Ten-Year Network Development Plan
2013-2022

Main Report

A fair partner to all

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european network
of transmission system operators
for gas

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Foreword

It is a great honour for me to present you the third Ten-Year Network Development Plan (TYNDP) of the European Network of Transmission System Operators for Gas (ENTSOG). This report is a telling example of successful engagement and co-operation between Transmission System Operators (TSOs) and industry stakeholders. We are grateful that stakeholders from across Europe have shared their expertise with us.

ENTSOG has taken up the challenge to produce this TYNDP with the aim of meeting increasing expectations from regulators and stakeholders, and I believe that we have succeeded. This third edition of the TYNDP is our most in-depth and detailed European-wide Plan yet, something we are very proud of.

The TYNDP is more than a legal obligation for ENTSOG. It is the reference showing how the European gas system could develop over the next decade. Our Europe-wide model allows us to illustrate the contribution of gas infrastructure to the objectives of the European energy policy – competition, sustainability and security of supply – and market integration in particular. This report contains a lot of new analysis, from capacity and new gas infrastructure projects, to supply and demand.

The importance of the TYNDP is growing. It is used by ever more stakeholders for wider purposes. Energy infrastructure is the cornerstone of all European policy developments in energy. More than ever, the development of gas infrastructure requires a stable regulatory environment, a fair investment climate and a political understanding of the need for gas infrastructure over the long term. Gas is an essential element of the European energy mix and we believe that it will continue to play a vital role for the coming decades.

I sincerely hope that you will find the TYNDP both interesting and useful. I wholeheartedly encourage you to participate in the consultation process: your input will help us shape the future editions of this report.

Stephan Kamphues
ENTSOG President

Executive Summary

The European Network of Transmission System Operators for Gas (ENTSOG) has produced the third pan-European Ten Year Network Development Plan (TYNDP). The TYNDP 2013-2022 aims to provide a view of how European gas infrastructure could develop over the next ten years, from the perspective of the European Transmission System Operators.

The legal obligations from the 3rd Energy Package came into force on 3rd March 2011, making this Plan the first to go through the full 2 year cycle as envisaged in REG-715. ENTSOG has built on previous Reports, to offer the market the most detailed TYNDP yet. In response to feedback, ENTSOG has run an open and transparent stakeholder engagement process, which has provided the opportunity for stakeholders to influence this version of the TYNDP. ENTSOG is very grateful for all the input and time given by those who chose to participate.

The development of new gas infrastructure supports all three pillars of the European energy policy. It facilitates a liquid and competitive internal gas market, by increasing physical market integration. The resulting flexibility of the European gas system will enable and enhance supply diversification, even with declining indigenous production, thus enhancing Security of Supply. New gas infrastructure will also play an important role in improving sustainability in Europe, therefore helping the EU meet its environmental targets.

SUPPLY AND DEMAND

This TYNDP in line with 3rd Package obligations, presents a European Supply Adequacy Outlook capturing a wide range of potential supply scenarios to cover the European gas demand. ENTSOG looked to develop the supply aspect of the Report, by moving to a multi-scenario supply source approach. The range of supply is shown by a maximum and a minimum scenario, representing the limits for the amount of gas physically available to the European market.

This TYNDP shows yearly gas demand for Europe is expected to grow on average by 1% over the 10-year horizon. This growth is expected to come mainly from gas consumption by power generators. The electricity sector's demand is anticipated to increase by 33% over the 10-year period. In the Plan, another innovation has been the inclusion of an ENTSOG scenario showing gas demand for power generation, and enabling comparisonagainst ENTSO-E scenarios.

ENTSOG has also produced 4 daily demand situations for this TYNDP, and they are:

- Yearly Average Situation: This refers to the evolution of gas demand as an average of the annual figures.
- The Design-Case Situation: This refers to national peak demand figures per day as calculated by TSOs and laid down in National Development Plans.
- A Uniform Risk Demand Situation: This refers to the sum of the high daily consumption forecasts for each zone, based on a common definition of climatic conditions.
- 14-Day Uniform Risk Situation: This refers to the sum of the average daily demand during a 14-day period of high gas consumption in each Zone.

ENTSOG has modelled substantially more cases in this Report than ever before, with over 200 cases modelled compared to 67 in the last Report. In line with the three pillars of European Energy policy, ENTSOG has produced results based on the following:

- Assessment of the resilience of the European gas system
- Highlighting the dependency of Zones on identified supply sources
- The ability of the European gas system to adapt to different flow patterns
- The capability of the European gas system to enable supply diversification

RESILIENCE ASSESSMENT

The resilience assessment modelling shows how much flexibility is available in the European gas system even in situations of very high daily demand. The key conclusion from the modelling is that under certain investment climate and supply conditions, there are Zones within the European gas system that will not have sufficient capacity to achieve a full supply-demand balance, unless a combination of FID and Non-FID projects are brought to market. The Zones affected and under what conditions are:

- Under the Reference Case: Bosnia-Herzegovina, Denmark, Sweden, Finland and Luxembourg
- Belarus Disruption: Lithuania and Poland
- Ukraine Disruption: Bosnia-Herzegovina, Bulgaria, Croatia, FYROM, Greece, Hungary, Romania, Serbia and Slovenia

SUPPLY DEPENDENCY ASSESSMENT

The dependence on a Supply source naturally reduces a Zone's overall Security of Supply. For the first time, ENTSOG analysed a Zone's dependence on each supply source. The results showed that no Zone had a supply dependency on Norwegian, Algerian, Libyan or Azeri supplies over 20%. The dependency on LNG is localised around the Iberian Peninsula, the south of France and Greece. LNG is already a diversified source of gas, due to its availability from multiple suppliers on the global market, meaning that Zones with an LNG dependency are less vulnerable to a single supplier loss. The implementation of the covered FID and Non-FID projects in the respective regions would reduce their reliance on LNG and further improve flexibility. The modelling showed a range of Zones being reliant on Russian gas with 10 Zones having a supply dependency of 60% or more in 2013. If the Non-FID projects in those regions came to fruition, this would have a profound impact on the level of dependency on Russian gas. The Non-FID 2022 outlook shows only 3 Zones with a dependency of over 20% and no Zones with a dependency of over 60%.

NETWORK ADAPTABILITY ASSESSMENT

ENTSOG modelled the Minimum and Maximum potential Supply scenarios of each source on the 10-year range. The results showed how the European gas system has the capability to face very different supply mixes despite the increasing spread between them.

SUPPLY SOURCE DIVERSIFICATION ASSESSMENT

The assessment of the Supply Source Diversification aimed at determining the ability of each Zone to access each identified supply source. The analysis showed the varying capability of the different Zones to accept supplies from a range of suppliers. It can be concluded that gas infrastructure within the European gas system has the ability to ensure that each Zone has, on average, 3 different suppliers providing at least 5% of yearly supply. In addition, the Report identifies which Zone can access which supply sources and whether the level of access of supply is over 5% or 20%, which were the two benchmarks set for the analysis.

ENTSOG encourages all stakeholders to provide feedback on this Report. Only through continued discussions with all stakeholders will the TYNDP evolve to meet increasing market expectations.

Introduction

This Ten Year Network Development Plan 2013-2022 (TYNDP) by ENTSOG provides a holistic and transparent view of potential European wide gas infrastructure developments. It uses network modelling to assess the resilience of the European gas system, the dependence of its Zones on identified supply sources, its ability to adapt so various supply pattens and its capability to enable supply diversification. It furthermore presents the European Supply Adequacy Outlook capturing a wide range of Potential Supply scenarios to cover the European gas demand.

The European 3rd Energy Package made it a legal obligation on ENTSOG to produce "a non-binding Community-wide ten-year network development plan including a European supply adequacy outlook every two years" (Art. 8(3)(b), REG-715). The 3rd Energy Package legal obligations came into force on 3rd March 2011, making this third Plan the first to go through the full 2 year cycle as envisaged in the Regulation.

