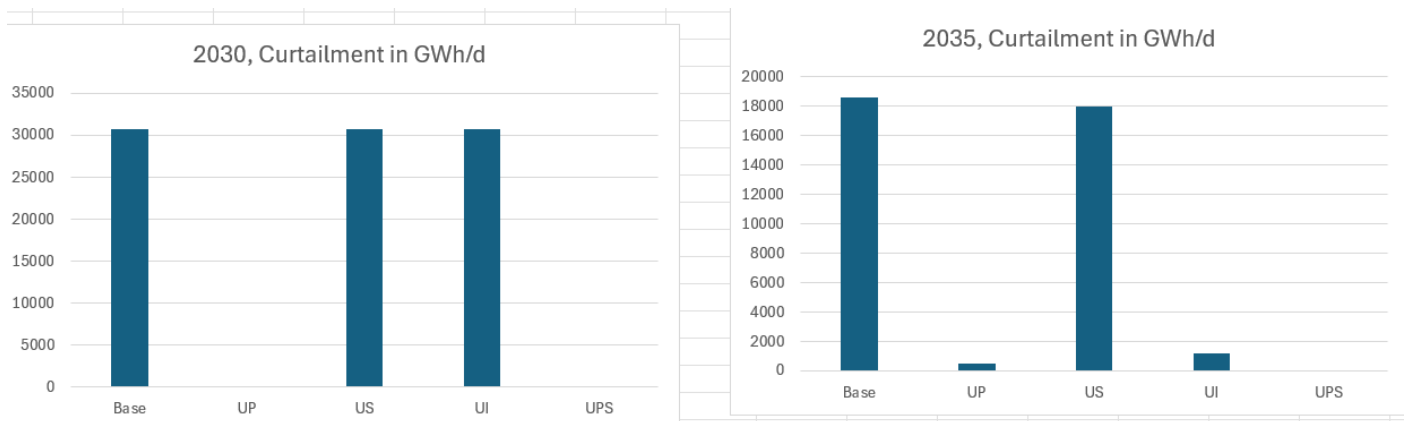


Figure 11. Hydrogen demand curtailment under unlimited infrastructure sensitivities for 2030 and 2035 (EU + UK + CH)

Imports are not utilised in the Base, UP, US, and UPS for 2030. By 2035, reduced storage bottlenecks and improved interconnections lower the need for additional extra-EU imports. Hydrogen demand is primarily met through increased SMR generation (+25% in 2030 and +26% in 2035) and better integration of DRES and SRES.

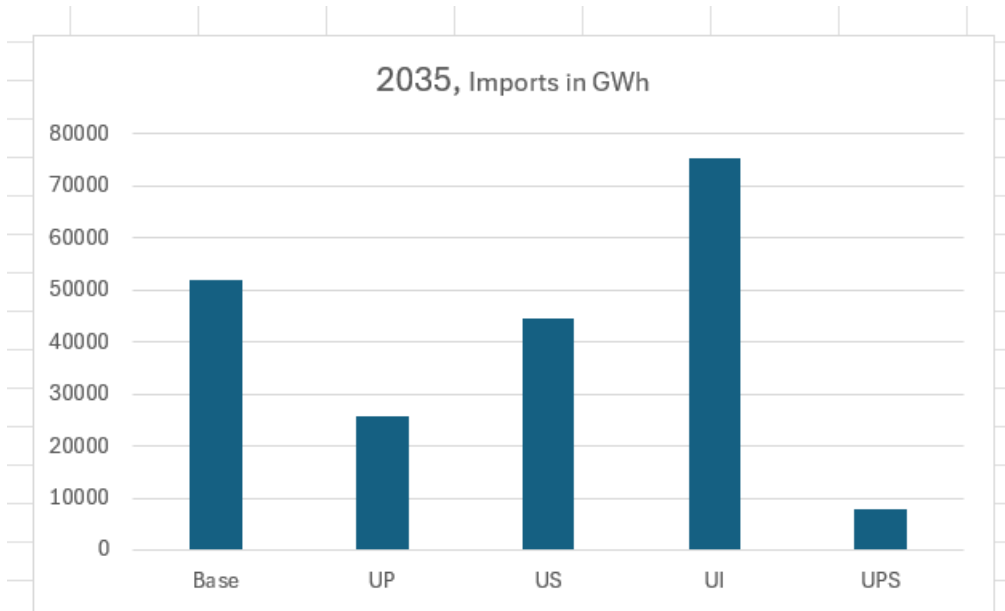


Figure 12: Hydrogen imports in GWh/y under unlimited infrastructure sensitivities for 2035 (EU + UK + CH)

Years 2040 and 2050:

The results for 2040 and 2050 indicate that hydrogen shortages can only be mitigated under the Unlimited Pipes and Storage (UPS) scenario. While shortages persist in all other cases, the Unlimited Imports (UI) scenario achieves the greatest reduction in curtailment and therefore represents the second-best performing option.

