european network
of transmission system operators
for gas

TEN-YEAR NETWORK DEVELOPMENT PLAN

2020

EXECUTIVE SUMMARY

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FOREWORD

I am proud to preface this sixth edition of the Union-wide Ten-Year Network Development Plan for gas. This TYNDP 2020 aims to support the European Climate and Energy ambitions, including the Green Deal and the European strategies for Hydrogen and Energy System Integration. I truly believe that the Ten-Year Network Development Plan 2020 delivers added-value to a wide range of stakeholder and decision-makers.

This TYNDP process has been delivered to you in a changing and important context for the role of gas in the European energy sector. The tasks for the infrastructure operators include as a major focus not only the security of supply but also the sustainability agenda.

The European gas infrastructure has seen decades of development and the existing international gas system already ensures a high level of market integration across most of Europe. The gas transmission infrastructure, LNG terminals and gas storages provide safe, reliable and affordable low carbon energy to European citizens. Furthermore, the gas infrastructure offers exceptional and cost-efficient opportunities for the EU to develop intermittent renewables and decarbonised gases at large scale, to meet European climate and energy goals.

TYNDP 2020 concludes that almost all gas infrastructure gaps can be addressed in the next 5 years by projects already initiated, including supply route disruptions. These investments will be mostly commissioned before 2025 and will bring affordable, diversified and competitive supplies of gas, increasingly decarbonised over time. However, it should be noted that, in specific areas, further development of the infrastructure is still required. It is particularly important for those areas in the context of evolving Member States decisions on their energy mix and embrace the decarbonisation agenda.

ENTSOG has undertaken significant changes to further improve the TYNDP, to meet stakeholders' feedback and to better interlink it with the electricity system. ENTSOG has worked on holistic scenarios, considering the full European energy system, built in cooperation with ENTSO-E to represent differentiated paths towards achieving the EU decarbonisation targets. For the first time TYNDP 2020 includes COP21 compliant scenarios, building on a carbon budget approach to reach Net-Zero 2050. Additionally, a national policy scenario, National Trends, was built to reflect the respective Member States' National Energy and Climate Plans (NECPs).

The Hybrid Energy Infrastructure, building on both electricity and gas systems as the cross-border energy carriers will enable delivery of more efficient, resilient, sustainable and faster and cheaper decarbonisation of the European energy sector. The joint efforts with stakeholders contributing to this TYNDP, shows the aim of the European energy players to work closely together to meet EU climate goals.

ENTSO-E and ENTSOG have developed this TYNDP 2020 building on the expertise and cooperation of more than 90 TSO experts from all over Europe. This work has resulted in the first ever full energy scenarios at European and national level with the highest level of transparency including numerous workshops and dialogue with stakeholders. This has been done with the objective to support the European energy and climate ambitions and in the European citizens' best social-economic welfare interests.

For the next TYNDP 2022, ENTSOG will internalise the Green Deal priorities, including EC Hydrogen and ESI Strategies, and furthermore, ENTSOG plans to organise deeper stakeholder involvement in planning process (DSOs, hydrogen producers/consumers, RES-E producers, NGOs, and others).

To streamline stakeholders' cooperation and as proposed to the European Commission and to all participants of last Copenhagen Infrastructure Forum, ENTSOG has suggested to establish Joint Advisory Panel for Scenarios (together with ENTSO-E) to facilitate neutrality and to improve transparency.

Transparency and cooperation between gas, hydrogen and electricity value chains is crucial, specifically in the context of a future European Hydrogen Backbone. ENTSOG is ready to facilitate coordinated development of the EU wide hydrogen backbone via ENTSOG's TYNDP process, ensuring speed and scale in hydrogen grid development. ENTSOG finds that this should start now and that it will contribute to the delivery of the EU Recovery Plan objectives.

On behalf of ENTSOG, I would like to thank all parties involved in the TYNDP 2020 process. I encourage you to provide your feedback through our upcoming consultation process to ensure full transparency in the process. This feedback, together with the ACER Opinion, will be duly considered before releasing the TYNDP final version in March 2021.

Jan Ingwersen
ENTSOG General Director

Picture courtesy of SGI

TYNDP 2020

The European gas infrastructure has seen decades of investment and development. The gas system connects most of European countries, ensuring the most efficient solution for transporting and storing large amounts of energy over long periods and distances.

The current gas infrastructure has achieved the internal energy market in most parts of Europe

TYNDP 2020 confirms the **strong resilience** of the gas infrastructure in terms of Security of Supply and its ability to enable **efficient competition and market integration**, provided there is no market distortion. However, **some specific areas still show investement needs** and the projects addressing these needs have either made their final investment decision (FID) or they have reached an advanced stage of development and are planned to be commissioned **within the next 5 years**.

The gas system is in transition towards net-zero 2050

The current gas infrastructure can already support the phase out of carbon intensive fuels in carbon intensive sectors such as industry and transport sectors, but also in the power sector. However, **more investments in renewables, decarbonisation and infrastructure conversion are needed**. Energy Transition (ETR) projects demonstrate their ability to decarbonise the energy system and next editions of the TYNDP will continue to assess them.

TYNDP 2020 confirms the interdependence of the electricity and gas sectors and the benefits of quick-wins to decarbonise the European energy system

In a net-zero future, **hydrogen and biomethane play a key role in the decarbonisation**. Indeed, the **gas system needs clean hydrogen from intermittent renewable sources**, like wind and solar, to decarbonise; and the **electricity system needs decarbonised gas** to support and secure the significant development of the electricity demand in any of the scenarios.

Furthermore, ready-to-implement solutions with no (or limited) investment like **coal to gas switch in the power sector could already save more than 85 MtCO_2 year**, and will reduce the need for further investment in decarbonisation post 2050.

The European gas system is one of the key players in achieving the European energy and climate targets. The gas infrastructure offers unique opportunities – in energy storage, transmission and integration of renewables – to support the decarbonisation of the overall energy system in a cost effective, secure and achievable way.

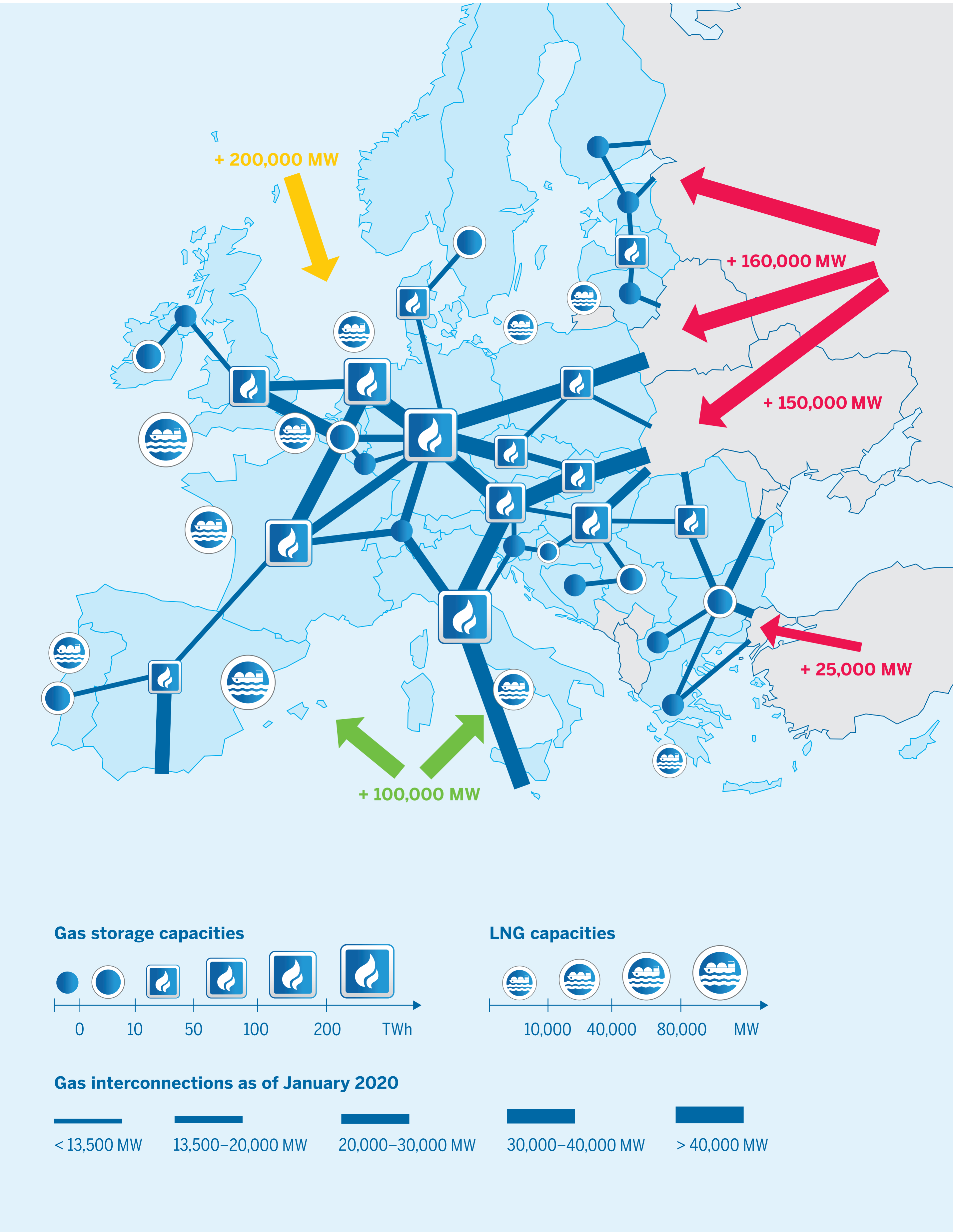


Figure 1 EU gas system 2020 at a sight

1 A NEW TYNDP 2020 TO SUPPORT THE EUROPEAN GREEN DEAL

1.1 TYNDP 2020 SCENARIOS: NET-ZERO 2050 AND COP 21 COMPLIANT

TYNDP 2020 scenarios support the European energy and climate ambitions

Scenarios are the corner stone of the joint gas and electricity interlinked model of ENTSOG and ENTSO-E. For the 2020 editions of their TYNDP, ENTSOG and ENTSO-E have developed **sustainability-oriented scenarios reaching net-zero carbon emissions in 2050** and considering either national policies as defined by the Member States' National Energy and Climate Plans (**NECPs**) or the objectives as defined in the Paris agreement (**COP 21**). Therefore, all **scenarios comply with European and national ambitions** and were largely **supported by stakeholders** during the definitions of the scenarios' storylines.

Furthermore, building on the ever-improving interlinked model developed jointly by ENTSO-E and ENTSOG, the COP 21 scenarios – Distributed Energy and Global Ambition – are built on a **holistic approach to the European energy system** considering the total primary energy mix of Europe to ensure consistency across all sectors, beyond considering the sole interactions between gas and electricity.

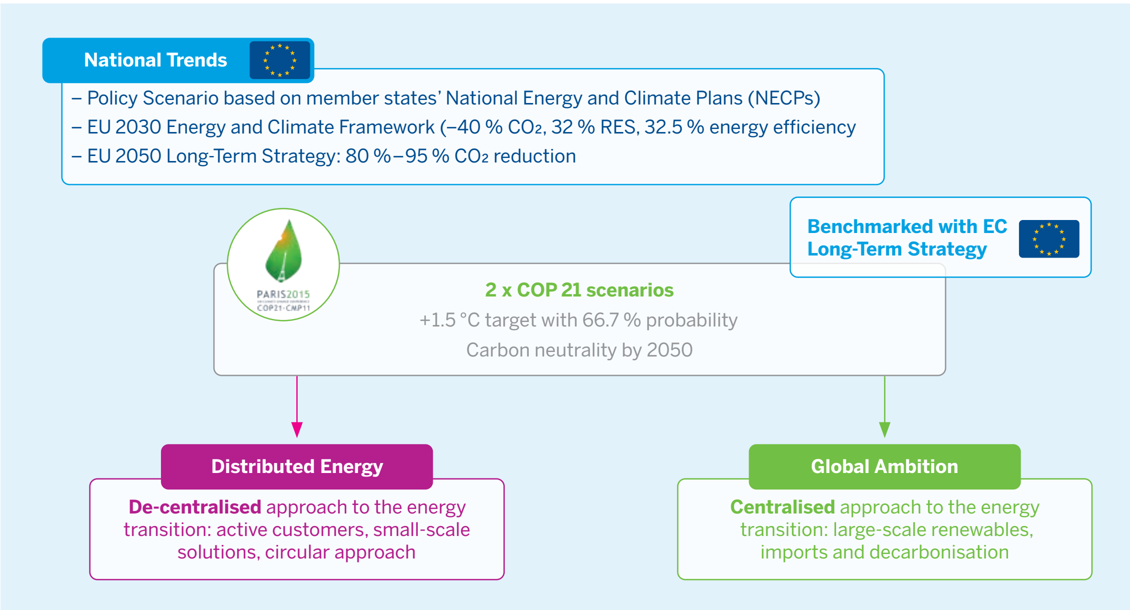


Figure 2 TYNDP 2020 scenarios: storylines

1.2 THE GAS SYSTEM IS A KEY ASSET TO REACH NET-ZERO 2050

Existing infrastructure can already support decarbonisation but development of clean gases is necessary

TYNDP 2020 scenarios show that reaching a net-zero economy by 2050 must result in energy efficiency improvements and a generally decreasing trend for the overall gas demand. **The current infrastructure**, backbone of the European gas market, **already supports the displacement of more carbon intensive fuels** (e. g. coal phase-out in heating, power and industry, or oil phase-out in the transport sector). However, as the European energy system goes more and more decarbonised, the **gas demand is partly sustained by those energy intensive sectors**, where the high energy density of gas and its mature and efficient storage and transmission capabilities are key assets. Therefore, **an adaptation of the energy infrastructure is necessary to develop significant production capacities of renewable and decarbonised gas, and to adapt the demand to new gases like hydrogen**. Such projects are not covered by the current TEN-E regulation and are introduced for the first time by ENTSOG in TYNDP 2020 as part of the Energy Transition (ETR) category in addition to the project categories already covered by the regulation[1].