Since the first publication of the Plan, ENTSOG has strived to increase the quality of the Report in close co-operation with its various stakeholders. Based on TYNDP 2011-2020 feedback ENTSOG targeted and worked on three key areas for further improvement:

- Stakeholder involvement in the development and scoping process
- Demand analysis methodology and scenarios
- Market Integration analysis

ENTSOG is committed to open and transparent stakeholder engagement, and the TYNDP 2013-2022 is a demonstration of this commitment. ENTSOG has run an inclusive consultation process that gave stakeholders the opportunity to become fully engaged in the TYNDP development. Whilst developing this Plan, ENTSOG held an intensive set of stakeholder workshop sessions dedicated to the TYNDP. The sessions were based on the best practises developed during the Network Code development process. These Stakeholder Joint Working Sessions (SJWS), covered the following areas:

- Supply
- Demand
- Market Integration
- Security of Supply
- Infrastructure projects

Additionally, ENTSOG also hosted bi-lateral meetings to discuss the TYNDP development with individual parties, further emphasising ENTSOG's 'open door' policy. It was vital from the ENTSOG perspective that stakeholders could participate in the TYNDP development process from the earliest possible stage. ENTSOG hopes that an increasing number of stakeholders will take up the open invitation to contribute towards future TYNDP development.
The stakeholder engagement process has resulted in the following additions, being incorporated into this TYNDP:

- Additional High Daily Demand Situations
- A multi scenario supply approach
- A review of European political scenarios out to 2050
- A review of ENTSO-E gas demand for power generation

Due to the afore mentioned modifications ENTSOG has expanded the scope for modelling which resulted in the TYNDP 2013-2022 covering well over 200 cases compared to the 67 cases modelled in the 2011-2020 edition.

The TYNDP begins with a chapter on infrastructure projects which covers a detailed overview of FID and Non-FID projects. Detailed information about all projects can be found in Annex A

The Methodology chapter provides a detailed description of the conceptual approach and assumptions taken by ENTSOG in developing the TYNDP. It outlines how the ENTSOG Network Modelling tool (NeMo Tool) operates, including the specifications of the cases used. The cases are divided into four categories to capture the contribution of gas infrastructure to meet the objectives of the European energy policy and such to the level of infrastructure-related Market Integration. The chapter also outlines the considered demand and supply situations. Besides the Design-Case Demand Situation, ENTSOG developed two additional high daily demand cases based on a common definition of climatic conditions. By moving from a single supply scenario to a multi-scenario approach ENTSOG has endeavoured to improve the supply aspect of the Report as well. The multi-scenario supply approach enhances the robustness of the modelling results by analysing a range of potential future supply levels.

The Supply and Demand chapter, covers the Supply Adequacy Outlook by showing the different supply and demand projections on the 10-year range. The detailed demand projections are based on TSO data. A comparison is also made between ENTSOG's forecast and outlooks produced by other organisations and institutions. Supply scenarios are a reflection of publicly available data from governmental and other recognised sources.

The Assessment Results chapter presents the outcome of the network modelling along the categories of cases defined. It identifies:

- potential investment gaps in the European gas system under normal Situations and in Supply Stress through the calculation of Remaining Flexibility of each Zone of the system
- dependence of some Zones on a single supply source
- the ability of the system to adapt to various supply patterns
- the capability of the system to enable its Zones to access different supply sources

Moreover, additional indicators are proposed to measure Import Route Diversification and Import Dependency.

The TYNDP Annexes provide access to the input data for the ENTSOG network model, detailed information on all TYNDP infrastructure projects and additional historical information regarding the covered Zones of the European gas system.

In general the TYNDP showcases the European TSOs close working relationship and co-operation within ENTSOG to produce this Plan. ENTSOG would also like to recognise the important contribution made by stakeholders during the TYNDP scoping and development process. In order to ensure the TYNDP continues to improve and meet future expectations, ENTSOG welcomes feedback and further market participation.

Infrastructure Chapter

GENERAL

To ensure the completion of the European Internal Energy Market it is vital that tailored gas infrastructure is developed. The number of projects included in this TYNDP illustrates that the market is willing to invest heavily in gas infrastructure. Infrastructure projects will nevertheless only come on stream if there is a stable investment climate, which includes a fair regulatory settlement, ensuring that market parties are incentivised to commit to long term investments.

This TYNDP provides to the market information on the status of the infrastructure projects, whilst also showing through network modelling what impacts the projects will have on the resilience of the European gas system and Market Integration.

Expanding the capacity at Interconnection Points must be done in conjunction with reinforcing the upstream and downstream systems. This ensures that the development of capacity at cross border points benefits the system as a whole, and ensures not only the free flow of gas across borders, but allows gas to flow to the consumer throughout the entire supply chain.

GAS INFRASTRUCTURE AND EUROPEAN ENERGY POLICY

The development of new gas infrastructure supports the three pillars of the European energy policy. It enables and facilitates a liquid and competitive common gas market, through increased market participation and integration. The resulting increased flexibility of the European gas system will enable and enhance supply diversification thus improving the security of gas supply. Gas infrastructure can also have a significant role to play in improving sustainability in Europe, especially with gas likely to play a key role in helping the EU meet its environmental targets.

The EU has made reversing climate change one of its top legislative priorities. European legislation has been enacted to try and reverse climate change in Europe, with each Member State having legally binding targets to meet, so that the EU can achieve its 20-20-20 targets by 2020. In order for these targets to be achieved a significant amount of renewable energy generation is required to come on-line by 2020 and beyond. Natural gas could play a vital role in mitigating the Security of Supply risks associated with increasing renewable energy sources. Gas offers the market the necessary flexibility while being abundant, available and affordable.

Natural gas plays a significant role within the EU energy mix, and there is considerable merit for this to continue over the forthcoming decades. However there are two key uncertainties that have to be overcome, political decisions and regulatory frameworks. There has to be a reliable investment climate where investors can make reasonable returns over the whole life of an infrastructure asset. There have been mixed political messages on the future of natural gas, while investment in tailored gas infrastructure is imperative to facilitate the completion of the European Internal Energy Market, including the integration of the European 'Energy Islands'. The construction of tailored gas infrastructure projects also helps diversify supplies and increase Security of Supply for all European citizens.

The European gas industry and TSOs in particular are undergoing a period of radical change; unbundling, harmonised access rules through European Network Codes, enhanced competition changing suppliers' strategies compared to the past. The European gas system still requires significant investment in order to be fully sufficient. Physical system flexibility will be essential to ensure market flexibility and Market Integration, and that gas can act as an enabler for the increasing amount of renewable electricity generation.

With the Large Combustion Plant Directive closing down ageing power plants, the nuclear shutdown in Germany and beyond, and the long lead in time it takes to connect remote renewable energy sources, transition from more polluting fossil fuel generation to natural and green gas across Europe will be essential to safeguard electricity generation in the short to medium term.

DATA COLLECTION PROCESS

In order to provide a holistic view of the European gas system over the next 10-year period, it is important that all relevant infrastructure projects are incorporated into the TYNDP. ENTSOG has endeavoured to run an open and transparent data collection process, and actively encouraged project promoters to submit their projects. ENTSOG pro-actively collected data from project promoters that are not directly obligated to submit data to ENTSOG (The 3rd Energy Package REG-715). Projects not submitted by their respective promoter have not been considered in the Report.
Regarding projects that are promoted by TSOs, the TYNDP is in line with the latest National Development Plans where they existed at the time of this TYNDP data collection.

ENTSOG collected a vast amount of data from a wide spectrum of European parties. The collection of this data is repeatedly one of the most challenging aspects of producing a TYNDP. In order to improve the data collection phase of the TYNDP, ENTSOG held an on-line collection process. This innovation eased the burden on project promoters and made the process more robust overall. Furthermore, initial discussions with stakeholders suggest the change has been well received.

The chart below represents the composition of the submitted projects according to the infrastructure type and FID/Non-FID status:

Image courtesy of FGSZ

Figure 2.1
Number of projects in TYNDP 2013-2022 per type

For comparison purposes, the chart below represents the composition of the submitted projects according to the infrastructure type and FID/Non-FID status as submitted for the previous TYNDP 2011-2020.