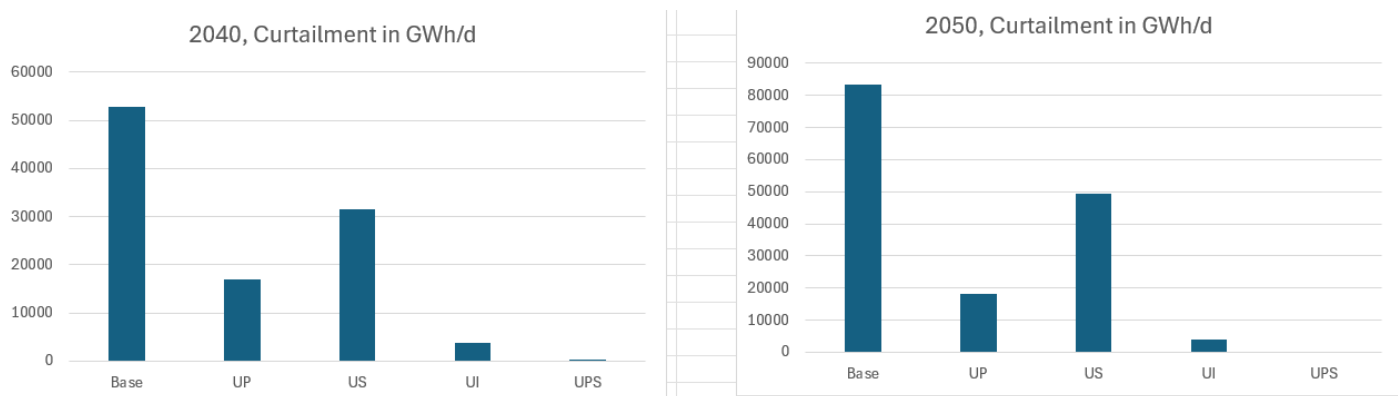


Figure 13: Hydrogen demand curtailment under unlimited infrastructure sensitivities for 2040 and 2050 (EU + UK + CH)

Under the UPS scenario, unlimited pipeline capacity limits hydrogen shortages to the winter months (November to February/March), while additional storage helps satisfy demand during these periods. Under the unlimited imports scenario, shortages occur every month indicating that bottlenecks persist, while greater flexibility is needed to meet hydrogen demand in Europe. The lack of flexibility is offset by almost three times more hydrogen imports delivered via pipelines and LH₂. This is also evident in the US scenario, where the additional flexibility provided by storage reduces the use of LH₂ imports by almost 100% in 2040 and by 75% in 2050.

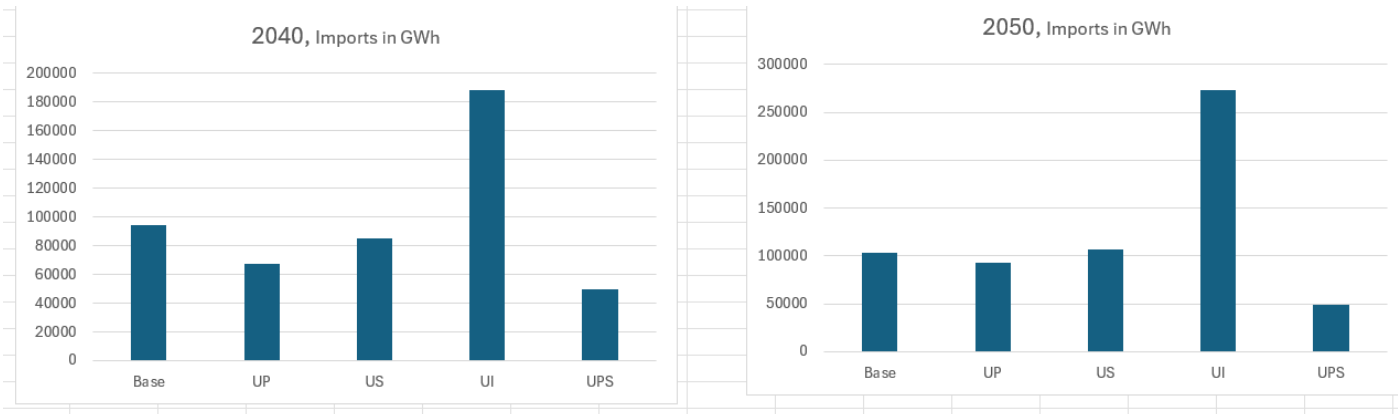


Figure 14: Hydrogen imports in GWh/y under unlimited infrastructure sensitivities for 2040 and 2050 (EU + UK + CH)

6.5. Analysis under-supply sensitivity: low renewables and electrolyser capacities (Low RES)

The sensitivity analysis presented in this section aims to complement the IGI assessment by evaluating the impact of reduced availability of electrolytic hydrogen supply. In the IGI base case, electrolytic hydrogen represents approximately 80% of the satisfied demand.

In the IGI modelling framework, electrolysers are supplied by dedicated renewables (DRES), by shared renewables (SRES), or alternatively by electricity procured from the power market⁷. As a result, installed capacity and availability of renewable electricity generation for hydrogen production are key-factors enabling the full deployment of electrolytic hydrogen supply.

This sensitivity assesses how the hydrogen supply mix may diversify and how the infrastructure gaps could change in response to a significant reduction in electrolyser capacity, assumed at 10%, together with a corresponding reduction in the expected capacities of the associated renewable energy sources, as described in section 6.2 of Annex D2.

6.5.1. Development of hydrogen supply and demand over the assessment period

Overview: supply-demand balance and yearly flows

While native hydrogen demand remains unchanged, the distribution of hydrogen supply varies significantly. Hydrogen imports – both via pipeline and in liquid form – as well as hydrogen production from natural gas increase to partially compensate for the reduction or unavailability of electrolytic supply. In line with demand growth, the increase in imports and natural-gas-based hydrogen production is significantly more pronounced in 2040 and 2050.

It should also be noted that, despite the flexibility provided by alternative supply sources, not all hydrogen demand met under the reference electrolytic supply assumptions can be replaced by other sources. As a result, hydrogen demand curtailment increases in all the years assessed, with more pronounced increase in 2040 and 2050, as curtailment rates rise progressively, mainly driven by demand growth.

Changes in the hydrogen supply mix also affect market clearing prices, as detailed in section 4.2. Overall, reduced electrolytic production leads to higher market clearing prices. As a consequence of this price increase, the analysis shows a subsequent reduction in hydrogen demand for electricity generation, specifically from hydrogen-fired CCGTs.