Picture courtesy of SGI

1 As defined in Annex II.2 of Regulation (EU) 347/2013.

Gas is part of the solution towards net-zero 2050

TYNDP scenarios confirm the need for various renewable and decarbonisation technologies and the interdependence of the gas and electricity systems in reaching a net-zero European energy system by 2050.

Indeed, as the energy transition will create a change in the use of primary energies depending partly on the level of electrification and on whether it is produced locally or centralised, gas as an energy carrier has a necessary and key role to play and needs to be decarbonised.

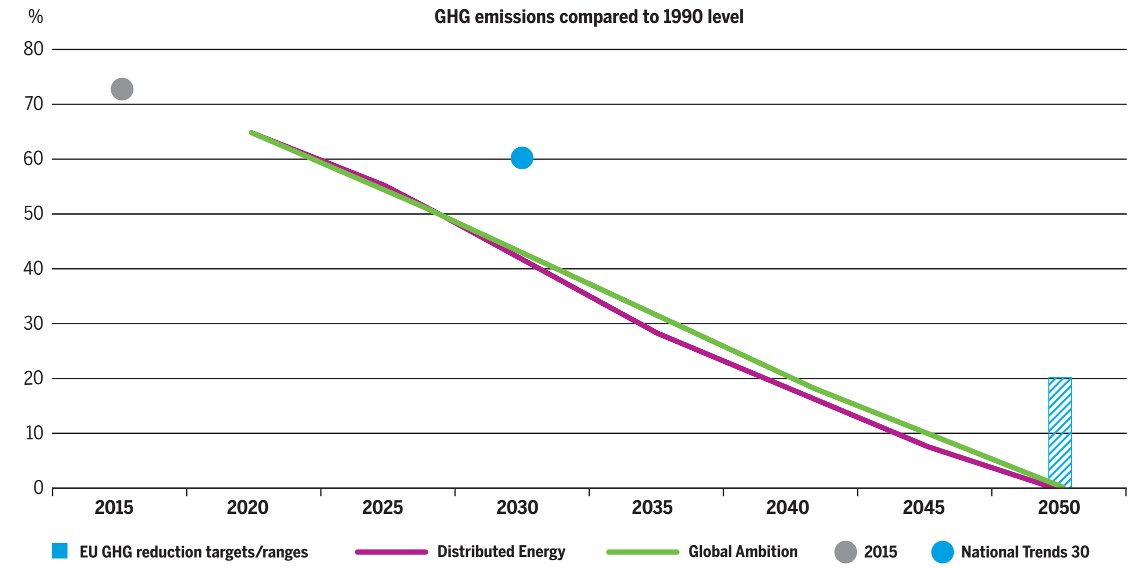


Figure 3 GHG emissions in TYNDP 2020 scenarios

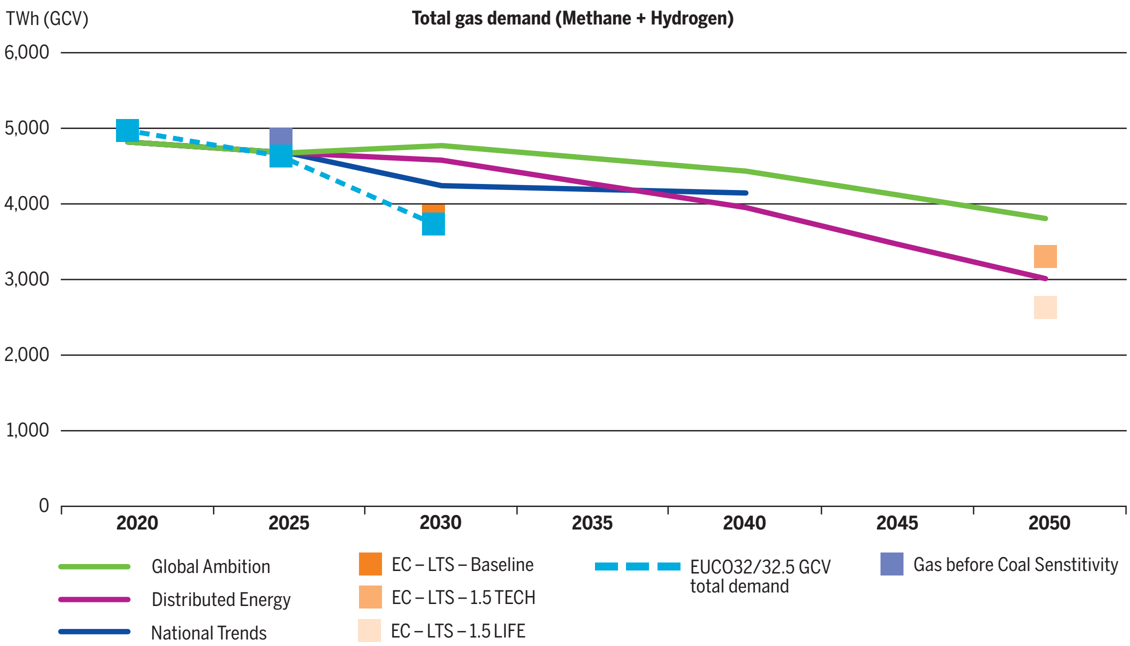


Figure 4 Total primary gas demand (incl. gas demand for power generation) – benchmark with EC Long-Term Strategy

ETR projects will drive the decarbonisation

To support Europe in its Climate and Energy ambitions, ENTSOG made the choice to collect and assess projects contributing to the decarbonisation of the gas system on a transparent and non-discriminatory basis.

For this first exercise, ENTSOG already collected a large number of projects. Submitted ETR projects reflect the wide variety of solutions needed to decarbonise the energy sector, from renewable generation to demand conversion including CO_2 storage and infrastructure conversion. Based on the information collected[2], ENTSOG has estimated that TYNDP 2020 ETR projects can contribute to more than 3,100 MtCO_2 savings per year. Since the ETR projects collection is not a regulatory requirement, they were submitted to ENTSOG on a voluntary basis. Therefore, the assessment is not comprehensive and the impact of the assessed ETR projects can be considered the very tip of the iceberg.

Energy Transition category already accounts for more than 25 % of TYNDP 2020 projects.

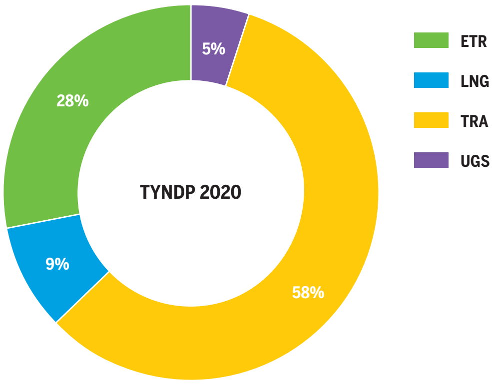


Figure 5 Project categories submitted to TYNDP 2020

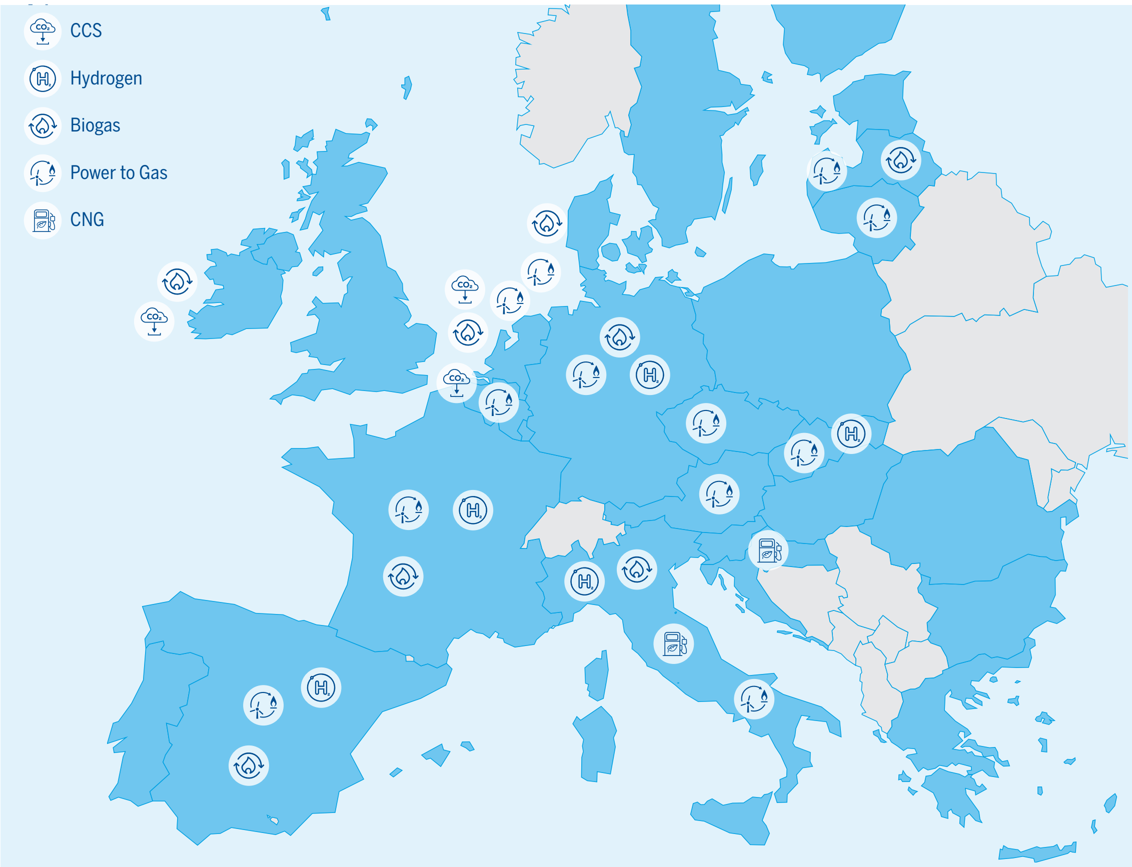


Figure 6 Distribution of ETR projects submitted to TYNDP 2020 per type of projects

2 In some cases promoters were not able to provide the required technical information to assess their project contribution to CO_2 savings.

ETR projects evaluated in TYNDP 2020 could save more than 3,100 MtCO_2 till 2050.

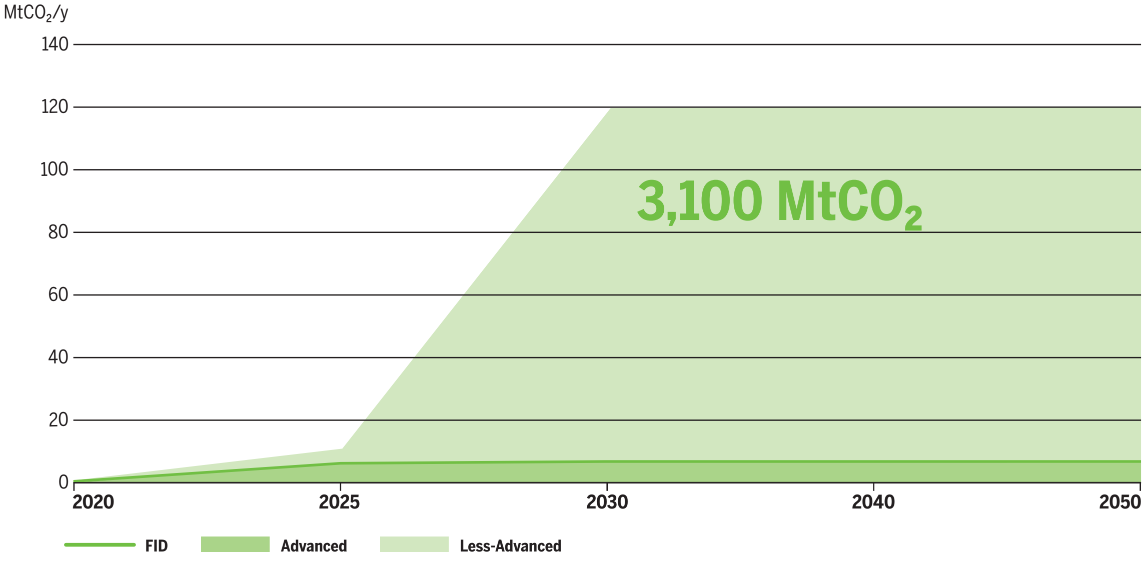


Figure 7 CO_2 savings generated by ETR projects in TYNDP 2020

More than 1,000 km of pipeline retrofitting submitted to TYNDP 2020 for the next 10 years

For the first ETR projects collection, around 1,100 km of pipeline retrofitting has been submitted to TYNDP 2020 and they concern France and Germany. According to some TSOs studies, the potential retrofitting activity could reach 6,800 km by 2030[3].