- LNG Terminal - FID
- LNG Terminal - Non-FID
- Pipeline (incl. Infrastructure Projects) - FID
- Pipeline (incl. Infrastructure Projects) - Non-FID
- Storage Facility - FID
- Storage Facility - Non-FID

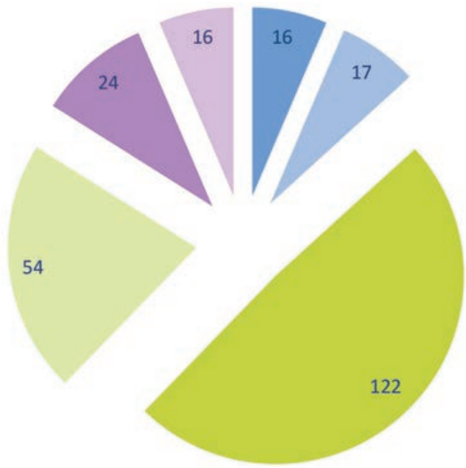


Figure 2.2
Number of projects in TYNDP 2011-2020 per type

Image courtesy of Snam Rete Gas

Figure 2
Number of projects in TYNDP 2011-2020 per type

The overview of all projects submitted for this TYNDP is provided below. Projects are listed in five separate tables according to the infrastructure type of the project. The following infrastructure types were considered:

- Transmission, incl. CS
- LNG Terminal
- Storage Facility
- Production Facility
- Interconnection with a gas-fired power plant

Each table is sorted alphabetically according to the name of the project promoter and the code assigned to their project for reference purpose. The full information supplied on each project can be found in Annex A (Infrastructure Projects) which also provides enhanced search and sorting functionalities on all projects.

Table 2.1.
Overview of all Transmission projects, incl. CS, submitted for TYNDP 2013-22 listed by project promoter

PROJECT PROMOTER	NAME	CODE	COMMISSIONING
bayernets GmbH	MONACO section phase II (Finsing-Amerdingen)	TRA-N-240	2018 Q4
	MONACO section phase I (Burghausen-Finsing)	TRA-N-241	2017 Q4
BH Gas d.o.o.	Gaspipeline Zenica - Brod	TRA-N-224	2022*
Bulgarian Ministry of Economy, energy and tourism (MEET)	Interconnection Bulgaria - Serbia	TRA-N-137	2015
Bulgartransgaz EAD	Interconnection Bulgaria–Romania	TRA-F-057	2013 Q2
	Enabling permanent bi-directional capacity in the existing interconnection point between Bulgaria and Greece	TRA-F-143	2013
	Enabling permanent bi-directional capacity in the interconnection points between Bulgaria and Romania – Negru Voda 1, 2 and 3	TRA-F-144	2013
	Interconnection Turkey-Bulgaria	TRA-N-140	2014
	Black Sea CNG	TRA-N-145	2015
Creos Luxembourg S.A.	OS GRTgaz/Creos	TRA-N-013	2017 Q3
DEPA S.A.	Interconnector Greece Bulgaria - IGB	TRA-N-149	2015 Q1
	East Med	TRA-N-189	2017 Q4
DESFA S.A.	Komotini-Thesprotia pipeline	TRA-N-014	2018
	Compressor Station Kipi	TRA-N-128	2018
	Reverse flow at GR-BG border (Greek part)	TRA-N-188	2014 Q4
Edison	GALSI Pipeline	TRA-N-012	2016 Q3

PROJECT PROMOTER	NAME	CODE	COMMISSIONING
Enagás S.A.	CS Border at Biriatou)	TRA-F-156	2015 Q4
	Power increase CS Haro	TRA-F-157	2016 Q4
	New Utilities CS Tivissa	TRA-F-158	2016 Q4
	CS Zaragoza power increase	TRA-F-160	2016 Q4
	Guitiriz-Lugo	TRA-F-164	2013 Q4
	Loop Bermeo-Lemona	TRA-F-166	2015 Q4
	Loop Castelnou-Villar de Arnedo	TRA-F-169	2016 Q4
	Loop Llanera-Otero	TRA-F-170	2013 Q4
	Loop Treto-Llanera	TRA-F-171	2013 Q4
	Loop Villapresente-Burgos	TRA-F-173	2014 Q4
	Martorell-Figueras	TRA-F-175	2013 Q4
	Nuevo Tivissa-Arbós	TRA-F-180	2016 Q4
	Musel Terminal-Llanera	TRA-F-181	2013 Q4
	Zarza de Tajo-Yela	TRA-F-186	2013 Q4
	CS Zamora power increase	TRA-N-159	2018 Q4
	Iberian-French corridor: Eastern Axis-Midcat Project (Pipeline Figueras-French border)	TRA-N-161	2020 Q4
	Loop Arrigorriaga-Lemona	TRA-N-167	2018 Q4
	Interconnection ES-PT (3rd IP)	TRA-N-168	2017 Q4
	Loop Vergara-Lemona	TRA-N-172	2019 Q4
	Igerian-French corridor: Eastern Axis-Midcat Project (CS Martorell)	TRA-N-176	2020 Q4
	Castropodame-Zamora	TRA-N-278	2017 Q4
	CS La Barbolla	TRA-N-279	2021 Q4
	Lugo-Villafranca del Bierzo	TRA-N-280	2017 Q4
	Villafranca del Bierzo-Castropodame	TRA-N-281	2017 Q4
	Zamora-Barbolla-Adradas	TRA-N-282	2021 Q4
Enemalta Corporation	Connection of Malta to the European Gas Network - Pipelines	TRA-N-031	2018 Q4
Energinet.dk	Ellund-Egtved	TRA-F-015	2013 Q4
eustream, a.s.	Slovakia - Hungary interconnection	TRA-F-016	2014 Q4
	System Enhancements - Eustream	TRA-F-017	2017
	Poland - Slovakia interconnection	TRA-N-190	2016 Q4
FGSZ Natural Gas Transmission	Városföld-Ercsi-Győr	TRA-N-018	2015 Q3
	Ercsi-Győr	TRA-N-018	2015 Q3
	Csepel connecting pipeline	TRA-N-019	2014 Q4
	Ercsi-Szazhalombatta	TRA-N-061	2016 Q3
	Hajduszoboszlo CS	TRA-N-065	2018 Q4
	Városföld CS	TRA-N-123	2016 Q3
	Local Odorisation - FGSZ	TRA-N-124	2015 Q3
	Romanian-Hungarian reverse flow Hungarian section	TRA-N-286	2015 Q4
Fluxys	Bretella	TRA-F-207	2016 Q4
	Reverse Flow TENP Germany	TRA-N-208	2016 Q4
	Reverse Flow Transitgas Switzerland	TRA-N-230	2016 Q4
Fluxys Belgium	Alveringem-Maldegem	TRA-F-205	2015 Q4
	Zeebrugge Compression Project	TRA-N-270	2016 Q4
Fluxys Belgium / Creos	Luxembourg Pipeline	TRA-N-206	2016