Table 6: Supply and demand balance expressed in TWh/y (GCV terms) for the PCI/PMI infrastructure level and all years for base case and Low Res and electrolyser capacities

Yearly hydrogen supply-demand balance	PCI/PMI IL		PCI/PMI IL		PCI/PMI IL		PCI/PMI IL	
	2030		2035		2040		2050	
	BASE	LOW RES	BASE	LOW RES	BASE	LOW RES	BASE	LOW RES

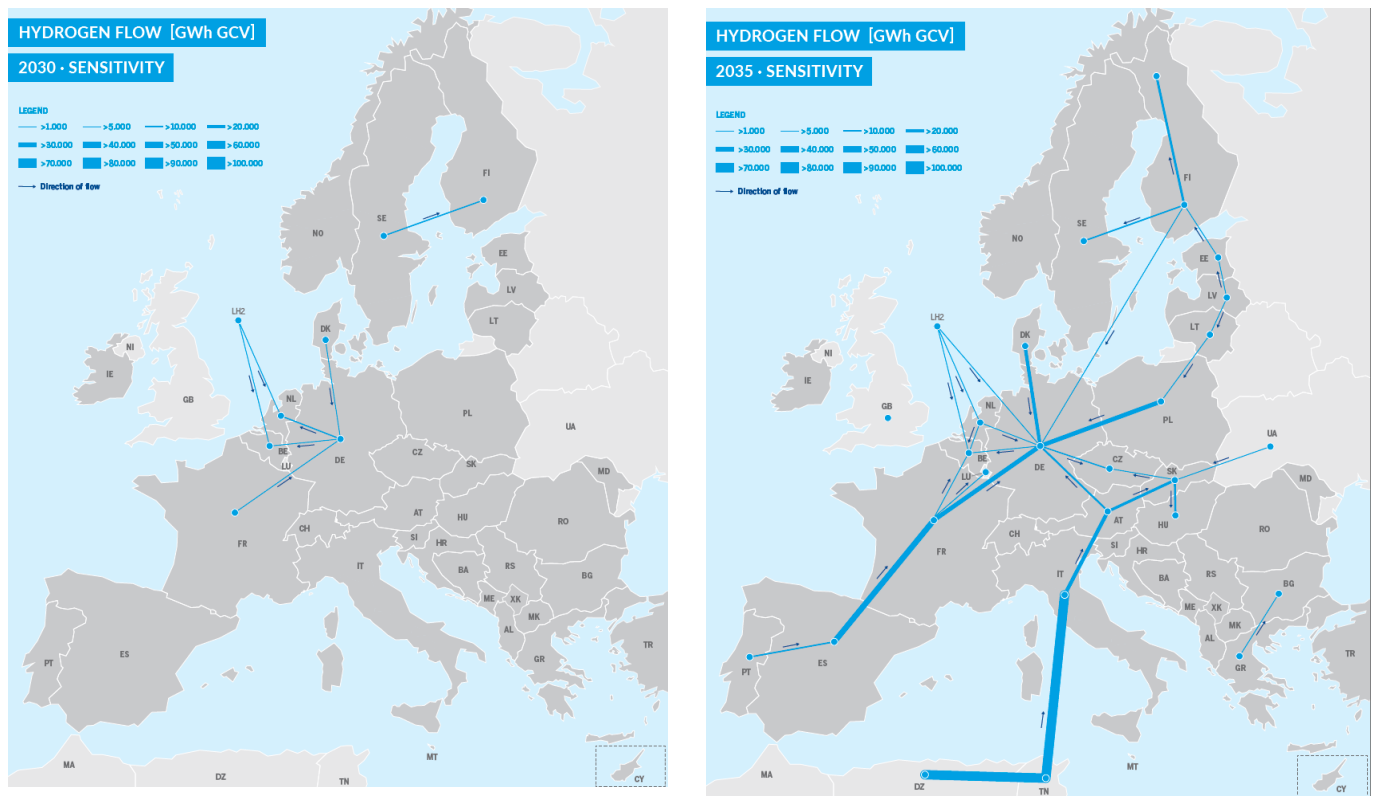
⁷ Electrolyser and associated RES (DRES, SRES or e-market RES) are described in sections 8.4 and 8.6 of ENTSO-E and ENTSG 2026 Scenarios Methodology Report