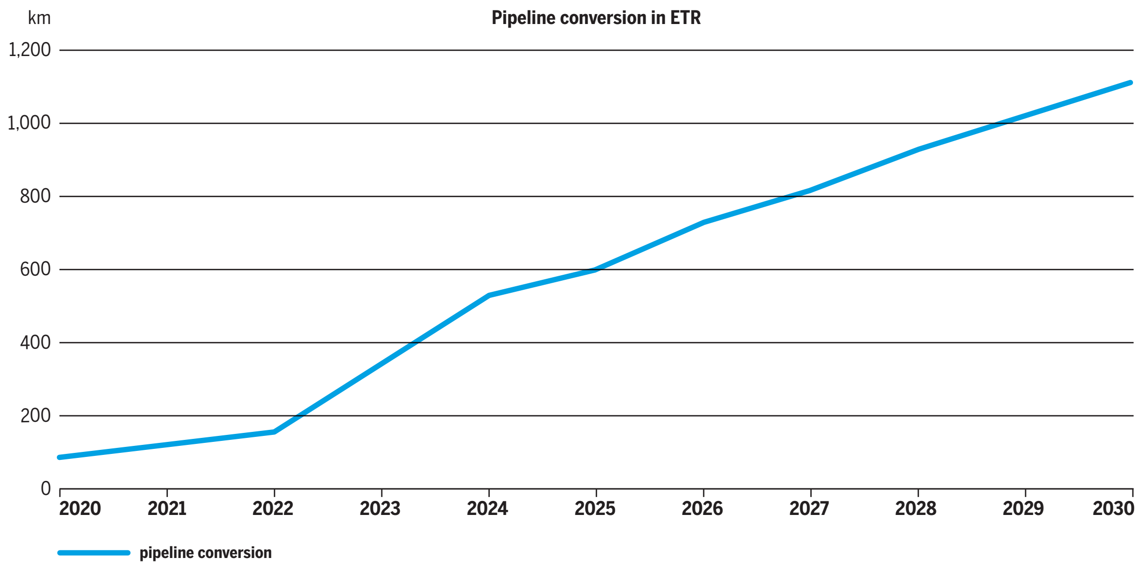


Figure 8 Length of pipeline retrofitting in ETR projects in TYNDP 2020

3 https://gasforclimate2050.eu/sdm_downloads/european-hydrogen-backbone/

Quick wins are no regret options

The carbon budget approach considered in the COP 21 scenarios shows that the later the transition happens, the more you need to compensate for CO_2 emissions after reaching net-zero. Therefore, quick decisions made today can save a lot compensation measures after 2050.

With no further investments and no matter in which scenario, coal to gas switch can be implemented today and save more than 85 $MtCO_2$ per year (more than the annual CO_2 emissions of Austria), and other solutions already exist to quickly replace relatively higher carbon intensive fuels with gas in carbon intensive sectors such as industry and heating or in sectors where the energy needs to be stored and transported like mobility, including train, shipping and aviation.

The transmission infrastructure as a backbone to integrate clean gases and support an efficient energy market

As production capacities of clean gases need to scale up, renewable gases – like offshore power to gas – will be produced further from the consumption areas and will be unevenly distributed throughout Europe, depending where the best potential is located. The most recent ETR projects demonstrate that the existing gas infrastructure can already connect the production or import facilities to the consumption areas, and thus to the storages to cope efficiently and securely with the energy demand seasonality. ETR projects also include conversion projects when the integration of clean hydrogen requires an adaptation of the existing infrastructure.

Picture courtesy of Terega

1.3 TYNDP: NATIONAL EXPERTISE AT THE SERVICE OF THE EUROPEAN ENERGY AND CLIMATE AMBITIONS

TYNDP 2020 relies on the expertise of the European gas and electricity Transmission System Operators (TSOs). TSOs are at the interface of upstream production operators, mid-stream LNG and storage operators, downstream consumers and distribution systems. They operate national networks and the largest cross-border energy infrastructure, backbone of the European Energy market and are essential to the cooperation between Member States to ensure the security of the energy supply of the EU.

Building on this unique expertise and the guidance received by the stakeholders, TYNDP 2020 scenarios are developed to comply with the European energy and climate ambitions and reflect contrasted usages of the infrastructure: centralised and decentralised.

SCENARIO DEVELOPMENT TEAM
90 gas and electricity European TSOs
+30 regional teams (gas & electricity) working together
to achieve common EU targets

ETHICS
Commitment to EU Social Economic Welfare

NATIONAL RELEVANCE
National commitments & EU targets

INNOVATION
Full-energy scenarios
country-specific data
Carbon Budget

EXPERTISE
- Operating X-border infrastructure 24/7
- Security of Supply and Infrastructure Planning
- Interacting daily with producers (RES and conventional), DSOs, LNG and Storage operators
- Peer-review by TSOs

STAKEHOLDER ENGAGEMENT
9 Public Workshops and Consultations
+100 Stakeholders involved over 2 years
Full Transparency: Report, Data Set, Process

An inclusive and transparent TYNDP

TYNDP 2020 is based on the joint ENTSOG and ENTSO-E Interlinked Model that combines national and technical expertise of more than 90 electricity and gas TSOs, as well as the participation of more of 100 stakeholders in numerous workshops. Therefore, TYNDP 2020 scenarios reflect the views of all the stakeholders who participated in the whole process from the definition of the storylines and the supply assumptions to the finalisation of the key parameters like electrification levels.

Continuing a tradition of high transparency, all methodologies, input data, technical data and results are available for download on ENTSOG website[4].

And to further clarify the neutrality of ENTSO-E and ENTSOG in the TYNDP processes, the associations will consider how to address this with a reinforced stakeholder involvement for the next edition.

4 https://www.entsog.eu/tyndp#entsog-ten-year-network-development-plan-2020


Picture courtesy of iStock

2 THE FUTURE ROLE OF GAS TOWARDS NET-ZERO 2050

2.1 GAS AND ELECTRICITY NEED EACH OTHER

Gas and electricity rely on each other to achieve full decarbonisation

TYNDP 2020 scenarios show that power-to-gas is a key technology to integrate electricity from variable renewables to a larger scale. Power-to-gas supports the development of variable renewables, like wind and solar, since it allows to produce hydrogen when the electricity demand is lower than the renewable electricity production. Furthermore, biomethane and hydrogen produced from renewable electricity can be stored in the gas system for longer period and transported efficiently over longer distances, complementing the short term flexibility of battery storage.

Equally, the gas system needs all decarbonisation technologies, including power-to-gas, to further decarbonise the gas supply, which can in return be used to produce decarbonised electricity when the electricity demand is higher than the renewable electricity generation.

Higher electrification comes with higher gas demand for power generation

All TYNDP 2020 scenarios consider a significant progress of the electricity demand in line with the European Commission's Long-Term Strategy[5]. The development of electricity demand together with development of variable renewable generation from wind and solar requires reliable gas back up for power generation. Furthermore, with higher electrification, the electricity demand becomes more seasonal and temperature-dependent, therefore, during dark, cold and shorter days in winter with limited wind generation, the electricity system requires back-up capacities which can cope with long periods of limited variable renewable generation. Therefore, higher development of electrificiation comes with higher gas demand for power generation, and also with additional stress on the gas system, which is assessed under the 2-week dunkelflaute[6] cases.

Picture courtesy of iStock

5 https://ec.europa.eu/clima/policies/strategies/2050_en

6 2-week period with minimum variable renewable power generation from wind and solar.

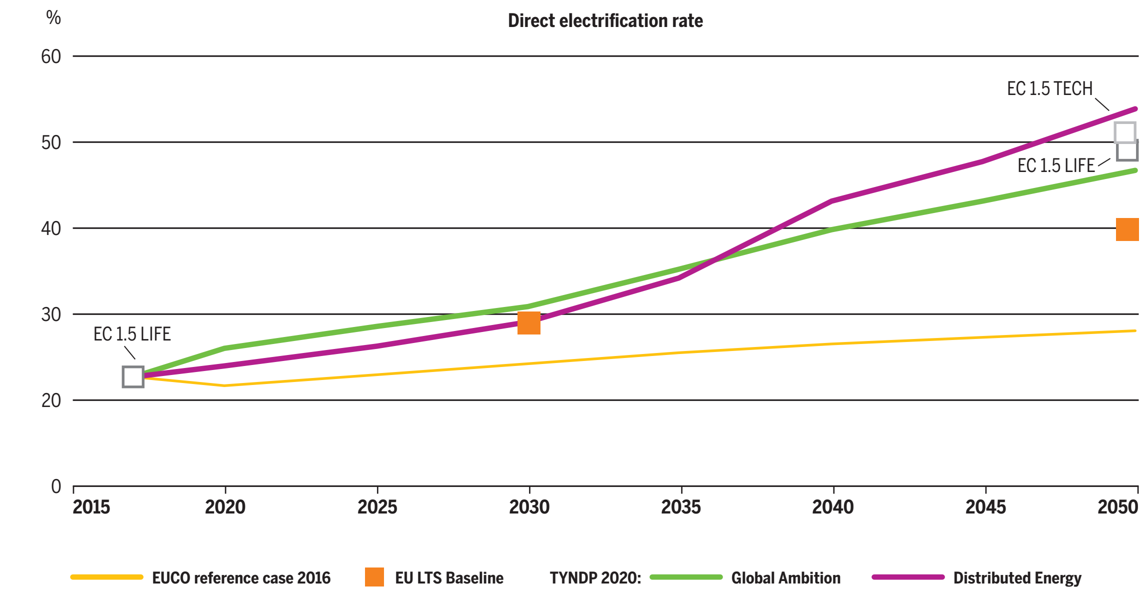


Figure 9 Direct electrification rate in TYNDP 2020 scenarios

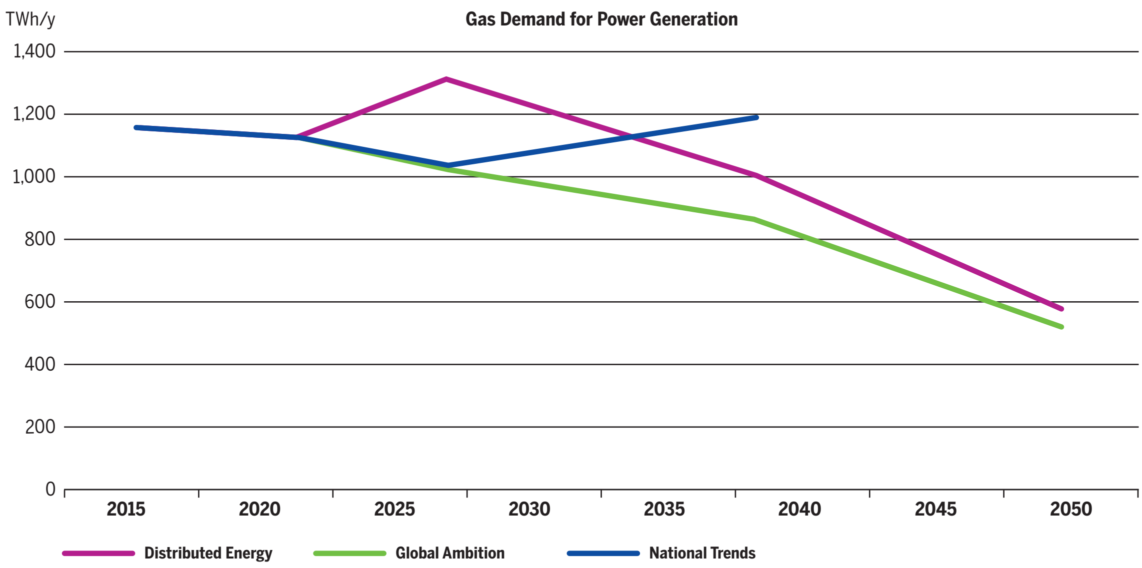
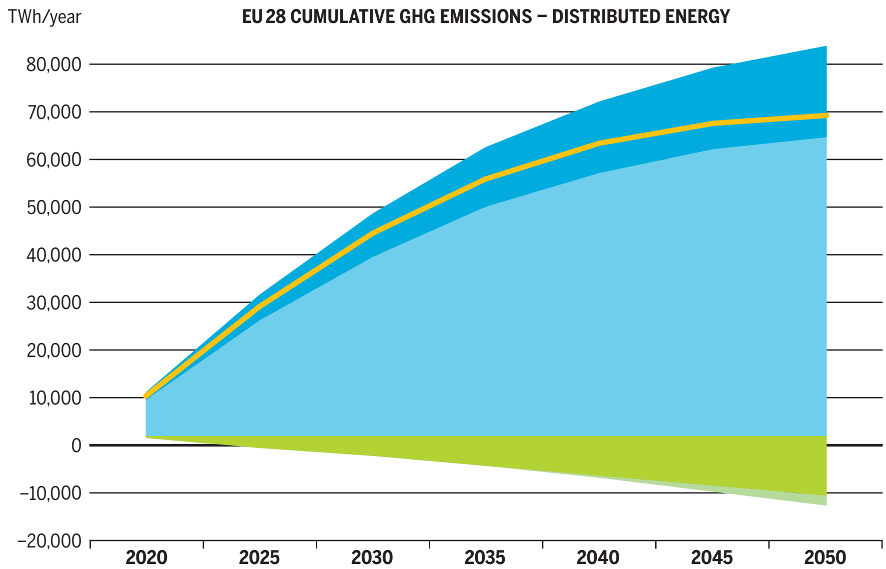


Figure 10 Gas demand for power generation in TYNDP 2020 scenarios

2.2 ALL TECHNOLOGIES ARE NEEDED: RENEWABLES, DECARBONISATION AND CO_2 CAPTURE

TYNDP 2020 scenarios confirm that a net-zero EU can be reached by 2050 within a budget of ca 63 $MtCO_2$ emitted along the course. However, it requires the combined development of the various technologies to increase the renewable energy production as well as decarbonising currently available energy sources. Furthermore, the definition of a carbon budget for the EU would require further CO_2 reduction after 2050, reinforcing the need for carbon capture and sequestration (CCS) technologies.

This is reflected in the gas composition of the COP 21 scenarios, Distributed Energy and Global Ambition, developed by ENTSOG and ENTSO-E where the development of renewable gases such as biomethane and hydrogen from power-to-gas needs to be complemented with decarbonised gas to reach the carbon neutrality of the gas mix by 2050.