PROJECT PROMOTER	NAME	CODE	COMMISSIONING
Gas Connect Austria GmbH	Bidirectional Austrian-Czech Interconnector (BACI, formerly LBL project)	TRA-N-021	2019
GASCADE Gastransport GmbH	Extension of GASCADE grid in the context of the Nord Stream (on-shore) project	TRA-N-249	2014 Q1
Gaslink	Physical Reverse Flow at Moffat Interconnection Point	TRA-N-059	2017
	Twinning of South West Scotland Onshore System	TRA-N-060	2015 Q1
	Physical Reverse Flow on South North Pipeline	TRA-N-071	2017
Gassco AS	Zeebrugge Compression Project	TRA-N-056	2016 Q4
Gastrade S.A.	Alexandroupolis Independent Natural Gas System - Pipeline Section	TRA-N-063	2015 Q4
Gasum Oy	Balticconnector (FI-EE)	TRA-N-023	2016 Q4
Gasunie Deutschland Transport Services GmbH	Extension of existing gas transmission capacity in the direction to Denmark - 1. Step	TRA-F-231	2014 Q4
	Extension of existing gas transmission capacity in the direction to Denmark - 2. Step	TRA-N-232	2015 Q4
Gasunie Transport Services B.V.	System Enhancements FID update - Gas Transport Services	TRA-F-268	2014 Q3
	Blending	TRA-N-191	2020
	Entry capacity expansion GATE terminal	TRA-N-192	2016
	Gas Compressor Optimisation Program	TRA-N-193	2022*
Gazprom	South Stream Project (Onshore Section)	TRA-N-187	2015 Q4
GAZ-SYSTEM S.A.	Upgrade of gas infrastructure in northern and central Poland	TRA-F-248	2014
	Gas Interconnection Poland-Lithuania (GIPL)	TRA-N-212	2017
	The North-South Gas Corridor in Eastern Poland	TRA-N-245	2020
	The North-South corridor in Western Poland	TRA-N-247	2021
	PL - DK interconnection (Baltic Pipe)	TRA-N-271	2020
	PL - CZ interconnection	TRA-N-273	2017
	Upgrade of PL-DE interconnection in Lasów	TRA-N-274	2015
	PL - SK interconnection	TRA-N-275	2016
	Upgrade of the entry points in Lwówek and Włocławek on the Yamal-Europe pipeline	TRA-N-276	2015
GRTgaz	Arc de Dierrey	TRA-F-036	2015 Q4
	Entry capacity increase from Belgium to France	TRA-F-037	2013 Q4
	Developments for the Dunkerque LNG new terminal	TRA-F-038	2015 Q4
	Iberian-French corridor: Western Axis (CS Chazelles)	TRA-F-039	2013 Q1
	Reverse capacity from France to Belgium at Veurne	TRA-F-040	2015 Q4
	Eridan	TRA-F-041	2016
	New interconnection IT-FR to connect Corsica	TRA-N-042	2018
	Developments to merge GRTgaz North and South zones	TRA-N-043	2018
	New interconnection to Luxembourg	TRA-N-044	2018
	Reverse capacity from CH to FR at Oltingue	TRA-N-045	2018
	Exit capacity increase to CH at Oltingue	TRA-N-046	2019
	Reverse capacity from France to Germany at Obergailbach	TRA-N-047	2018
	Developments for Montoir LNG terminal expansion at 12,5bcm - 1	TRA-N-048	2018

PROJECT PROMOTER	NAME	CODE	COMMISSIONING
	Est Lyonnais pipeline	TRA-N-253	2019
	Developments for the Fos faster LNG new terminal	TRA-N-254	2019
	Fos Tonkin LNG expansion	TRA-N-255	2019
	Iberian-French corridor: Eastern Axis-Midcat Project (CS Montpellier and CS Saint Martin de Crau)	TRA-N-256	2020
	New line Between Chemery and Dierrey	TRA-N-257	2021
	Developments for Montoir LNG terminal expansion at 16,5bcm - 2	TRA-N-258	2021
	Fosmax (Cavaou) LNG expansion	TRA-N-269	2020
IGI Poseidon S.A.	Poseidon Pipeline	TRA-N-010	2017 Q4
Latvijas Gaze	Enhancement of Latvia-Lithuania interconnection	TRA-N-131	2021 Q4
Lietuvos Dujos	Gas pipeline Jurbarkas-Klaipeda	TRA-F-239	2013 Q4
	Enhancement of Capacity of Pipeline Klaipeda-Kiemenai	TRA-N-238	2017 Q4
Maersk Oil and Gas A/S	Tie-in of Norwegian off-shore natural gas transmission system to Danish off-shore natural gas infrastructure	TRA-N-218	2014 Q4
Magyar Gaz Tranzit Zrt.	Slovak-Hungarian interconnector (Vecsés-Szada-Balassagyarmat)	TRA-F-148	2014 Q1
	AGRI Pipeline - Hungarian section	TRA-F-195	2022*
	South Stream Hungary	TRA-F-196	2015 Q1
Ministry of Cyprus	Trans-Mediterranean Gas Pipeline	TRA-N-054	2018 Q2
NABUCCO Gas Pipeline International	Nabucco Gas Pipeline Project (“Nabucco Classic”)	TRA-N-077	2018 Q4
	Nabucco Gas Pipeline Project (“Nabucco West”)	TRA-N-078	2018 Q4
National Grid Gas plc	System Capacity Enhancements FID	TRA-F-025	2013
	System Capacity Enhancements non-FID - National Grid	TRA-N-026	2022*
Naturgas	Bilbao Terminal-Treto	TRA-F-155	2013 Q4
NET4GAS, s.r.o.	GAZELLE project	TRA-F-134	2013
	Bidirectional Austrian Czech Interconnection (BACI, formerly LBL project)	TRA-N-133	2019
	Connection to Oberkappel	TRA-N-135	2022
	Poland-Czech Republic Interconnection within the North-South Corridor (STORK II)	TRA-N-136	2017
Nord Stream AG	Nord Stream 4	TRA-N-069	2018 Q4
	Nord Stream 3	TRA-N-267	2017 Q4
Open Grid Europe GmbH	System enhancements, including the connection of gas-fired power plants, storages and the integration of power to gas facilities	TRA-N-243	2020
	Stepwise change-over to physical H-gas operation of L-gas networks	TRA-N-244	2020

PROJECT PROMOTER	NAME	CODE	COMMISSIONING
Plinacro Ltd	Interconnection Croatia/Bosnia and Herzegovina (Slobodnica- Bosanski Brod-Zenica)	TRA-N-066	2015
	Ionian Adriatic Pipeline	TRA-N-068	2018
	Interconnection Croatia/Serbia Slobdnica - Sotin (Croatia) - Bačko Novo Selo (Serbia)	TRA-N-070	2022*
	LNG main gas transit pipeline (Part of North-South Gas Corridor) Zlobin-Bosiljevo-Sisak-Kozarac-Slobodnica	TRA-N-075	2022*
	International Pipeline Omišalj - Casal Borsetti	TRA-N-083	2018
	Interconnection Croatia/Slovenia (Bosiljevo - Karlovac - Lučko - Zabok - Rogatec)	TRA-N-086	2016
	LNG evacuation pipeline Omišalj - Zlobin (Croatia) - Rupa (Slovenia)	TRA-N-090	2015
Plinovodi d.o.o.	CS Kidričevo (3rd unit 3,5 MW)	TRA-F-096	2014
	M2/1 Trojane – Vodice	TRA-F-097	2014
	M2/1 Rogaška Slatina – Trojane	TRA-F-104	2014
	M5 + R51 Vodice – TE-TOL	TRA-F-105	2015
	MRS Šempeter - reconstruction	TRA-F-110	2014
	CS Ajdovščina (3rd unit up to 5 MW)	TRA-N-092	2016
	CS Ajdovščina (2nd phase - 4th and 5th unit on M3/1 pipeline of total power up to 20 MW)	TRA-N-093	2022*
	CS Kidričevo (2nd phase - up to 3 units with total power up to 30 MW)	TRA-N-094	2016
	CS Rogatec (up to 2 MW)	TRA-N-095	2022*
	M9a Lendava - Kidričevo (including CS Kidričevo 3rd phase with up to 5 units of total power up to 80 MW)	TRA-N-098	2016
	M3/1a Gorizia/Šempeter - Ajdovščina	TRA-N-099	2017
	M10 Vodice - Rateče	TRA-N-100	2017
	M8 Kalce - Jelšane	TRA-N-101	2017
	CS Vodice II (on M2/1 pipeline up to 3 units with total power up to 30 MW)	TRA-N-102	2022*
	Godovič - Žiri - Škofja Loka	TRA-N-103	2022*
	M5 Jarše - Novo mesto	TRA-N-106	2022*
	M6 Ajdovščina - Lucija	TRA-N-107	2015
	M3 pipeline reconstruction from CS Ajdovščina to Šempeter/Gorizia	TRA-N-108	2022*
	M1/3 SLO-A border crossing	TRA-N-109	2022*
	M9c Interconnector with Croatia	TRA-N-111	2016
	R15/1 Lendava - Kidričevo	TRA-N-112	2018
	R38 Kalce - Godovič	TRA-N-113	2022*
	R61 Lucija - Sečovlje	TRA-N-114	2021
	R51c Kozarje - Vevče, MRS Kozarje	TRA-N-115	2022*
	R51b TE-TOL - Fužine/Vevče	TRA-N-116	2022*
	R51a Jarše - Sneberje, MRS Jarše	TRA-N-117	2022*
	R45 Novo mesto - Bela Krajina	TRA-N-118	2022*
	R25/1 Trojane - Hrastnik	TRA-N-119	2022*
	R52 Kleče - TOŠ	TRA-N-120	2022*
	R297B Šenčur - Cerklje	TRA-N-121	2022*
	R21AZ Zreče Loop (Slovenske Konjice 2nd phase)	TRA-N-122	2022*