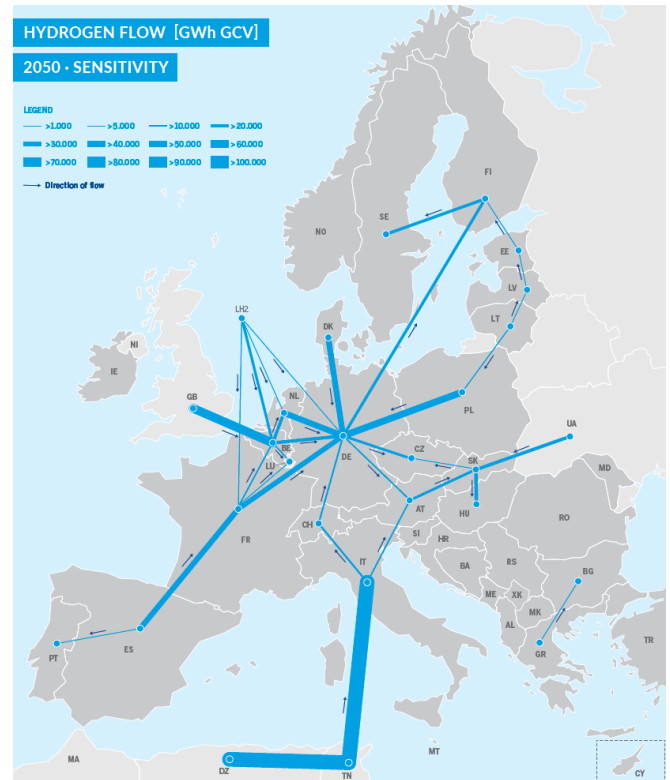
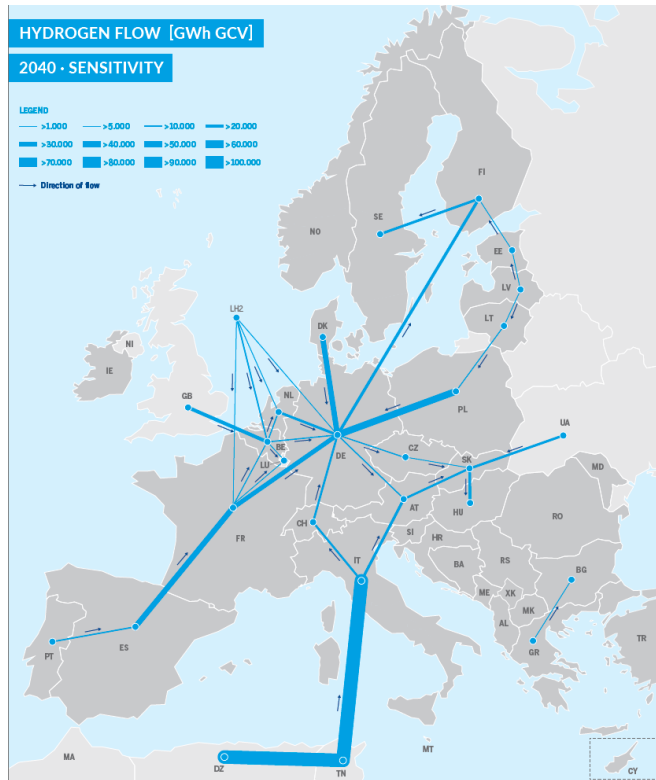
H ₂ produced via electrolysis	204	191	593	519	1005	857	1698	1491
H ₂ produced using natural gas	95	107	116	152	107	161	152	206
H ₂ shipped imports	0	0	0,37	1,17	14,88	24	22,84	38,68
H ₂ pipeline imports	0	0	62	79	107	127	115	144
H ₂ injection fuel	0,08	0,09	0,45	0,44	0,51	0,50	0,58	0,57
Demand CCGT H ₂	0,80	0,6	27	9	85	39	59	20
Curtailed H ₂ native demand	36	37	22	23	62	80	98	167
Total native H ₂ demand	334		766		1210		2027	
% CR on native demand EU27	11%	11%	3%	3%	5%	7%	5%	8%
Total H ₂ demand	335	335	793	775	1296	1250	2087	2048
Total H ₂ supplied	299	298	771	751	1234	1169	1988	1880

As shown in Figure 15 below, changes in the annual distribution of flows are directly linked to the lower availability of electrolytic hydrogen supply. Compared with the base assessment, the following differences are observed:

- Reduced flows through the Iberian and Baltic corridors.
- Increased flows through the North African and Ukrainian import corridors.
- Increased liquid hydrogen imports into France, Germany, Belgium and the Netherlands.

Figure 15. Hydrogen flows through the different assessment years in the under-supply sensitivity.