	2020	2025	2030	2035	2040	2045	2050
Cumulative non-CO_2 emissions	1,534	5,132	8,394	11,298	13,821	15,963	17,725
Cumulative CO_2 emissions	6,735	21,985	34,486	43,860	50,456	54,784	57,113
Cumulative credits from pre- and post-combustive CCS	0	0	−56	−260	−642	−1,165	−1,778
Cumulative credits from BECCS	0	0	0	0	0	0	0
Cumulative credits from LULUCF	−627	−2,253	−3,963	−5,757	−7,635	−9,598	−11,644
Net Cumulative CO_2eq emissions	7,642	24,864	38,860	49,141	55,999	59,984	61,416

Figure 11 EU28 Cumulative emissions in $MtCO_2$ – Distributed Energy scenario

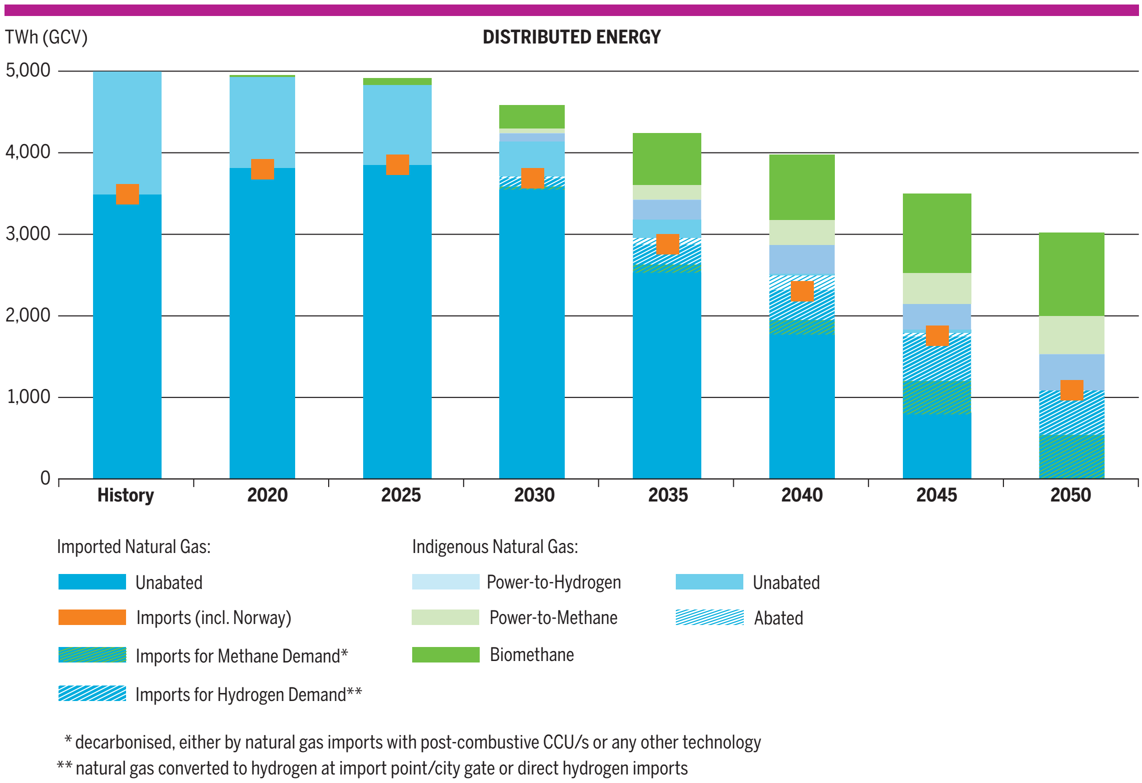


Figure 12 Gas mix composition – Distributed Energy scenario

2.3 QUICK MEANS CHEAPER

Quick wins are essentials

Some quick wins like coal-to-gas switch in power generation can come at no cost. However, the large scale deployment of energy efficiency solutions or renewable and decarbonisation technologies require further investment.

Global warming depends on the quantity of greenhouse gases released in the atmosphere. Therefore, limiting the global warming to 1.5 °C requires to reach carbon neutrality, but equally to limit the amount of CO_2 that will be released in the meantime. Also, a quick transition will require limited additional investment in "negative emissions" technologies whereas a late transition towards carbon neutrality will require larger investments to capture the additional CO_2 that will be emitted.

2.4 GAS TO SUPPORT THE ENERGY INDEPENDENCE OF EUROPE

Gas can displace coal and oil in many sectors and still reduce the overall energy dependence of the EU

Europe can reduce its dependence to energy imports by further improving its energy efficiency and developing renewable electricity and gas capacities. Both COP 21 scenarios show that electrification together with the penetration of gas in energy intensive sectors such as industry and transport, can reduce the energy dependence of the EU even further down compared to the EC Long-Term Strategy scenarios.

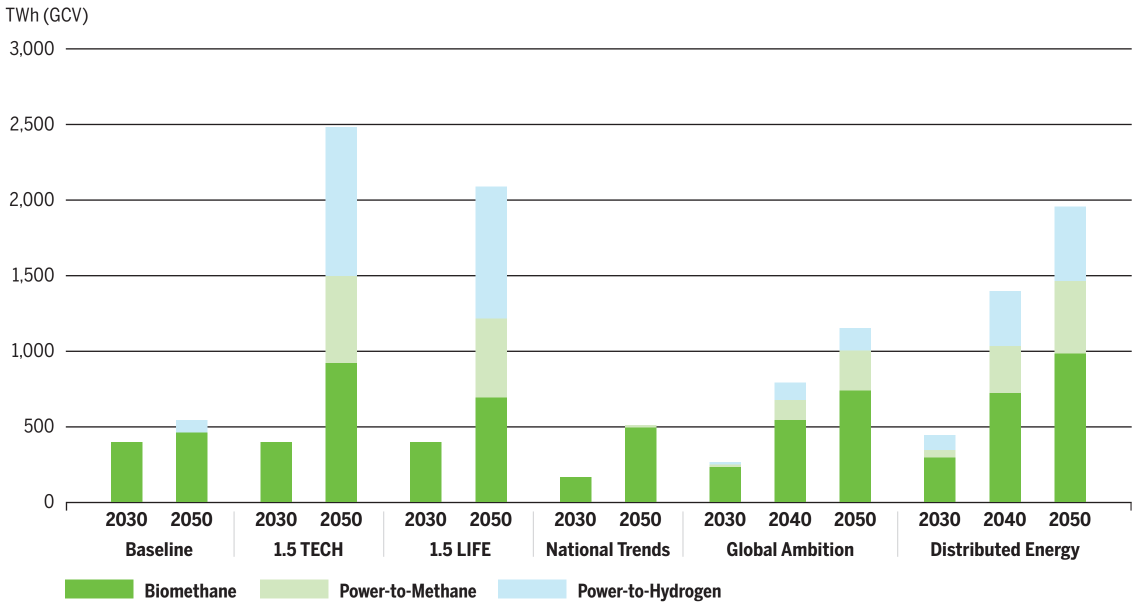


Figure 13 Renewable gas production in the EU

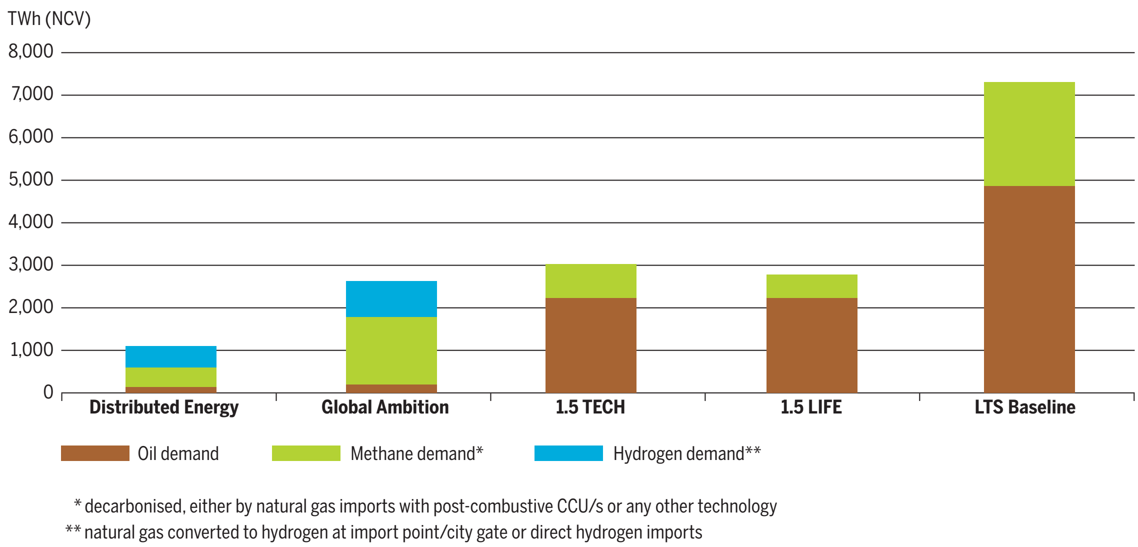


Figure 14 Energy imports to the EU in 2050

3 THE GAS INFRASTRUCTURE: AN EFFICIENT AND RELIABLE ASSET TO DECARBONISE THE ENERGY SYSTEM

3.1 A WELL DEVELOPED AND EFFICIENT GAS MARKET

Since TYNDP 2018, progress has been made in terms of gas infrastructure projects enabling the EU to move towards the full achievement of the internal energy market with the implementation of 10 projects.

The TYNDP assessement show, looking at the 2020 situation, that the current infrastructure already achieves many of the aims of the internal energy market with some exceptions in specific areas. To investigate the investment needs on the longer term, TYNDP looks at what the FID and advanced projects[7] will already allow to deliver in terms of security of supply, market integration and competition over the 20 next years, in all scenarios.

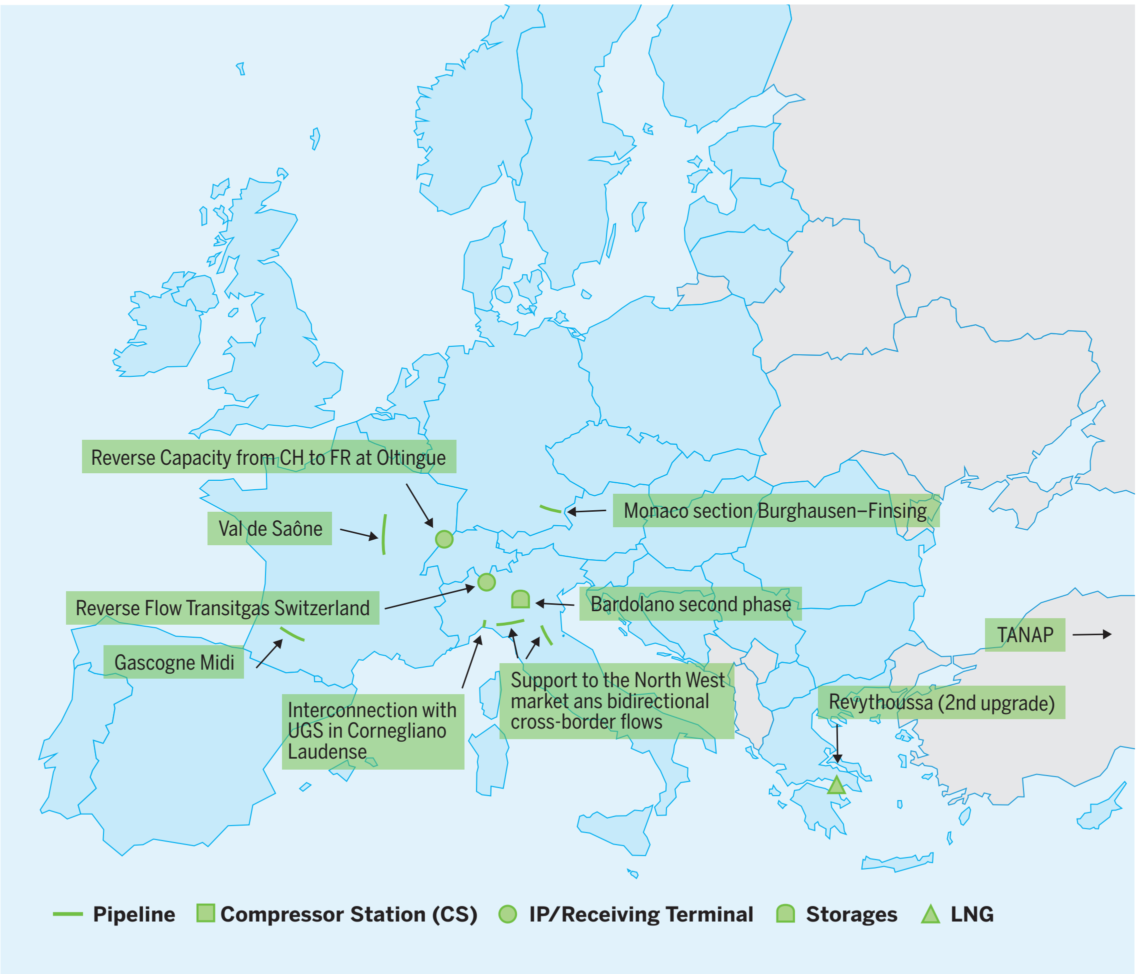


Figure 15 Projects commissioned since 2018

7 the majority of them is planned to be commissioned by 2020, see Figure 29

The European gas infrastructure can minimise or mitigate the dependence on all supply sources within the next 5 years

LNG supply

As the EU indigenous production of gas is declining and renewable gas generation will take some time to scale up, the overall dependence of the EU on gas imports increases in all scenarios in the next 5 years and starts decreasing as of 2030. However, this dependence only concerns the Russian supply and to a more limited extent the LNG supply.

Indeed, in all scenarios and over the whole time-horizon, the existing gas infrastructure already allows for a fully effective cooperation towards LNG dependence, and in 2040, the EU shows no dependence at all on LNG. Furthermore, the assessment confirms that the EU is not dependent on any LNG specific supplier and can always find alternative supply, even to the largest LNG basin.