PROJECT PROMOTER	NAME	CODE	COMMISSIONING
	M3/1c Kalce - Vodice	TRA-N-261	2017
	M3/1b Ajdovščina - Kalce	TRA-N-262	2017
	M9b Kidričevo - Vodice (including CS Vodice I - 4 units with total power up to 60 MW)	TRA-N-263	2018
Premier Transmission Ltd	Physical reverse flow from Northern Ireland to Great Britain and Republic of Ireland via Scotland to Northern Ireland pipeline	TRA-N-027	2016
REN - Gasodutos, S.A.	PT-ES Interconnector Pipeline Spanish Border-Celorico	TRA-N-283	2017 Q4
	PT-ES Interconnector Cantanhede Compressor Station	TRA-N-284	2019 Q4
	PT-ES Interconnector Pipeline Cantanhede-Mangualde	TRA-N-285	2021 Q4
Snam Rete Gas S.p.A.	Cross Border Bi-directional Flows - Phase 1	TRA-F-213	2015 Q4
	Cross Border Bi-directional Flows - Phase 2	TRA-F-214	2016 Q4
	Adriatica and Tirrenica pipelines	TRA-N-007	2022*
	Development in North East Italy	TRA-N-008	2022*
	Second Southern initiative	TRA-N-009	2022*
	Panigaglia	TRA-N-215	2022*
Socar	TANAP Trans Anatolian Natural Gas Pipeline Project	TRA-N-221	2018 Q1
Tauerngasleitung GmbH	Tauerngasleitung Gas Pipeline Project	TRA-N-035	2018 Q4
terranets bw GmbH	Nordschwarzwaldleitung	TRA-N-228	2016
TIGF	Artère de Guyenne (Phase B Girland Project)	TRA-F-250	2013
	Artère de l'Adour (former Euskadour) (FR-ES interconnection)	TRA-F-251	2015 Q4
	Iberian-French corridor: Eastern Axis-Midcat Project	TRA-N-252	2020
Trans-Adriatic Pipeline AG	Trans Adriatic Pipeline	TRA-N-051	2018 Q4
Transgaz	RO-BG Interconnection	TRA-F-029	2013 Q2
	Integration of the transit and transmission system - reverse flow Isaccea	TRA-F-139	2013
	Reverse flow at Negru Voda	TRA-F-142	2013
	Reverse flow on the interconnector Romania - Hungary	TRA-N-126	2013 Q4
	AGRI Pipeline - Romanian section (East-West Pipeline)	TRA-N-132	2015
Vörguteenus	Balticconnector (Including CS)	TRA-N-072	2016 Q1
	Karksi GMS	TRA-N-084	2015 Q4
White Stream	White Stream	TRA-N-053	2019 Q4

Table 2.2.
Overview of all LNG terminal projects submitted for TYNDP 2013-22 listed by project promoter

PROJECT PROMOTER	NAME	CODE	COMMISSIONING
API Nova Energia S.r.l.	api nòva energia S.r.l. – LNG off-shore regasification terminal of Falconara Marittima (Ancona, Italy)	LNG-N-085	2016 Q1
Balti Gaas plc	Paldiski LNG Terminal	LNG-N-079	2015 Q3
BBG	Bilbao's 3rd LNG Storage Tank	LNG-F-150	2014 Q4
	Bilbao Send-Out increase 1000000	LNG-F-152	2015 Q4
	Bilbao's 4th LNG Storage Tank	LNG-N-151	2018 Q4
	Bilbao Send-Out increase 1400000	LNG-N-153	2019 Q4
	Bilbao Send-Out increase 1200000	LNG-N-154	2018 Q4
BG Group	Brindisi LNG	LNG-N-011	2017 Q4
DEPA S.A.	Aegean LNG Import Terminal	LNG-N-129	2016 Q1
DESFA S.A.	Revythoussa (2nd upgrade)	LNG-F-147	2016 Q1
EdF	Dunkerque LNG Terminal	LNG-F-210	2015 Q4
Elengy	Montoir LNG Terminal Expansion	LNG-N-225	2018 Q4
	Fos Tonkin LNG Terminal Expansion	LNG-N-226	2019 Q1
	Fos Cavaou LNG Terminal Expansion	LNG-N-227	2020 Q2
Elering	Tallinn LNG Terminal	LNG-N-146	2017 Q4
Enagás S.A.	Musel LNG terminal	LNG-F-178	2013 Q4
	Musel's 3th LNG Storage Tank	LNG-N-174	2016 Q4
	Musel's 4th LNG Storage Tank	LNG-N-177	2019 Q4
	Musel Send-Out increase	LNG-N-179	2020 Q4
Enemalta Corporation	Connection of Malta to the European Gas Network - LNG Regasification Infrastructure	LNG-N-211	2018 Q4
Fluxys LNG	LNG Terminal Zeebrugge - Capacity Extension & 2nd Jetty	LNG-N-229	2017
Fos Faster LNG	Fos Faster LNG Terminal	LNG-N-223	2019
Gas Natural Rigassificazione Italia	Zaule - LNG Terminal in Trieste (Italy)	LNG-N-217	2018
Gascan	Gran Canaria LNG Terminal	LNG-F-163	2015 Q4
	Tenerife LNG Terminal	LNG-F-183	2014 Q4
	Gran Canaria 2º LNG Tank	LNG-N-162	2018 Q4
	Gran Canaria send out increase	LNG-N-165	2018 Q4
	Tenerife 2º LNG Storage Tank	LNG-N-184	2017 Q4
	Tenerife Send-Out increase	LNG-N-185	2017 Q4
Gastrade S.A.	Alexandroupolis Independent Natural Gas System - LNG Section	LNG-N-062	2015 Q4
Gasum Oy	Finngulf	LNG-N-024	2018 Q4
	Pansio LNG	LNG-N-277	2015 Q4
Gate Terminal B.V.	Gate terminal phase 3	LNG-N-050	2016 Q3
GAZ-SYSTEM S.A.	LNG terminal in Świnoujście	LNG-F-246	2014
	Upgrade of the LNG terminal in Świnoujście	LNG-N-272	2020
GNL Italia	Panigaglia LNG	LNG-N-216	2022*
Klaipedos Nafta	Klaipeda LNG terminal	LNG-F-058	2014 Q4
Nuove Energie S.r.l.	Porto Empedocle LNG	LNG-N-198	2017 Q2
OLT Offshore LNG Toscana S.p.A	OLT Offshore LNG Toscana SpA	LNG-F-089	2013 Q2
OutoKompu Oyj	Tornio ManGa LNG Terminal project	LNG-N-194	2016 Q1

PROJECT PROMOTER	NAME	CODE	COMMISSIONING
Plinacro Ltd	LNGRV	LNG-N-082	2015
Saggas	Sagunto Send-Out increase 1.200.000 Nm3/h	LNG-N-182	2014 Q4
Shannon LNG	Shannon LNG Terminal	LNG-N-030	2017
Sorgenia S.p.A.	LNG Medgas Terminal S.r.l.	LNG-N-088	2017 Q1
Swedegas AB	Gothenburg LNG (preliminary)	LNG-N-032	2015

Table 2.3.