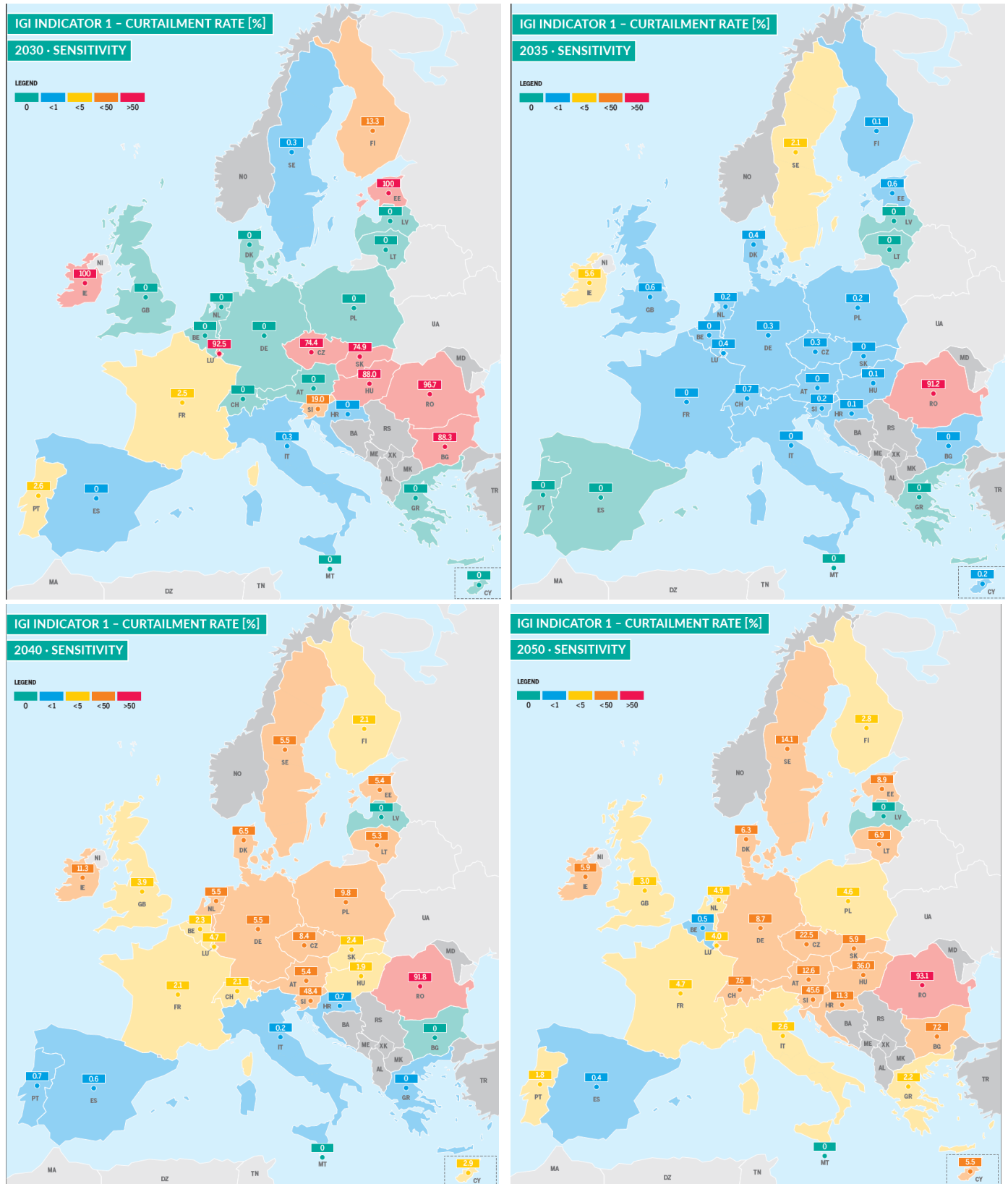




6.5.2. IGI indicator 1: Curtailed hydrogen demand in DHEM in the hydrogen under-supply sensitivity

Figure below shows yearly average curtailment rates of hydrogen demand in the Zone 2 nodes of different countries under the hydrogen under-supply sensitivity. The yearly average hydrogen curtailment rates are thereby colour-coded in the table to indicate levels relative to the set threshold.

Figure 16. Yearly average hydrogen demand curtailment rate at country level in the PCI/PMI hydrogen infrastructure level for base weather scenario in the under-supply sensitivity and check of the threshold of IGI indicator 1 (unit: %).



As in the base case, the number of countries experiencing hydrogen demand curtailment increases across the assessment years under the low P2X and RES sensitivity. Curtailment occurs in 16 of 27 countries in 2030, 21 in 2035, 24 in 2040 and 25 in 2050, compared to 13, 14, 23 and 25 respectively, in the base case. The impact on the number of countries exceeding the IGI Indicator 1 threshold is more evident in 2035. However, the additional curtailment observed in 2035 remains limited.

In 2030, the overall pattern remains comparable with the base case, with the highest curtailment rates persisting in countries already significantly curtailed in the base case assessment. Some of these countries include Bulgaria from 85.57% to 88.31%, Czechia from 69.81% to 74.37%, Hungary from 85.23% to 88.04%, Luxembourg from 90.78% to 92.53% and Slovakia from 68.95% to 74.85%. Ireland and Estonia remain fully curtailed. A notable change compared with the base case is observed in Slovenia, where curtailment increases from 0% to 19% aligned with the same reduction in electrolytic capacity, higher than EU average reduction.

By 2035, the development of the PCI/PMI hydrogen infrastructure reduces the high curtailment rates observed in 2030, as in the base case. Nevertheless, the Low P2X and RES Sensitivity results in a broader geographical distribution of curtailment than in the base case, as more countries exceed the IGI indicator 1 threshold. More concretely, Austria, Belgium, Bulgaria, France, Croatia, Hungary and Poland experienced no curtailment in the base case, but they indicated some curtailment in the sensitivity, yet below 0.2%. Two countries stand out, namely Romania, where curtailment increases from 89.11% to 91.18%, and Ireland, where it increases from 3.55% to 5.59%.

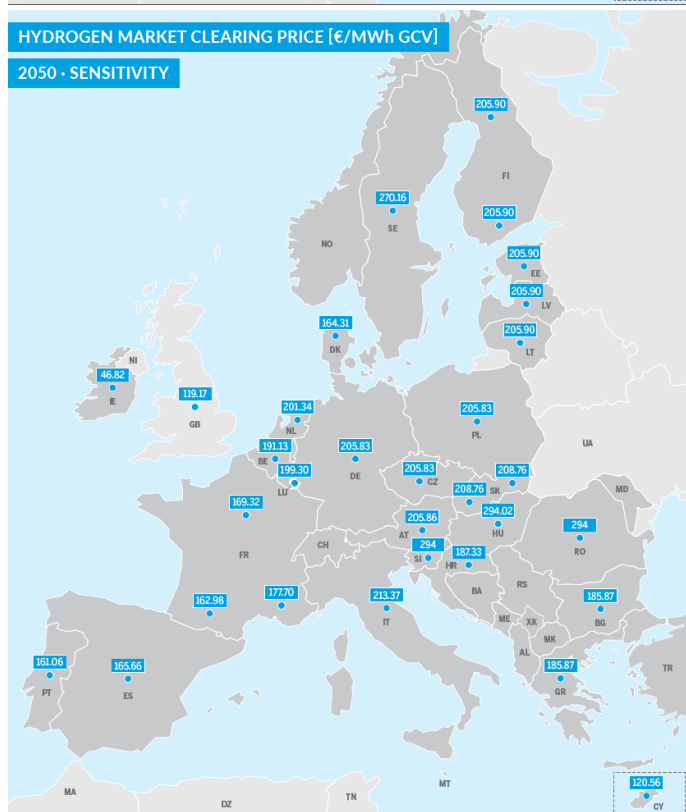
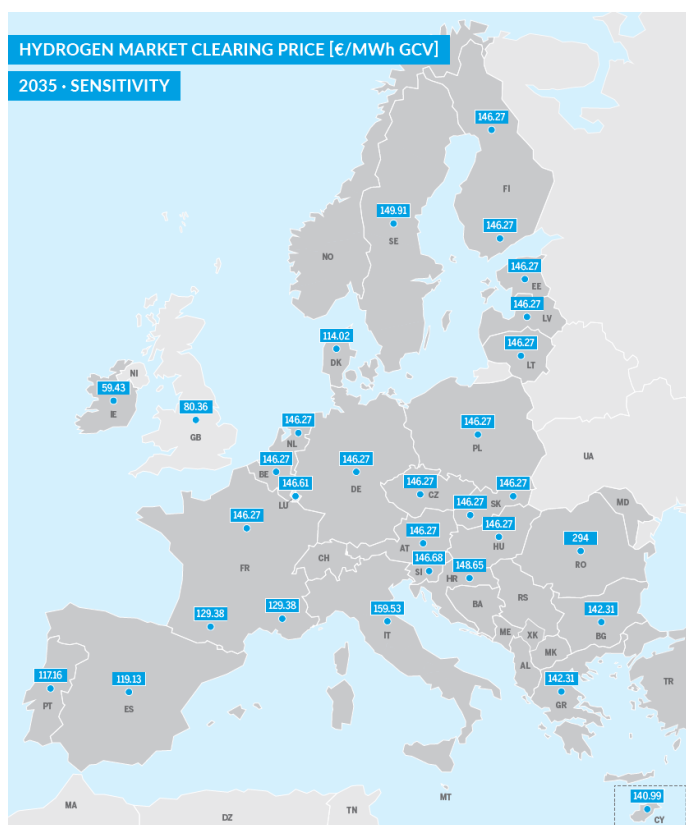
In 2040, hydrogen demand curtailment is already widespread under the base case, with 23 countries exceeding the IGI Indicator 1 threshold. The impact of the sensitivity is reflected less in the number of affected countries – increased to 24. The largest increase is observed in Slovenia, where curtailment rises from 36.54% to 48.43%. Additionally, Czechia increases from 4.08% to 8.42%, Ireland, from 8.52% to 11.32%, and Poland, from 7.04% to 9.78%. Higher curtailment is observed also across several interconnected markets, including Austria, Germany, Denmark, the Netherlands and Sweden around 3% increase. Romania remains the country with the highest curtailment rate, increasing from 89.85% to 91.78%.