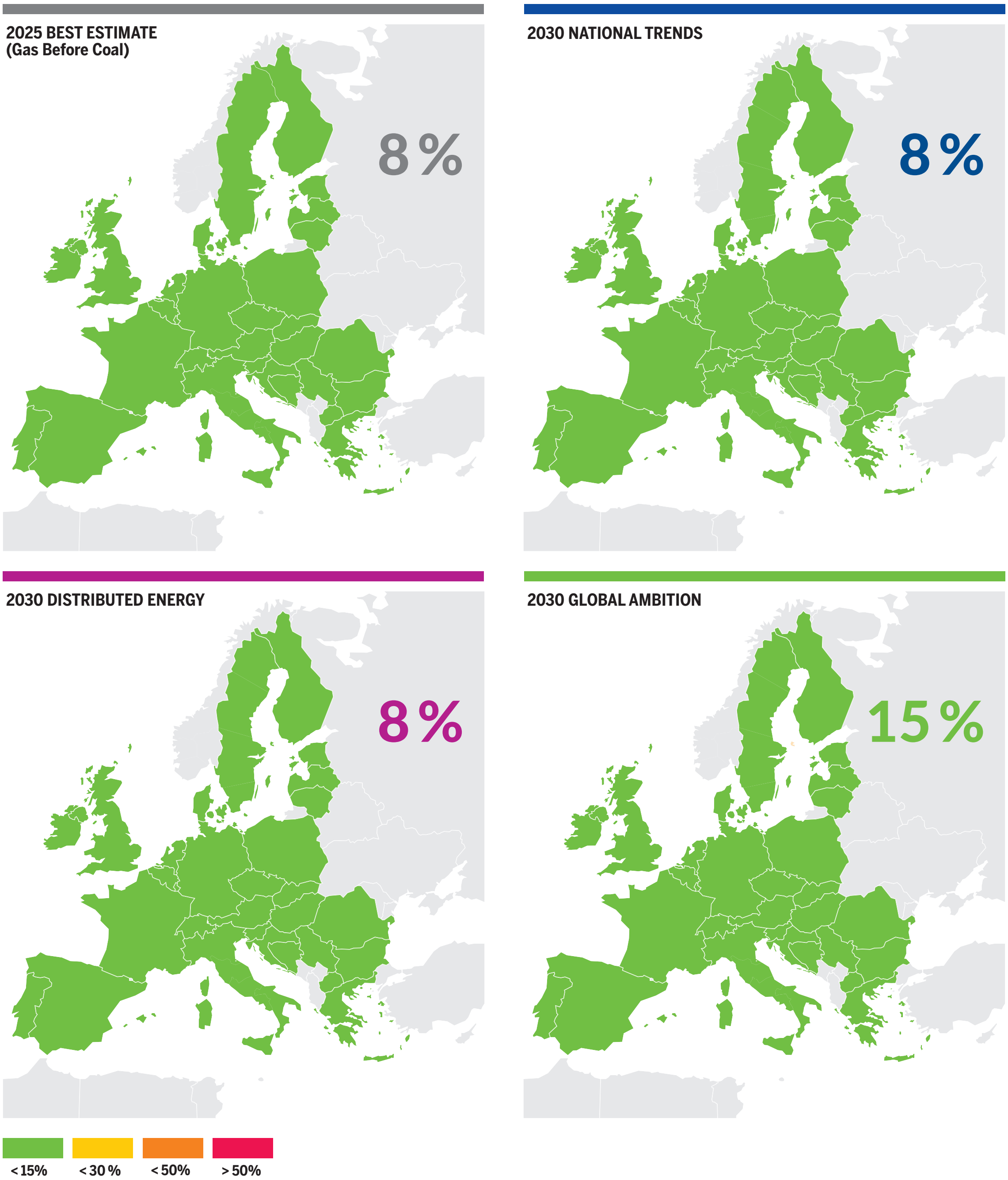
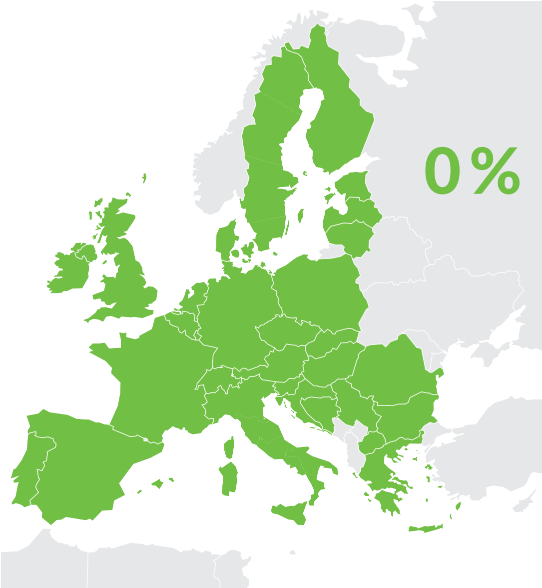


Figure 16 EU annual dependence to the LNG supply in 2025 and 2030 – Existing infrastructure

Legend for Figures 17 and 18

< 15% | < 30 % | < 50% | > 50%



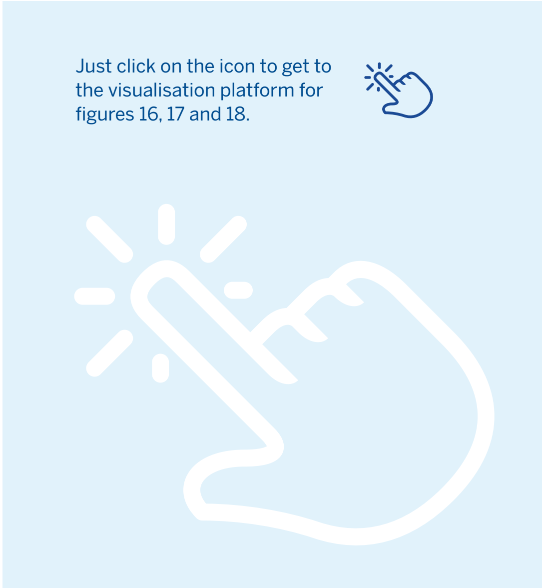


Figure 17 EU annual dependence to the largest LNG basin between 2020 and 2040 – Existing infrastructure, all scenarios

Russian supply

Regarding the Russian supply, FID and advanced projects to be commissioned in the next 5 years prove to achieve an efficient cooperation between the different Member States so that all of the EU can limit the dependence on LNG to its minimum and spread it evenly among all regions of the EU[8].

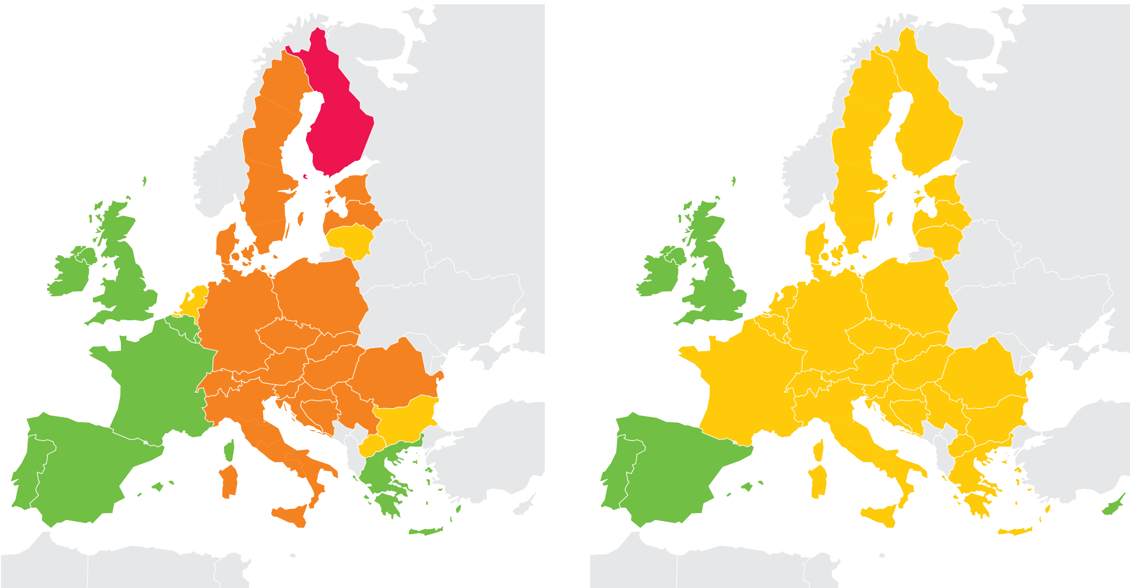
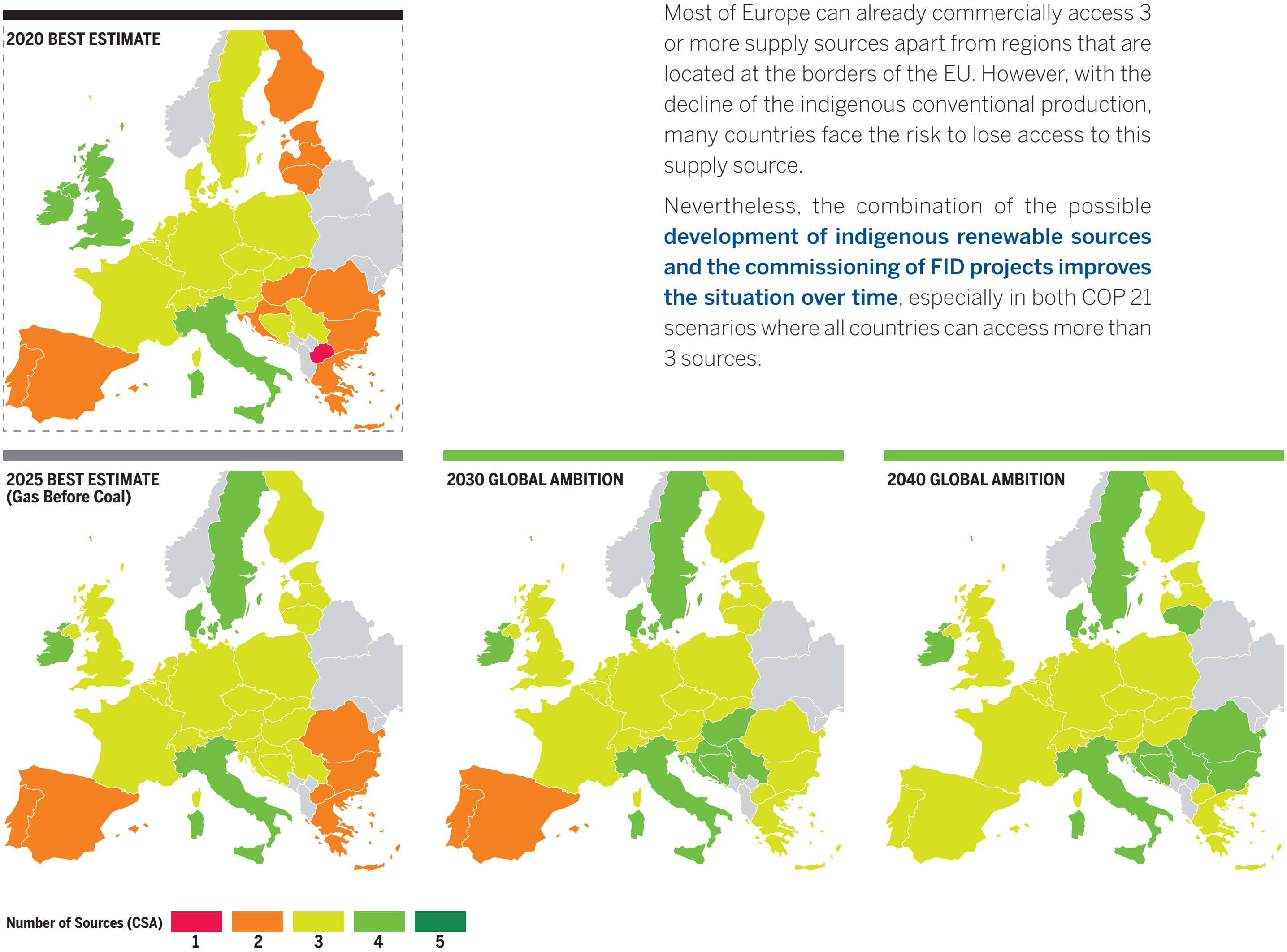


Figure 18 Dependence to Russian supply in 2025 – Existing infrastructure (left) vs FID and Advanced projects commissioned by 2025 (right)

8 The Iberian Peninsula, Cyprus, Malta and the British isles show no dependence at all since they do not belong to any of the Eastern supply risk groups due to their geographical locations

The gas infrastructure allows the EU to commercially access a wide variety of supply sources



Most of Europe can already commercially access 3 or more supply sources apart from regions that are located at the borders of the EU. However, with the decline of the indigenous conventional production, many countries face the risk to lose access to this supply source.

Nevertheless, the combination of the possible **development of indigenous renewable sources and the commissioning of FID projects improves the situation over time**, especially in both COP 21 scenarios where all countries can access more than 3 sources.

Figure 19 Commercial Supply Access – Global Ambition scenario, Existing infrastructure + FID projects

Furthermore, the assessment of different gas price configurations for the different sources shows that the gas infrastructure is capable of maximising or minimising the imports of some supply sources in order to benefit from cheap supply sources or to be protected from specific high prices.