Overview of all storage facility projects submitted for TYNDP 2013-22 listed by project promoter

PROJECT PROMOTER	NAME	CODE	COMMISSIONING
Bulgartransgaz EAD	UGS Chiren Expansion	UGS-N-138	2014
	Construction of new gas storage facility on the territory of Bulgaria	UGS-N-141	2020
E.ON Földgaz	Pusztaederics - Compressor System Reconstruction	UGS-N-209	2013
	Zsana UGS - Decrease of the minimum injection capacity	UGS-N-234	2016 Q4
E.ON UK	Holford	UGS-F-091	2013 Q1
EdF	Salins des Landes	UGS-N-204	2021 Q1
Edison Stocaggio S.p.A.	San Potito e Cotignola	UGS-F-236	2013 Q2
	Nuovi Sviluppi Edison Stoccaggio	UGS-N-235	2016 Q1
	Palazzo Moroni	UGS-N-237	2014 Q2
Energean Oil & Gas S.A.	Underground Gas Storage at South Kavala	UGS-N-076	2018
Gas Natural	Underground Gas Storage in salt leached caverns in the Bages area, North-Eastern Spain	UGS-N-127	2023 Q4
GdF Suez Energy Romania	Depomures	UGS-N-233	2015 Q4
Halite Energy Group Ltd	Preesall Gas Storage	UGS-N-203	2016
ITAL Gas Storage S.r.l.	Cornegliano UGS	UGS-N-242	2015 Q1
King Street Enegy Ltd	King Street Energy Storage Project	UGS-N-087	2017 Q4
Kinsale Energy Ltd	Southwest Kinsale Storage Expansion Project	UGS-N-197	2015 Q3
Latvijas Gaze	Modernisation of Incukalns Underground Gas Storage	UGS-N-130	2025 Q4
Lietuvos energija AB	Syderiai	UGS-N-034	2019 Q4
Ministry of Cyprus	Mediterranean Gas Storage	UGS-N-067	2019 Q1

Table 2.3.
Overview of all storage facility projects submitted for TYNDP 2013-22 listed by project promoter

PROJECT PROMOTER	NAME	CODE	COMMISSIONING*
PGniG	KPMG Kosakowo	UGS-F-199	2021
	KPMG Mogilnio	UGS-F-200	2020
	PMG Brzeznica	UGS-F-201	2016 Q2
	PMG Husów	UGS-F-202	2015 Q2
	PMG Wierzchowice	UGS-F-220	2014 Q2
	PMG Wierzchowice extension	UGS-N-219	2022*
REN - Gasodutos, S.A.	Carriço UGS development	UGS-F-081	2014 Q4
RWE Gas Storage, s.r.o.	Expansion of the virtual storage operated by RWE Gas Storage	UGS-N-074	2022*
STOGIT	Bordolano	UGS-F-259	2015 Q4
	System Enhancements - Stogit - on-shore gas fields	UGS-F-260	2022 Q4
Storengy	Hauterives Storage Project - Stage 1	UGS-F-004	2014 Q1
	Stublach - Stage 1	UGS-F-006	2014 Q4
	Hauterives - Stage 2	UGS-F-265	2015 Q1
	Harsefeld	UGS-N-001	2019 Q2
	Alsace Sud	UGS-N-002	2022 Q4
	Etrez / Manosque	UGS-N-003	2014
	Peckensen Gas Storage	UGS-N-005	2017 Q2
	Behringen Gas Storage	UGS-N-049	2022 Q4
	Etrez / Manosque - Stage 2	UGS-N-264	2022
	Stublach - Stage 2	UGS-N-266	2020
TAQA Gas Storage B.V.	Gas Storage Bergermeer (GSB)	UGS-F-052	2014 Q1
Wingas Storage UK Ltd	Saltfleetby	UGS-N-033	2017 Q2

Table 2.4.
Overview of all production facility projects submitted for TYNDP 2013-22 listed by project promoter

PROJECT PROMOTER	NAME	CODE	COMMISSIONING*
Ministry of Cyprus	KPMG Ko Mediterranean LNG Export Terminal sakowo	PRD-N-055	2019 Q1

Table 2.5.
Overview of all projects regarding interconnections with a gas-fired power plant submitted for TYNDP 2013-22 listed by project promoter

PROJECT PROMOTER	NAME	CODE	COMMISSIONING*
DESFA S.A.	Megalopoli pipeline	POW-F-028	2013 Q3
Ministry of Cyprus	Internal Gas Pipeline Network	POW-N-073	2015 Q1

*Where this date had not been provided or the date was indicated as "beyond" a particular year of the covered period, an assumption was taken that the commissioning would be at the beginning of 2022, that is, the last year of this TYNDP. The year 2022 is then marked with a star throughout the TYNDP Report [*]

The information supplied is up-to-date as of 15 September 2012.

In conclusion, the aggregate of cost estimates broken down per infrastructure type and per FID and Non-FID projects is provided in the table below. The interconnections with gas-fired power plants are included under Transmission projects. It is noted that the figures do not cover all the projects listed above as some projects have not made any cost estimate available to ENTSOG.

Table 2.6.
Aggregate project cost estimates broken down per infrastructure type and project status (FID / Non-FID)*

INFRASTRUCTURE TYPE	FID	TOTAL COST* (BILLION €)	NUMBER OF PROJECTS
Transmission, incl. CS	FID	7.08	49
Transmission, incl. CS	Non-FID	53.43	144
Sub-total Pipelines		**60.51**	**193**
LNG Terminal	FID	1.76	10
LNG Terminal	Non-FID	6.90	35
Sub-total LNG Terminals		**8.66**	**45**
Storage Facility	FID	0.80	14
Storage Facility	Non-FID	2.80	28
Sub-total (Storage)		**3.60**	**42**
Production	**Non-FID**	**Confidential**	**1**
TOTAL*		**72.77**	**281**

* the figures do not cover all the projects listed above as some projects have not made any cost estimate available to ENTSOG; the total cost estimate hence covers only 35% of all projects; it is explicitly noted that this ratio cannot be extrapolated to calculate the total cost estimate for all projects

Image courtesy of GAZ-SYSTEM

Methodology

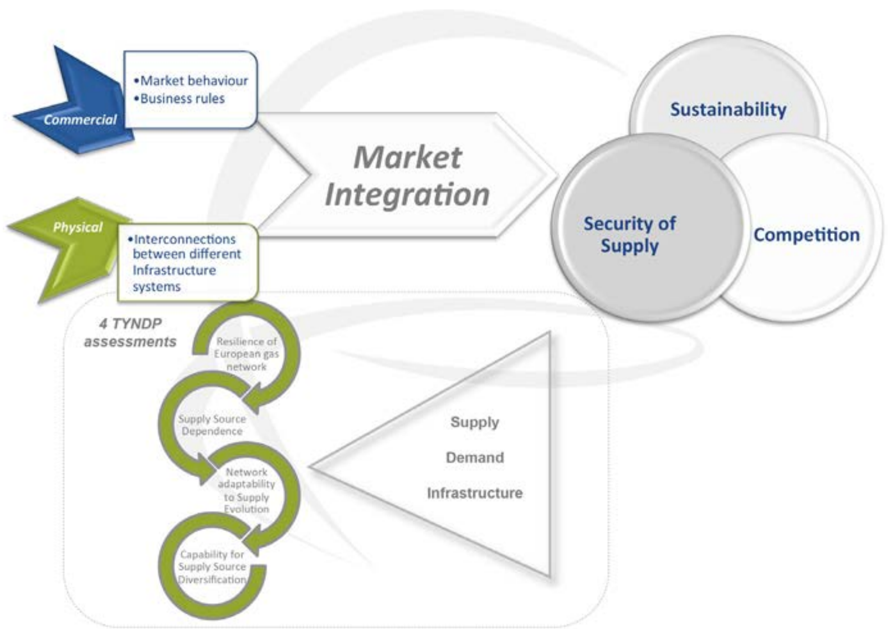
INTRODUCTION

The methodology of the TYNDP 2013-2022 builds on the principles used in the TYNDP 2011-2020. ENTSOG has significantly improved the Network Modelling tool and the definition of supply and demand situations compared to the TYNDP 2011-2020. ENTSOG has used the 'upgraded' Network Modelling tool (NeMo tool) to assess the role of the gas infrastructure in sustaining the pillars of the European energy policy, in particular Security of Supply and Competition. This assessment is carried out through an analysis of the resilience of the European gas network, the Supply Source Dependence, network adaptability to Supply Evolution and the capability for Supply Source Diversification.