All the countries experienced curtailment in 2050 in both base case and sensitivity. However, curtailment rates increase considerably in several countries. The largest increases are observed in Slovenia, from 27.54% to 45.63%, Czechia, from 10.15% to 22.49%, Sweden, from 3.47% to 14.10%, Croatia, from 2.99% to 11.30%, and Austria, from 5.35% to 12.62%. Higher curtailment is also observed in Germany, Bulgaria, Cyprus and Hungary, while Romania remains highly curtailed, increasing from 91.28% to 93.14%.

6.5.3. IGI indicator 2: Market clearing price spreads in DHEM in the hydrogen under-supply sensitivity

Overview: Hydrogen market clearing prices per country

Figure 17.: Average hourly hydrogen market clearing prices by country under the PCI/PMI hydrogen infrastructure level in 2030, 2035, 2040 and 2050 in the under-supply sensitivity (€/MWh).



Compared with the base case, the Low P2X and RES Sensitivity results in higher average hydrogen market-clearing prices across most European countries and assessment years, while broadly maintaining some of the geographical patterns identified under the base case. The reduction in P2X capacity and efficiency, together with the corresponding reduction in RES supply, reduces the availability of electrolytic hydrogen production and results in a general upward shift in hydrogen market-clearing prices. The magnitude of this effect increases over the assessment years.

In 2030, a similar pattern can be observed as in the base case. Countries where very high market-clearing prices occur, including Bulgaria, Estonia, Hungary, Ireland, Luxembourg, Romania, Slovenia and Slovakia, remain around to €294/MWh. At the same time, higher prices are evident in several other countries. The most pronounced increase is observed in Czechia, where the average price increases from €219.40/MWh to €294/MWh. Also, Spain – a major electrolytic hydrogen producer, records a significant increase, from €58.91/MWh to €110.17/MWh. Prices in Belgium, Germany, Denmark and the Netherlands increase by around €27/MWh. Despite these increases, lower prices continue to be observed in Finland.

By 2035, the effect of the sensitivity becomes more widespread. As in the base case, the expansion of the PCI/PMI hydrogen infrastructure level results in a common price of approximately €146/MWh (around €105/MWh in the base case). This market-clearing price convergence is maintained across interconnected markets including several Central and Northern European countries such as, Austria, Belgium, Czechia, Germany, Estonia, Finland, Lithuania, the Netherlands and Poland. The price increase in the Iberian Peninsula continues to occur, where average clearing prices increase by approximately €50/MWh.

In 2040, higher market-clearing prices prevail across the entire EU. A large group of interconnected countries that records prices around €122-135/MWh in the base case, moves towards approximately €170-185/MWh under the sensitivity. The increase is particularly significant in Slovenia, where the average market-clearing price rises from €198.07/MWh to €294/MWh. Sweden also shows a high increase, from €139.84/MWh to €203.30/MWh. Considerable increases are also observed in the Iberian Peninsula, the Netherlands and several Central and Northern European countries. Romania remains at €294/MWh, reflecting the persistence of the high price level already observed under the base case.

In 2050, the impact of lower P2X and RES availability remains significant compared to the base case. Prices in several Central and Northern European markets increase from approximately €145/MWh in the base case to around €206/MWh under the sensitivity. The Iberian Peninsula continues to experience higher price levels, with Spain increasing from €91.17/MWh to €165.66/MWh and Portugal from €78.27/MWh to €161.06/MWh. Sweden reaches €270.16/MWh, compared with €210.97/MWh under the base case. Hungary, Romania and Slovenia remain at or around €294/MWh, maintaining a clear separation from the price levels observed across much of the interconnected European hydrogen market.

While under the sensitivity hydrogen market-clearing prices are generally higher, an increase in absolute price levels does not necessarily imply an increase in infrastructure gaps according to IGI Indicator 2. The identification of infrastructure gaps depends on the resulting market-clearing price spreads between Zone 2 nodes and their assessment against the defined thresholds. Consequently, the impact of the Low P2X and RES Sensitivity on IGI Indicator 2 is assessed based on the evolution of these price spreads.