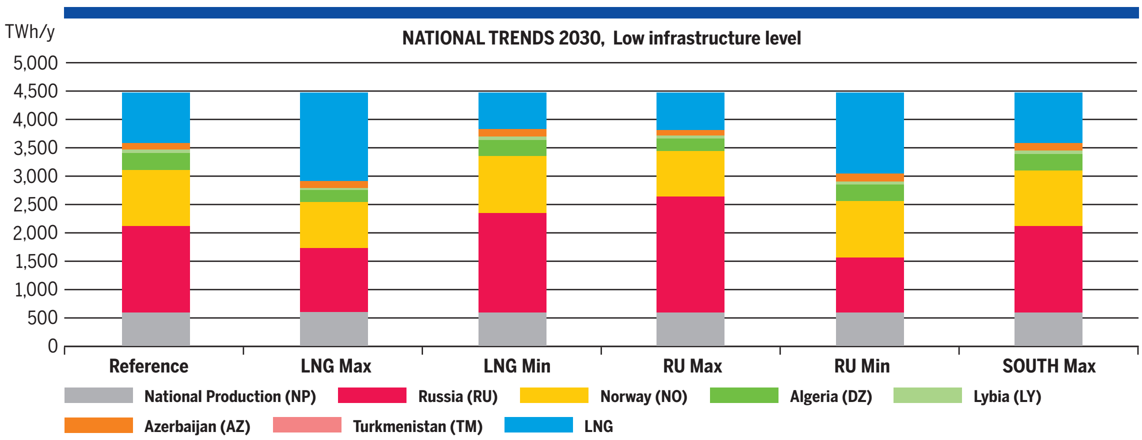


Figure 20 Annual EU supply mix per price configuration – National Trends, 2030

The gas infrastructure, a key asset to ensure price convergence

The gas infrastructure is key to enable an efficient and competitive gas market. Gas prices generally observed in the EU confirm the efficiency of the European gas infrastructure to ensure price convergence.

However, the assessment of the different infrastructure levels confirm that FID and advanced projects can further enhance the gas price convergence throughout Europe up to 35 % in Distributed Energy in 2030. The PCI infrastructure projects can improve the convergence of the European gas prices too, however to a lesser extent than the Advanced infrastructure projects.

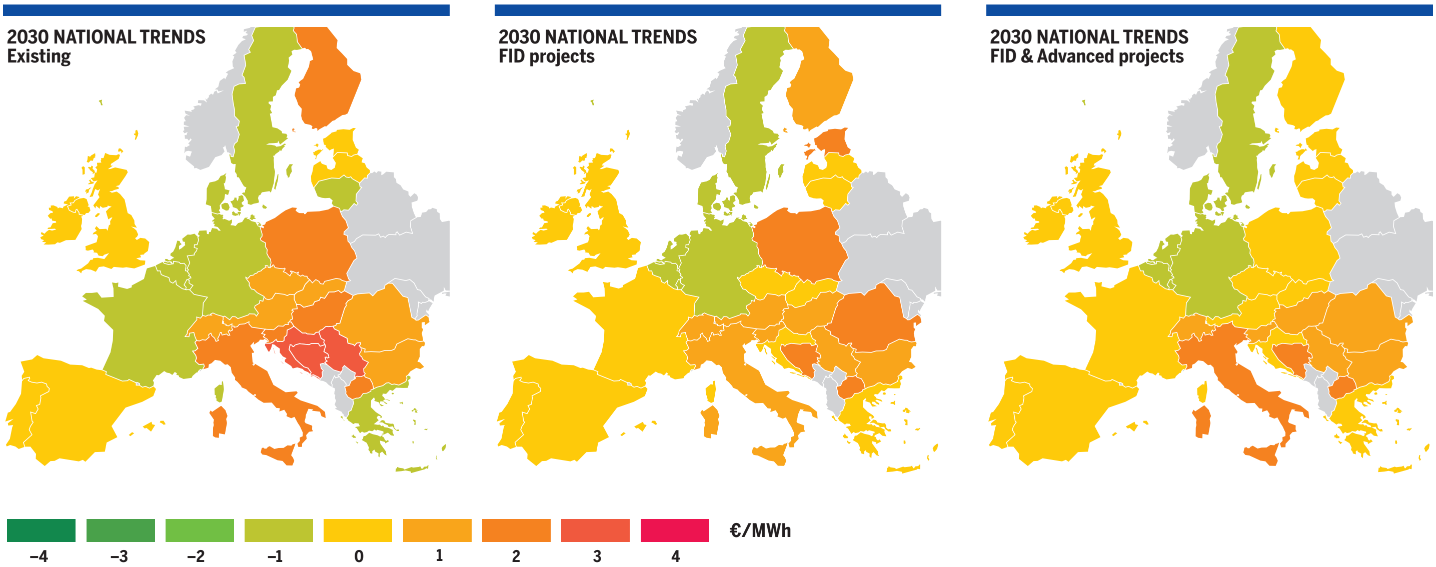


Figure 21 Average marginal price deviation per Member State per infrastructure level (Existing, Low, Advanced) – National Trends 2030

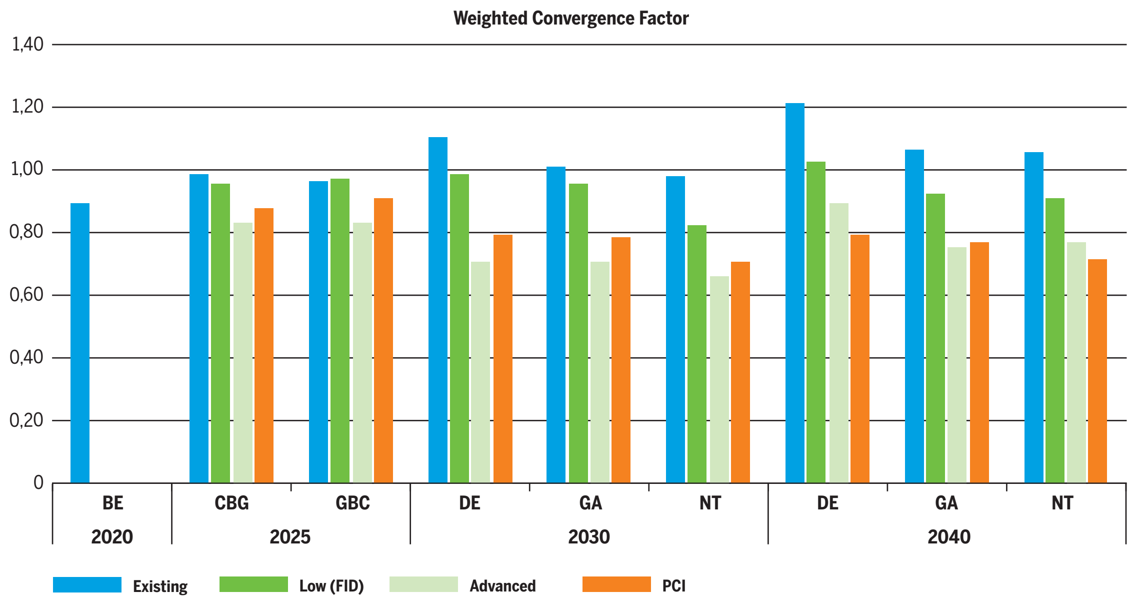


Figure 22 Average price deviation in the EU (weighted by their respective demand)

3.2 ENERGY SYSTEMS INTEGRATION POTENTIALS

SEASONAL ADEQUACY

The gas infrastructure can integrate significant volumes of intermittent renewables

The assessment confirms that the existing gas system can support the development of renewable gases and renewable electricity by integrating all the potential biomethane and renewable hydrogen as defined in the different scenarios, the necessary adaptations of the existing gas network are undertaken. The potential of the gas system combined with significant volumes of storage is perfectly adequate to cope with the intermittent renewable generation.

The gas system and its storage capacity are key to cope with the seasonality of the energy demand

On an annual basis the gas infrastructure generally offers the necessary flexibility to balance the seasonal inadequacy between the energy supply (rather stable over the year) and the energy demand (high in winter and low in summer). **The assessment confirms that the existing gas system can store more than 30 % of the current and future winter demand. This is another key element for integrating very seasonal supply such as solar energy without having to curtail other forms of renewable energy generation.**

In case of high demand situations under climatic stress, the role of gas storages in the gas system prove to be necessary for security of supply, since most of the gas supply delivered in peak demand situations comes from the gas storages (8,500 GWh/d to 15,500 GWh/d). In case of Dunkelflaute event, the share of the supply coming from the storages can go up to 40 % for 2 consecutive weeks, demonstrating the role of the gas infrastructure as a necessary infrastructure to support the development of intermittent renewables while ensuring security of energy supply for the EU.

Development of renewables bring flexibility on annual level but import capacities are needed to ensure security of supply in peak situations

The assessment of the gas infrastructure under Distributed Energy show that even with a significant share of indigenous renewable production, the storages need imports to be filled up in summer and additionally, imports are a key complement to storage withdrawals in winter.

Furthermore, the analysis of the supply mixes under various price configurations confirms that the gas infrastructure allows for the market to make arbitration between cheap and expensive supply source to minimise the cost of gas supply for the EU, and eventually, the consumers. Additional infrastructure also proves to be giving access to alternative supply sources increasing the security of gas supply in some countries.

The assessment of Low and Advanced infrastructure levels generally bring more flexibility to the gas system.

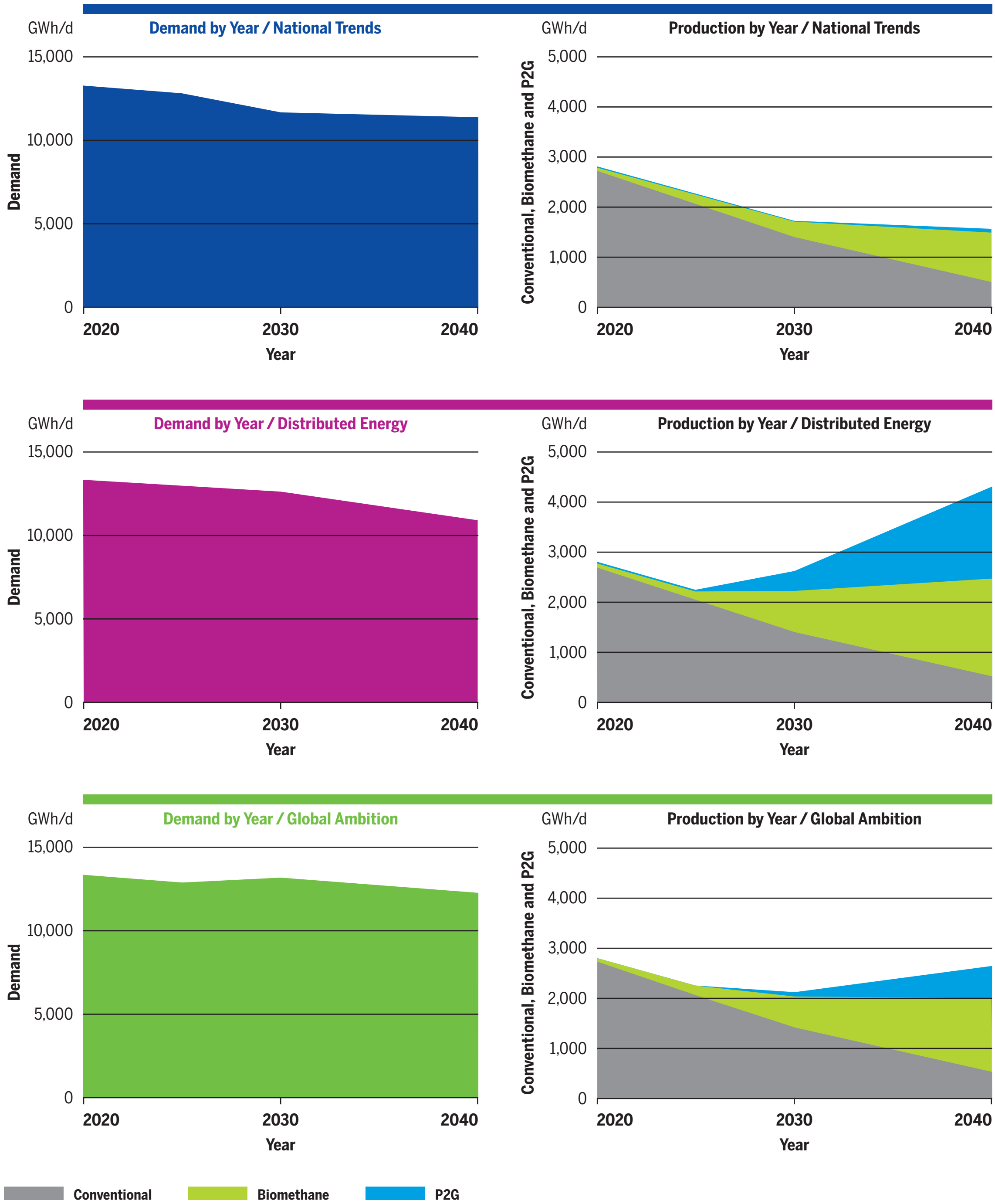


Figure 23 Annual demand and supply in TYNDP scenarios in the EU in GWh/d.

RESILIENCE TO EXTREME CLIMATIC EVENTS

The gas infrastructure is resilient to extreme climatic events in most parts of Europe

In all scenarios, the assessment shows that the existing European gas system is well developed and, in most European countries, resilient to severe climatic conditions such as a 1-in-20 peak day, a 2-week cold spell or a 2-week cold spell during a dunkelflaute event.