In addition, new capacity-based indexes have been introduced aiming at measuring the import route diversification and import dependency.

The results of the assessment give an overall indication of the level of infrastructure-related Market Integration. For the purpose of the TYNDP, Market Integration is defined as a physical situation of the interconnected network which, under optimum operation of the system, provides sufficient flexibility to accommodate variable flow patterns that result from varying market situations. Sufficient flexibility may be perceived differently by different market participants; some aspects may be also determined through the legislation (cf. Security of Supply Regulation). Where necessary, the TYNDP sets arbitrary values against which the results of the simulations are measured for the sake of the assessment.

Figure 3.1.
Graphical representation of the relationship between Energy policy pillars and Market Integration, and the role of the TYNDP in their assessment



The achievement of the desired level of Competition, Security of Supply and Sustainability is enabled through the achievement of the desired level of market integration. Market Integration can be measured at two levels:

- Commercial (determined by the market behaviour and business rules applicable on the respective market)
- Physical (determined by level of physical interconnection between the different infrastructure systems of the respective market)

The TYNDP assesses the physical layer of Market Integration through 4 assessments which analyse the way infrastructure can sustain the supply-demand balance under various supply-demand situations and infrastructure configuration.
The high uncertainty linked with the future of the gas market favours a case-based approach combined with sensitivity analyses. This approach has to strike the right balance between the likelihood of the occurrence and the stress they induce. By including FID and/or Non-FID project clusters in the network model along the existing infrastructure, the modelling results provide information on the potential of the planned projects to close potential investment gaps and determining the limiting factors to further Market Integration.

In this chapter the specifications of the NeMo tool used by ENTSOG are described. In addition, this chapter gives an overview of the more than 200 cases developed by ENTSOG to assess Security of Supply (the resilience of the system and source dependency) and the potential of infrastructures to support Market Integration. The results of the network modelling are presented in section 4 of the Results Assessment chapter.

NETWORK MODELLING TOOL (NEMO)

The current NeMo tool is the result of a multi-annual internal development process, with continuous improvement that goes back to 2008 and the first publication of European Winter Outlook by TSOs. The functionalities of the tool allow for consideration of firm capacity, Zones, and hub-to-hub products as established in the current regulatory frameworks. The functionality of the NeMo tool also allows for the focus of the analysis to be on the supply demand balance in the European gas infrastructure system and the identification of potential investment gaps. For this, the modelling tool is able to assess the ability to bring the gas from defined supply sources to the consumption points within any relevant case.

L-gas IPs are not separately modelled in this TYNDP but are part of the total modelling of the EU gas network. L-gas flows have been considered as the minimum flows between Netherlands, Belgium, Germany and France based on the historical values of 2009, 2010 and 2011. The reason for this is that the future need for L-gas substitution is not a matter of resilience of the system nor can L-gas be imported from somewhere else, which is the core focus of this TYNDP. The final outcome will be the result of on-going intensive interaction between governments and TSOs. Currently, evaluations are carried out regarding the possibilities for the substitution of L-gas; the impact this may have on infrastructures has not yet been determined. Due to its regional character the topic of L-gas will be covered by the upcoming Northwest Gas Regional Investment Plan.

2.1. Network & Market Topology

ENTSOG builds its model on the the results of hydraulic simulations performed by TSOs using the methodology of the "Network Flow Programming[1]". The ENTSOG tool for simulating the European Gas Network combines the capacity figures obtained through hydraulic simulations with a common approach to the assessment of European supply and demand balance. When assessing the resilience of the European gas system, ENTSOG uses linear modelling of the market (based on energy) with:

[1] Network Flow Programming is a methodology used in the Operational Research (study of logistic networks to provide for decision support at all levels). The term network flow program includes such problems as the transportation problem, the assignment problem, the shortest path problem, the maximum flow problem.

- nodes representing Zones. Nodes are the points characterized by a certain demand, representing an off-take that the model tries to balance with supply
- arcs representing cross-border or hub-to-hub capacity between nodes. Arcs are the paths carrying the gas from one node to another, characterized by a lower and an upper flow limit, defining the possible range for the calculated flows. The upper limit may represent a Supply Potential of a given source or the capacity of infrastructures.

The linear approach enables the NeMo tool to compute a great number of cases in short time, and focus is thus on the analysis of the results.

The combination of arcs and nodes provides a very flexible architecture that can be easily updated with additional infrastructure, while the flow ranges between the nodes can be used to control the simulated flow pattern. The modelling tool considers cross-border net flows between Zones as a way to combine network and market characteristics.

The graphic below illustrates the complexity of the architecture of the European gas system as modelled in the NeMo tool.

Figure 3.2.
Architecture of the European gas system in the ENTSOG Network Modelling tool