Hydrogen market clearing price spreads

Figure 18 and Figure 19, provide the results of IGI indicator 2 based on the thresholds 1 and 2 for all the assessment years and borders in the under-supply sensitivity.

Figure 18. IGI Indicator 2 - Average hydrogen market-clearing price spreads between countries in 2030, 2035, 2040 and 2050 in the under-supply sensitivity: Threshold 1 (€/MWh)

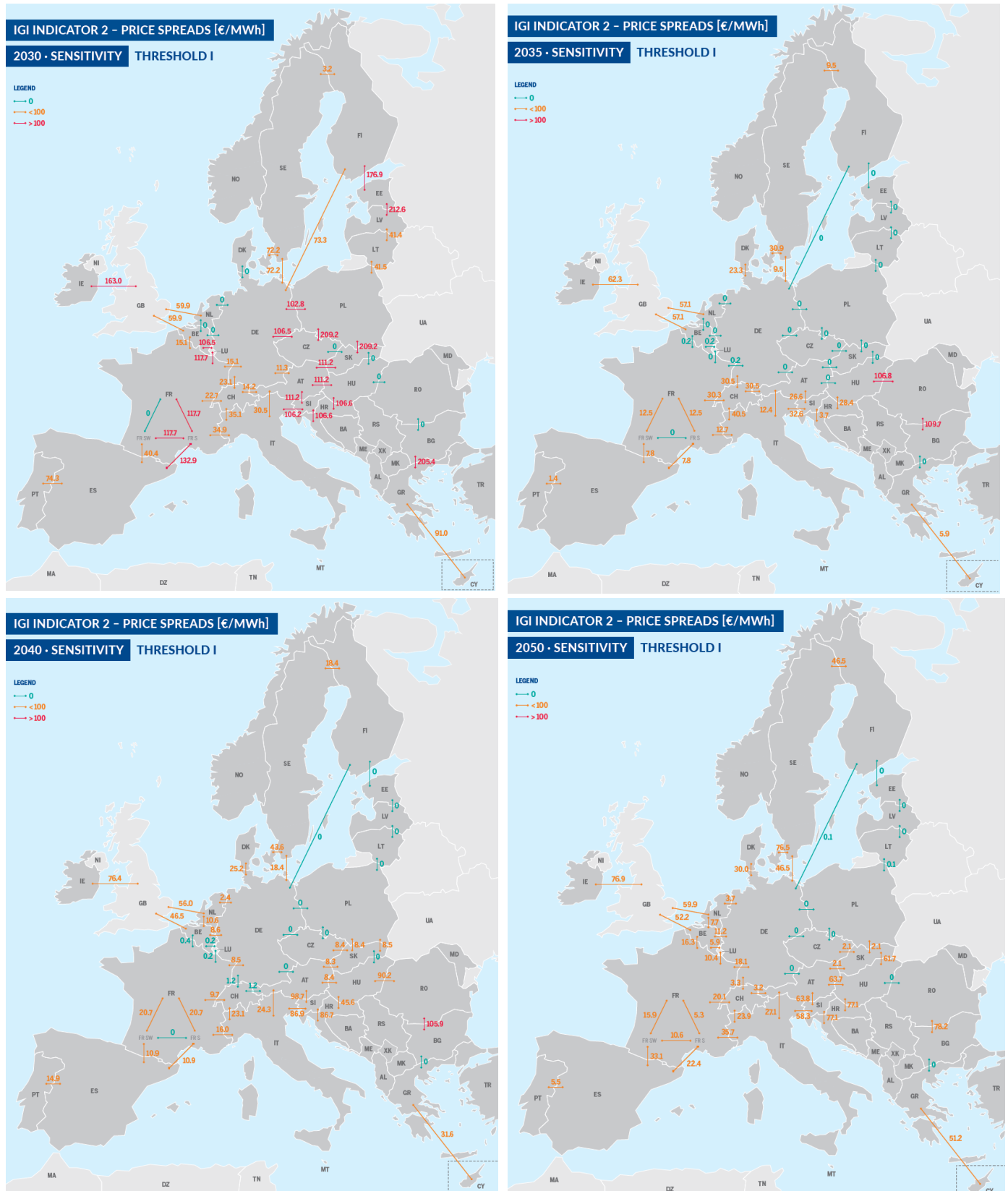
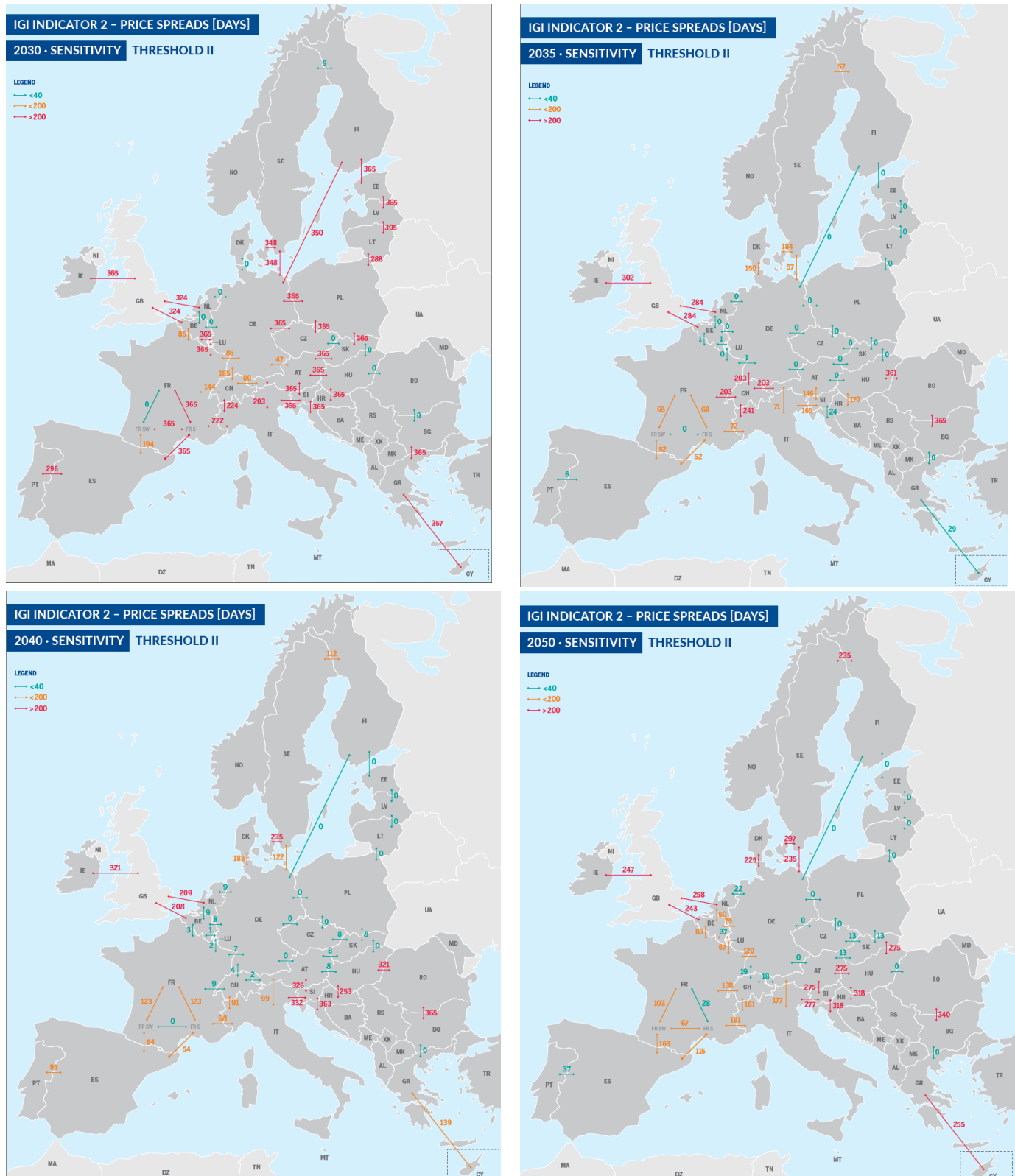