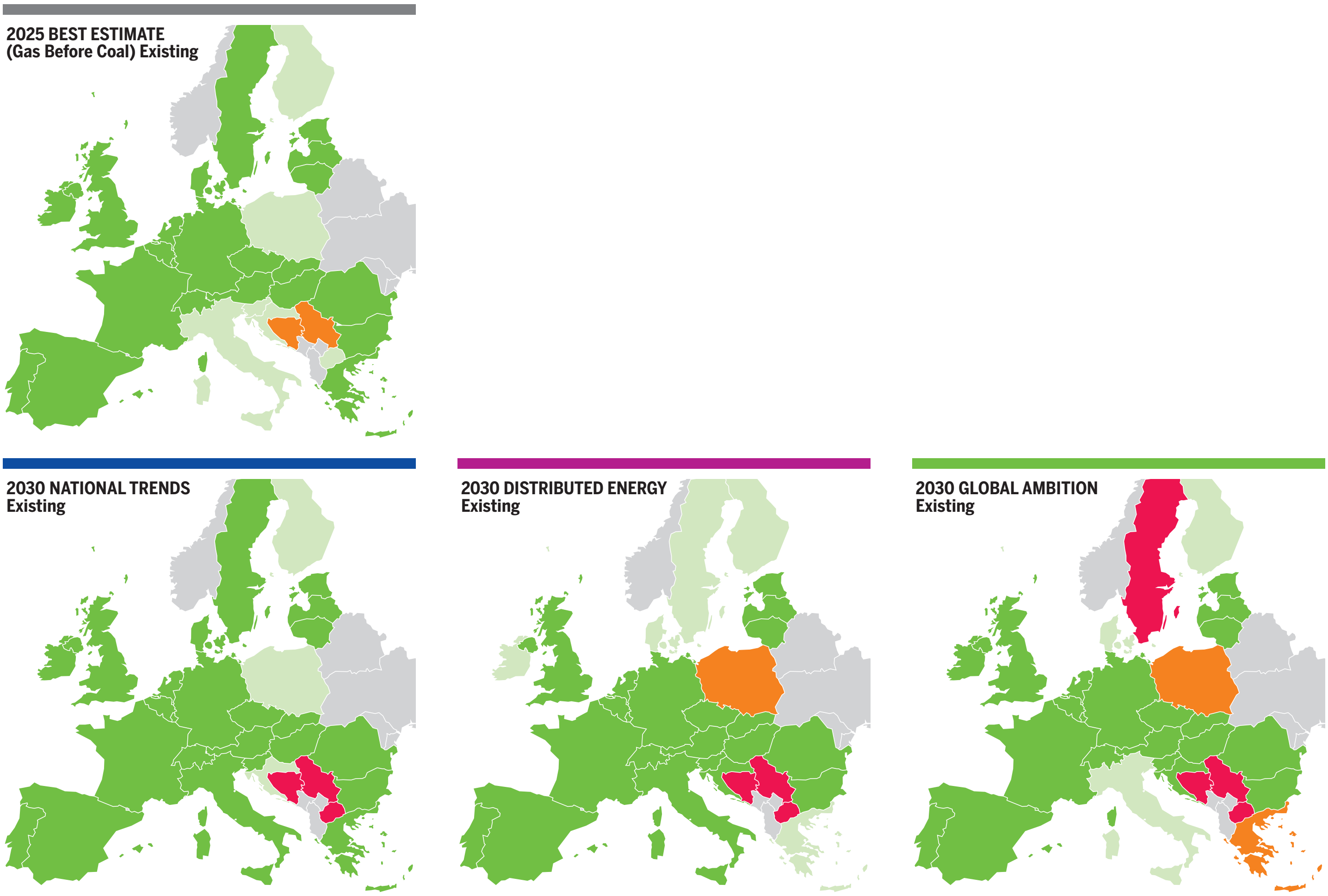
The gas system can therefore ensure the European consumers to be supplied with the necessary amounts of gas for the next 20 years, even in case of extremely cold temperatures and limited intermittent renewable production.

FID and Advanced projects to be commissioned in the next 5 years almost fully mitigate the remaining gaps

While the existing infrastructure is already resilient in most part of Europe, some specific areas require the commissioning of further FID or Advanced infrastructure to fully mitigate their exposure to demand curtailment in case of a 1-in-20 peak day. Only Sweden remains exposed in Global Ambition scenario in 2030.

Picture courtesy of FGSZ

Existing infrastructure



With FID and Advanced projects (commissioned by 2025)

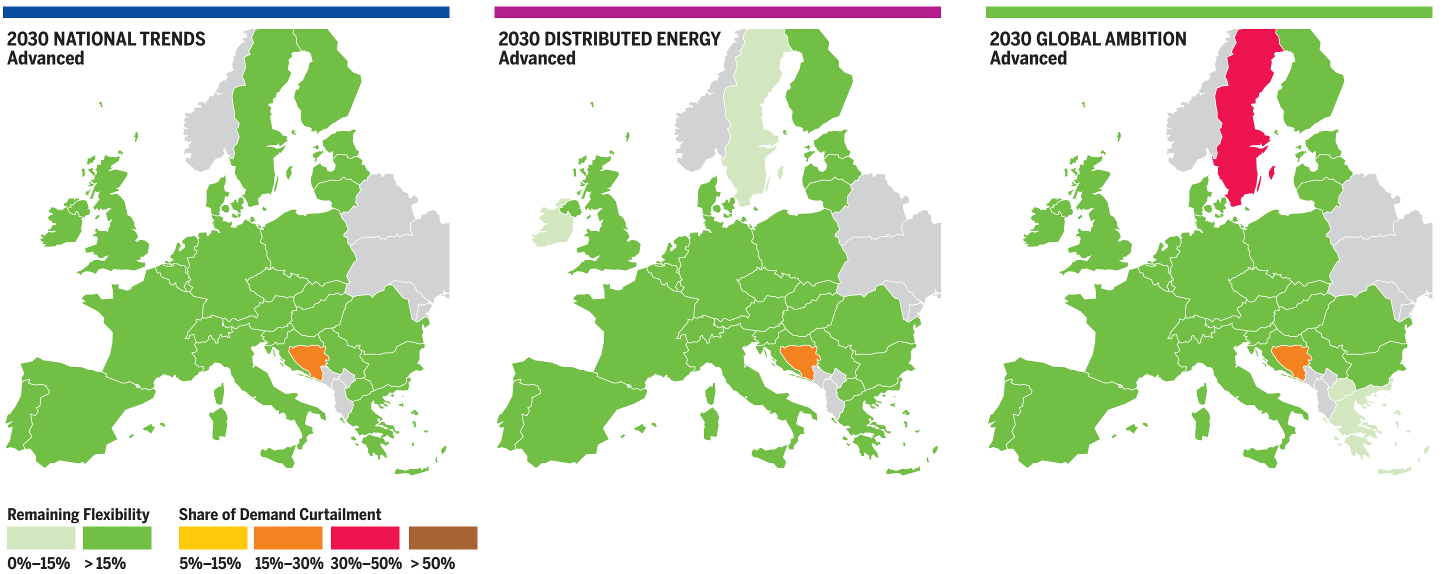


Figure 24 Exposure to demand curtailment in case of a 1-in-20 peak day – 2025 and 2030

The gas system and renewable gases can support the development of intermittent electricity renewable generation while ensuring a high level of security of energy supply, even during a 2-week Dunkelflaute

The assessment confirms that with the development of intermittent renewable power generation, the gas system is generally resilient but is under an increasing stress. However, biomethane production is beneficial to security of supply on an annual basis and during climatic stress due to its continuous operation. Power-to-gas technologies are beneficial for the security of gas supply on an annual basis too.

With the significant penetration of power-to-gas in the different scenarios after 2030, especially Distributed Energy, the gas supply becomes more and more variable. However, during climatic stress situations, especially during Dunkelflaute events, hydrogen from power-to-gas can be produced at its minimum, and the electricity demand requires large amounts of gas for power generation. In such extreme climatic cases for the electricity and gas sectors, the gas system, including gas storages, is key to ensure the necessary energy supply for all sectors.

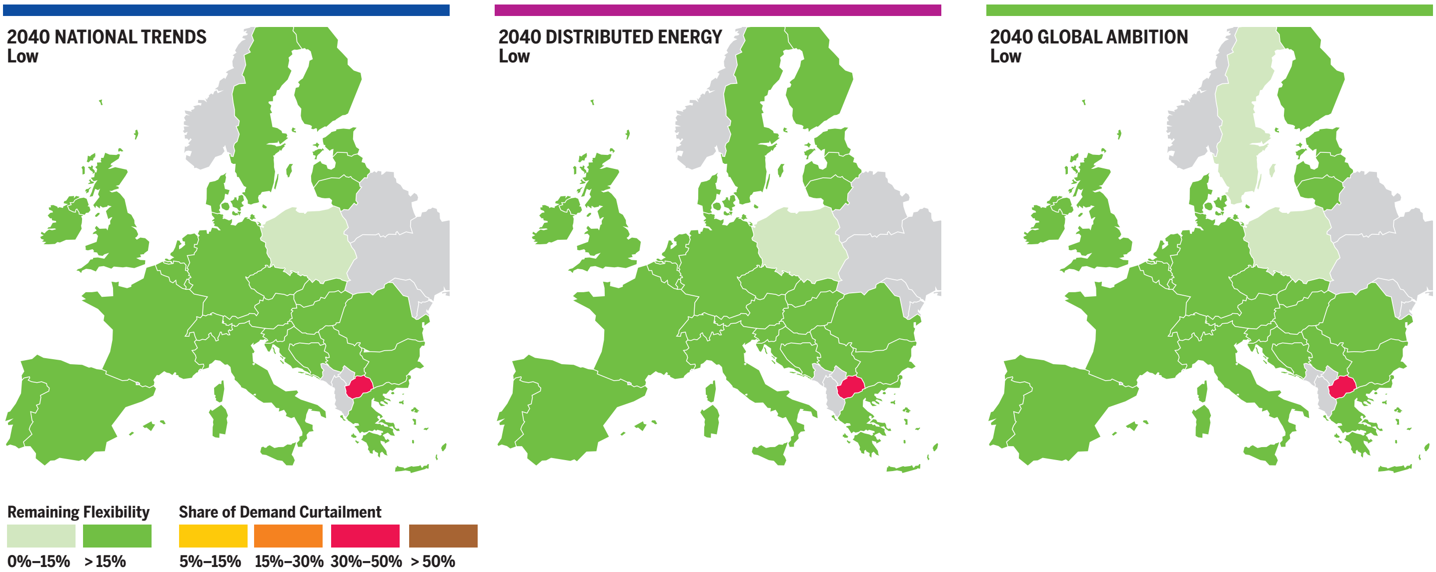


Figure 25 Exposure to demand curtailment in case of a 2-week Dunkelflaute – Low infrastructure level, 2040

Resilience to supply disruptions

The resilience of the gas infrastructure has significantly improved since TYNDP 2018 and the SoS simulation report

Most of Europe is protected from a possible risk of demand curtailment in case of any major supply route disruption during high demand situations.

However, for some supply route disruptions, infrastructure limitations keep on preventing some regions from being fully protected from a risk of demand curtailment. Nonetheless, projects submitted to the TYNDP can provide the necessary additional infrastructure to fully mitigate the situation.

Additionally, in some exposed areas, the assessment of the different scenarios show that the development of renewable gases efficiently contributes to security of supply and reduces the risk of demand curtailment.

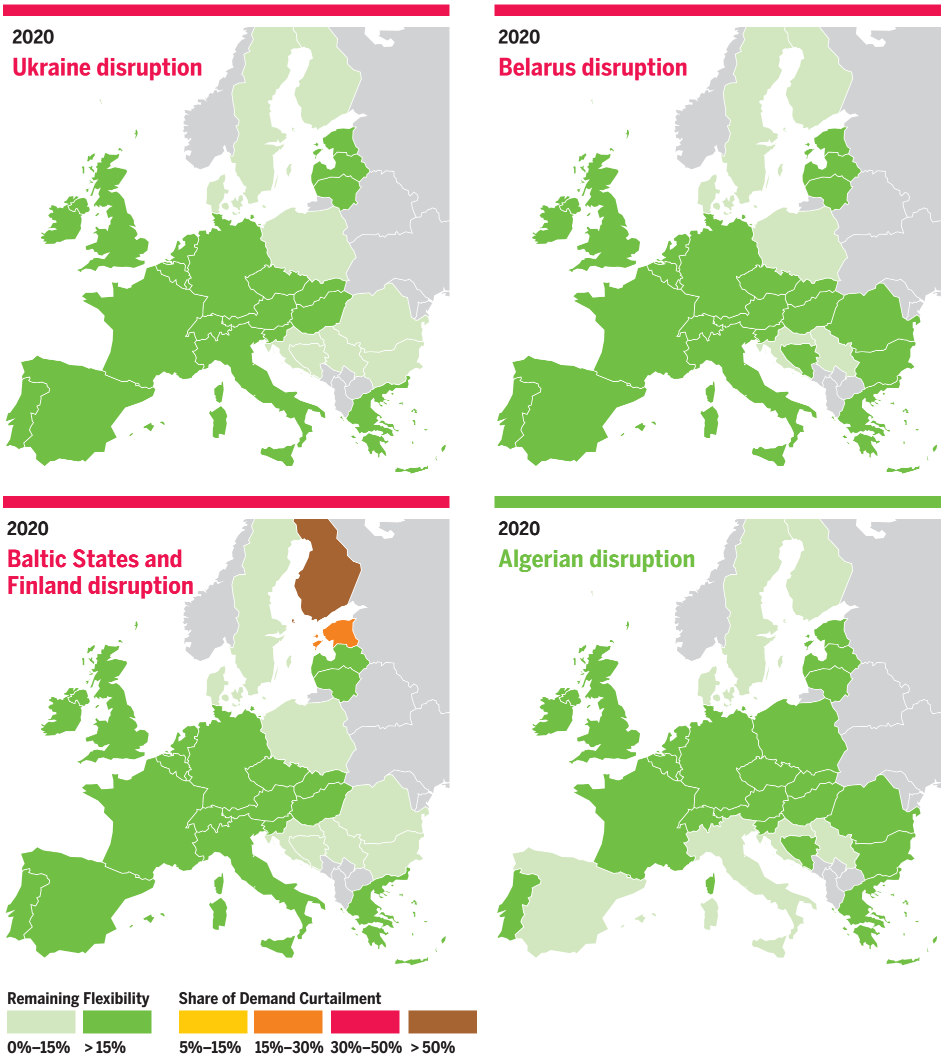


Figure 26 Exposure to demand curtailment in case of supply route Disruption during a peak day – 2020, Existing infrastructure

FID and Advanced projects can achieve the resilience of the gas system to future supply route disruptions by 2025

Only Finland remains exposed to a certain extent in case of disruption of all imports to the Baltic States and Finland.