Figure 19. IGI Indicator 2 - Number of days with hydrogen market-clearing price spreads between countries in 2030, 2035, 2040 and 2050 in the under-supply sensitivity: Threshold 2 (days)



As explained above and in section 6.3, a general increase or decrease in price levels does not necessarily translate into higher or lower market-clearing price spreads between countries. This is also observed in the present analysis, where neighbouring and interconnected markets experience similar price increase, and price convergence can be maintained despite the higher absolute price level.

2030 continues to show widespread price separation as in the base case. Several borders record Threshold 1 values and Threshold 2 values close or equal a full year, for example:

- Bulgaria-Greece border: 205.43 €/MWh and 365 days
- Estonia-Latvia border: 212.59 €/MWh and 365 days
- Czechia-Poland border: 209.24€/MWh and 365 days
- Ireland-United Kingdom border: 163.00 €/MWh and 365 days
- Austria-Hungary, Austria-Slovenia, Austria-Slovakia (West) borders: 111.20 €/MWh and 365 days

No price spread is observed at the Czechia-Slovakia border under the sensitivity, compared with 53.94 €/MWh and 149 days in the base case. This illustrates why market-clearing price spreads should not be interpreted in isolation. In this case, the absence of a price spread does not reflect improved market integration, but rather similar scarcity conditions in both neighbouring markets, which reach the same hydrogen curtailment price. Similarly, Spain-France South where the price spread is reduced from 170 €/MWh and 365 in the base case to 133 €/MWh and 365 days in the sensitivity, while the yearly average price of Spain increased from 59 €/MWh to 110 €/MWh.

By 2035, a substantial improvement in market integration remains visible despite the lower P2X and RES availability. Several of the large price spreads identified in 2030 disappear entirely. Examples include:

- Austria-Germany border: from 14.21 €/MWh and 80 days in 2030 to 0 €/MWh and 0 days in 2035
- Austria-Slovakia and Austria-Hungary: from 111.20€/MWh / 365 in 2030 to 0 €/MWh and 0 days in 2035
- Bulgaria-Greece border: from 205.43 €/MWh /365 days in 2030 to 0 €/MWh and 0 days in 2035

Similarly, Czechia-Germany, Czechia-Poland, Estonia-Finland, Estonia-Latvia and Germany-Poland show no price spread in 2035. These results indicate that the additional PCI/PMI infrastructure available by 2035 continues to support price convergence across a large part of the European hydrogen system, even under lower P2X and RES availability. Nevertheless, price spreads persist on several borders in 2035, particularly in: Bulgaria-Romania, Hungary-Romania, Ireland-United Kingdom and Belgium-United Kingdom.

In 2040 and 2050, price spreads reappear or widen across several borders, potentially reflecting demand growth that outpaces infrastructure or supply development in some areas and gives rise to persistent or renewed bottlenecks. As in the base case, this increase is much more pronounced for countries that are weakly connected such as Hungary and Croatia, or completely isolated Slovenia and Romania.

However, comparing to the base case, few price spreads decrease in the sensitivity:

- Bulgaria-Romania border in 2040: from 135 €/MWh and 366 days in base case to 106 €/MWh and 365 days in sensitivity
- Austria-Hungary and Austria-Slovenia border in 2050: from 107 €/MWh and 329 days in base case to 63 €/MWh and 275 days in sensitivity
- Austria-Italy border in 2050: from 41 €/MWh and 249 days in base case to 27 €/MWh and 177 days in sensitivity

This reflects the increase in average hourly hydrogen market-clearing prices across neighbouring countries, which in some cases occurs at similar levels and therefore results in narrower price differentials.