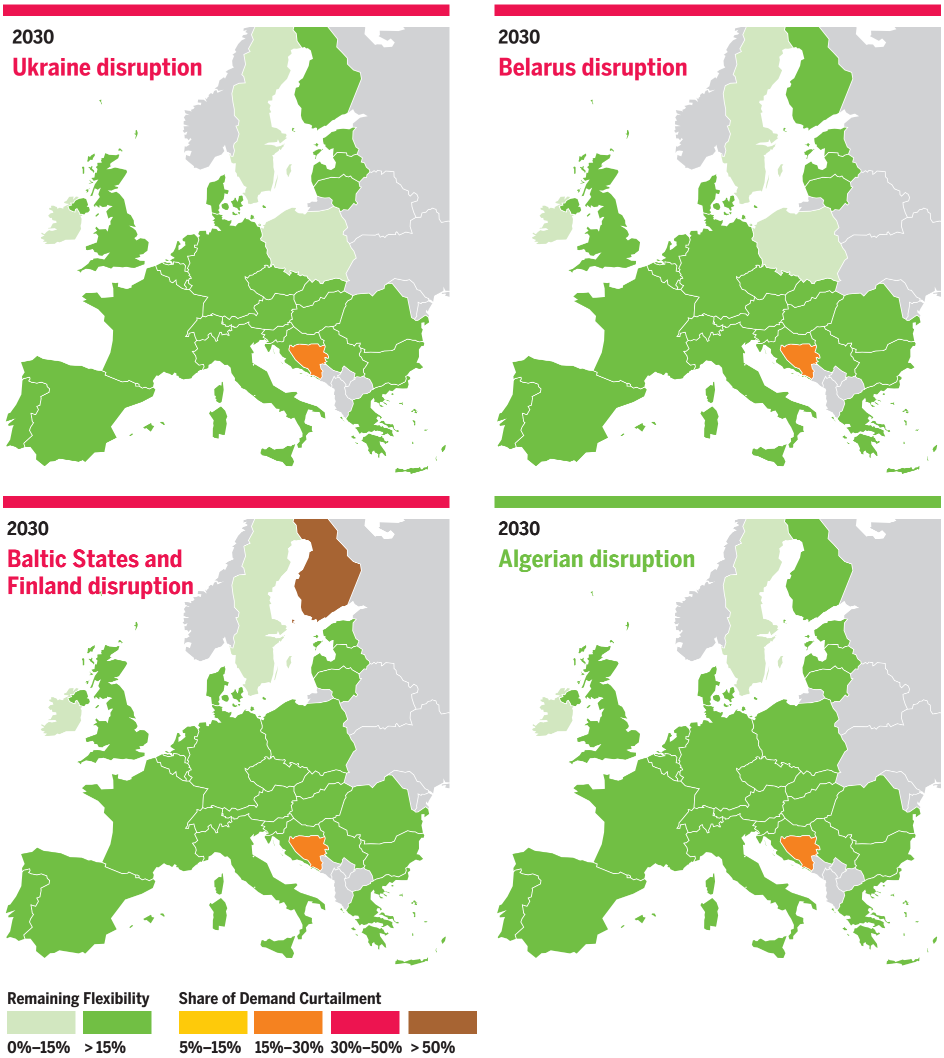


Figure 27 Exposure to demand curtailment in case of supply route Disruption during a peak day – 2030, Advanced infrastructure

RESILIENCE TO THE SINGLE-LARGEST INFRASTRUCTURE DISRUPTION

The resilience of the gas infrastructure improves significantly over time with the commissioning of FID and advanced projects.

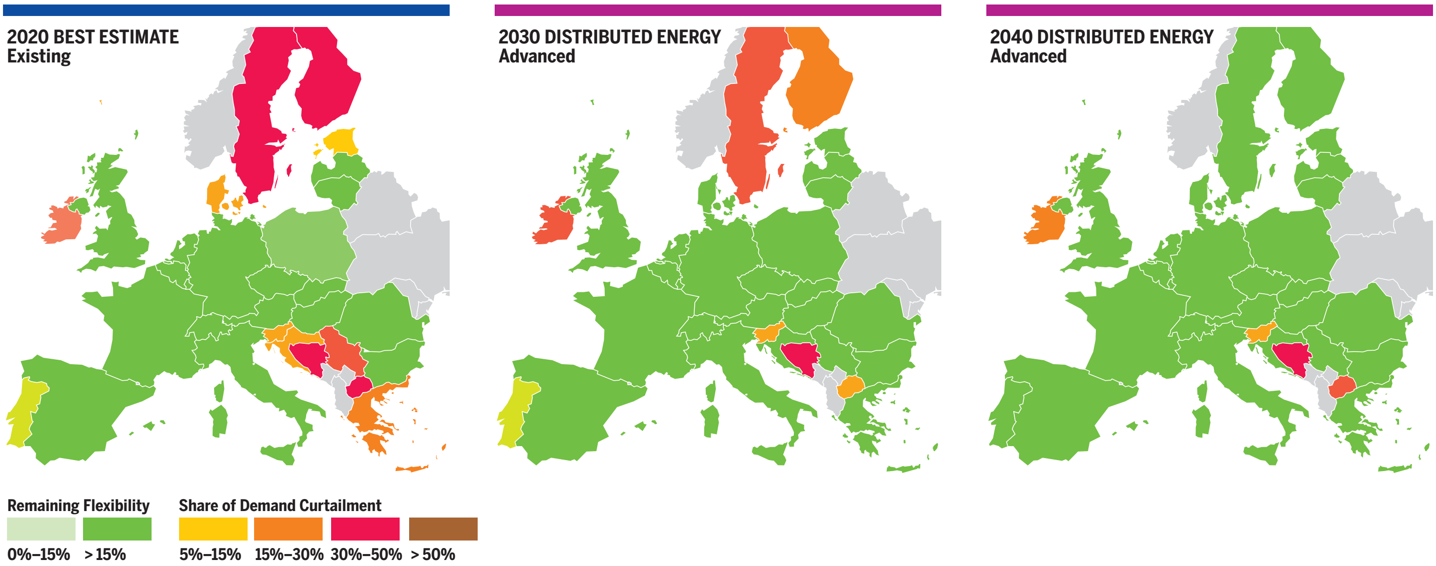


Figure 28 Exposure to demand curtailment in case of Single-Largest Infrastructure Disruption during a peak day

3.3 INFRASTRUCTURE GAPS CAN BE ADDRESSED BY 2025

Almost all infrastructure gaps can be addressed in the next 5 years by projects already initiated

Since TYNDP 2018, the commissioning of a number of projects has improved the resilience of the European gas system, however some infrastructure gaps remain in certain regions under certain scenarios.

TYNDP 2020 confirms that projects having already made their final investment decision (FID) and advanced projects to be commissioned in the next 5 years address efficiently most of the infrastructure needs to reach an effective level of cooperation between the different countries and allows the gas system to:

- Reduce its dependence towards all supply sources to its minimum,
- Provide access to minimum 3 supply sources to most of Europe by 2030 and to all countries by 2040,
- Minimise/maximise the access to the different supply sources depending on their price,
- Allow for an efficient price convergence throughout the EU,
- Be resilient to all climatic events, including a 1-in-20 years peak day,
- Be resilient to most of the supply route disruption including the Ukraine route, even in case of a peak day,
- Be resilient to a 2-week Dunkelflaute, even in Distributed Energy scenario in 2040, confirming the ability of the gas system to support the development of intermittent renewables,
- Be resilient to most Single-Largest Infrastructure disruptions.

However, a limited number of countries could still face some infrastructure limitations in some scenarios and in certain years:

- Finland in case of disruption of all imports from Russia towards the Baltic States and Finland,
- Sweden, in case of extreme climatic conditions in Global Ambition scenario in 2030 as of 2030.

The gas system proves to be resilient to cope with extreme temperatures and supply disruptions, while supporting intermittent renewables. These features of the gas system are key to achieve the European climate and energy objectives by supporting decarbonisation and energy system integration as set out by the European Green Deal.

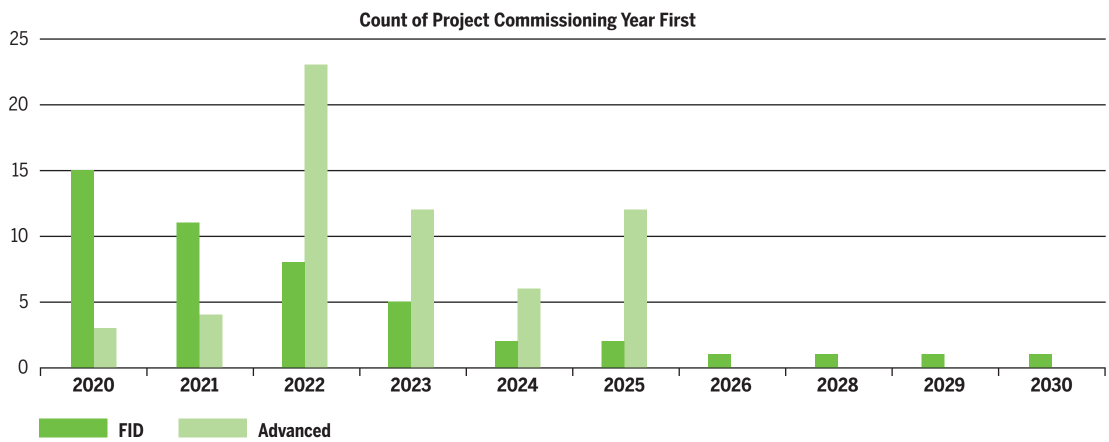


Figure 29 Commissioning date of FID and Advanced projects

4 TYNDP 2022 ON ITS WAY: A HYDROGEN-READY TYNDP TO SUPPORT THE EU CLIMATE AND ENERGY AMBITIONS

R&D: AN ADAPTED MODEL TO SUPPORT THE EU HYDROGEN AND ENERGY SYSTEM INTEGRATION STRATEGIES

ENTSOG is committed to the future of the energy system in Europe. For this purpose, TYNDP scenarios were developed in line with European climate and Energy ambitions.

To support the EU decarbonisation targets, ENTSOG TYNDP 2020 has taken a further step into this direction by collecting for the first time Energy Transition (ETR) projects. The assessment of the sustainability impact of the ETR projects confirms the capability of ENTSOG TYNDP to assess the renewable and decarbonised projects.

Further anticipating the future challenges to come, ENTSOG with TYNDP 2020 has paved the way to enhance its modelling capabilities in terms of assessing a hybrid gas system where methane and hydrogen coexist. The assessment of infrastructure projects in a hybrid dual gas quality system where the hydrogen market could be composed of several clusters and relying on a cross border interconnected hydrogen infrastructure or in a blend with natural gas. The final requirement for ENTSOG is to be able to deliver its next TYNDPs in line with the recently published Hydrogen and Energy System Integration strategies of the European Union.

This assessment framework, based on the current gas CBA methodology and its roadmap has been done in parallel to developing TYNDP 2020 and has delivered promising results for ENTSOG to be confident in its ability to assess future hybrid infrastructure and provide the European Commission with the necessary insights to support the development of the hybrid infrastructure in case such projects would be included in the future TYNDP editions.

With the work undertaken in the last two years, ENTSOG confirms that its model is fit for hybrid network assessment where both methane and hydrogen coexist, according to the three pathways identified in the ENTSOG Roadmap (methane, blending and hydrogen), and that the relevant projects can be assessed.

The test confirms that a dedicated hydrogen infrastructure as well as a gas network with hydrogen blending can support the development of supply and demand including hydrogen locally produced within the EU, while ensuring security of supply.

Looking forward to 2022!

LIST OF FIGURES

LIST OF **ABBREVIATIONS**

ACER	Agency for the Cooperation of Energy Regulators
Bcm/Bcma	Billion cubic meters/Billion cubic meters per annum
CBA	Cost-Benefit Analysis
CSA	Commercial Supply Access indicator
EC	European Commission
ENTSO-E	European Network of Transmission System Operators for Electricity
ENTSOG	European Network of Transmission System Operators for Gas
ETR	Energy TRansition projects
EU	European Union
FID	Final Investment Decision
GIE	Gas Infrastructure Europe
GHG	Greenhouse Gases
GRIP	Gas Regional Investment Plan
GWh	Gigawatt hour
LNG	Liquefied Natural Gas
Low infrastructure	Existing infrastructure + FID projects
MASD	Minimum Annual Supply Dependence indicator
MWh	Megawatt hour
NDP	National Development Plan
PCI	Project of Common Interest
RES	Renewable Energy Sources
SoS	Security of Supply
TSO	Transmission System Operator
TWh	Terawatt hour
TYNDP	Ten-Year Network Development Plan
UGS	Underground Gas Storage (facility)

COUNTRY CODES (ISO)

AL	Albania
AT	Austria
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BE	Belgium
BG	Bulgaria
BY	Belarus
CH	Switzerland
CY	Cyprus
CZ	Czech Republic
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
LY	Libya
MA	Morocco
ME	Montenegro
MK	FYROM
MT	Malta
NL	Netherlands, the
NO	Norway
PL	Poland
PT	Portugal
RO	Romania
RS	Serbia
RU	Russia
SE	Sweden
SI	Slovenia
SK	Slovakia
TM	Turkmenistan
TN	Tunisia
TR	Turkey
UA	Ukraine
UK	United Kingdom

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