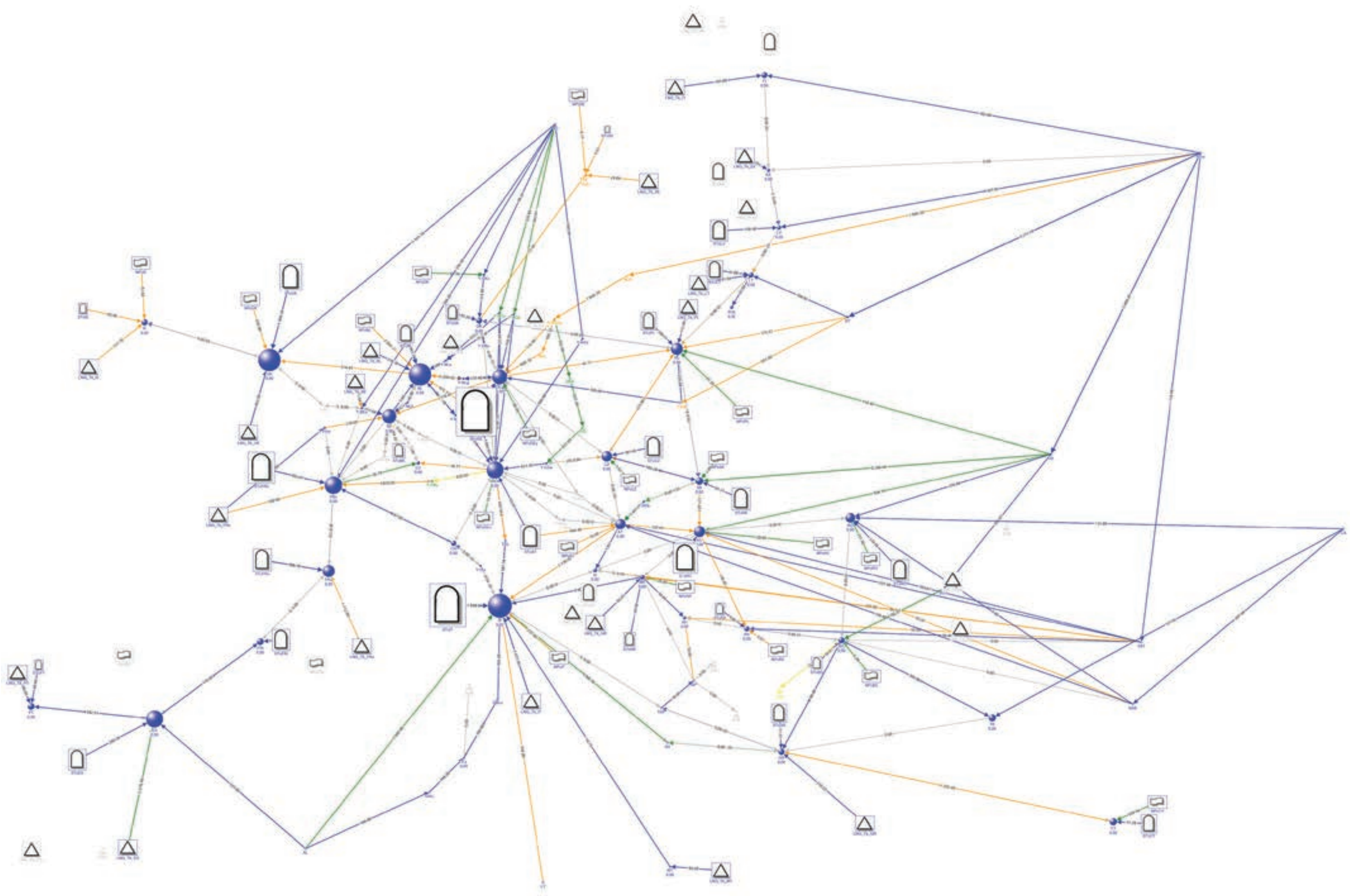
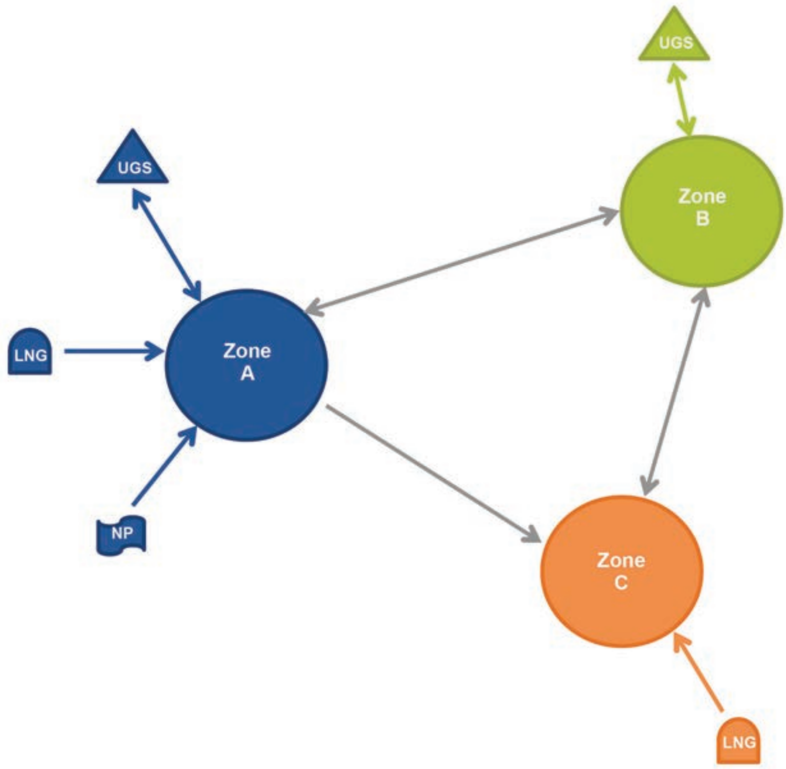


Figure 3.3.
General representation of the Zones (nodes) and interconnections between them (arcs) in the ENTSOG Network Modelling tool



Where a physical congestion has been identified from the top down approach, TSOs collaborate further through the GRIPs to identify potential mitigating measures.

Each Zone in Europe is represented by a node in the model where supply (National Production, LNG send-out, other imports and storage withdrawal) and demand (end consumption, storage injection, and exports) have to be balanced. This Zone thus represents a balancing zone for which the model uses one demand figure as input.

Cross-border capacities between two Zones are represented by arcs where the maximum flow limit in the model is determined by aggregating the capacities of Interconnection Point capacities, after applying the lesser rule on each side of the flange. The firm capacity on both sides of one Interconnection Point is the result of hydraulic Entry/Exit capacity simulations performed by the respective TSOs; this means there is no additional need to consider hydraulic simulation at the European level. Capacity calculation under the 3rd Energy Package could be considered as the translation by TSOs of a physical network into an Entry/Exit commercial offer. The basic principle of Entry/Exit capacity calculation is thus to carry out a hydraulic simulation of demand and supply patterns TSOs cover.

Interconnections between the transmission system and LNG terminals, storage facilities and National Production facilities within a market area are based on the same node and arc approach as the cross-border interconnections. Supply sources are defined per producing country. Supply sources are characterized by a Supply Potential representing the upstream volumes that can be imported into Europe. The different routes connecting a supply source to Europe are limited by the capacity of the respective import pipelines.

In the majority of cases Underground Gas Storage (UGS) is considered as a supply of last resort to cover excess demand. Relevant injection or withdrawal capacities are linked to the stock level applicable in the simulated case. LNG send-out is split up into an import and storage layer. Unlike UGS, LNG tank level has no impact on send-out capacity, except that stock level should remain in a given range.

The simulations of the diverse cases are done by giving different weights to certain arcs, i.e. some priority to specific sources, routes or interconnections, to achieve the objective of the assessment underlying the definition of the respective cases.

2.2. Perfect gas mix

The functioning of the tool assumes a perfect mix of gas at every node which is consistent with the assumption of a perfect market. The supply source composition of gas exiting a node is the same for every arc and equals the weighted average of entering gas composition. This approach fits perfectly with a market approach, results are however likely to deviate from the actual physical composition of gas depending on the level of interconnectivity of the respective network.

2.3. Tool functioning

The primary objective of the tool is to find a feasible flow pattern to balance supply and demand defined for the considered case whilst using the available system capacities defined by the arcs. UGS and LNG (partially) act as last resort supply to cover the gap between demand and supply, namely import sources and National Production. This is done by using a solver designed for linear network programming giving by default priority to the closest supply to meet demand. Each case calculation is based on a daily supply demand situation.

The considered infrastructure cluster is deemed sufficient for a given situation of demand and supply if the solver is able to find a flow pattern under which each node is balanced and all flows are within the limits defined for each arc. It is noted that this flow pattern is one among several possible ones as some regions of Europe always show sufficient flexibility to flow the gas through alternative routes. Where no feasible flow pattern can be found for a given case, this may be an indication of insufficient supply or network congestion. In this later case an investment gap may be identified by investigating the limits to finding a feasible flow pattern. This TYNDP also shows in a neutral way which projects are able to close such investment gaps.

2.4. Output

The first and principal output of a simulation for a specific case is the tool finding a feasible solution consistent with each node and arc constraint. If a solution is found, meaning the network is showing enough resilience and sufficient supplies are available, flows through all arcs are provided as an output of the model.

For each capacity arc, the simulated flow is compared to the technical capacity defined by the TSOs. For each Entry/Exit Zone, the Remaining Flexibility indicator is calculated as the aggregated relative Entry Capacity not used by the solver. It should be noted that the output represents one of possibly many flow patterns respecting all boundary conditions. As a result modelled flows should not be considered to be a forecast of flow patterns to be expected.

Where the model identifies investment gaps, planned infrastructure projects contributing to their mitigation are identified. In this way FID and Non-FID Clusters of future projects are tested on their impact on the resilience of the European gas network. This can provide useful information to third-party project promoters. The TYNDP does not in any way prioritise infrastructure projects.

DEFINITION OF CASE ELEMENTS

ENTSOG developed more than 200 cases. Each case is determined by:

- a year (see 3.1),
- an infrastructure cluster (see 3.2),
- a demand situation (see 3.3),
- a supply situation (see 3.4).

The considered settings of each of the above elements are described below.

3.1. Modelled years

To capture the dynamics of the next 10-years, all cases mentioned are simulated for 2013, 2017 and 2022. 2013 acts as the reference year. Most of capacity, demand and supply data are provided for all of the 10-years in the annexes.

3.2. Infrastructure clusters

All cases include two infrastructure clusters:

- FID Cluster: existing infrastructure + infrastructure with FID status
- Non-FID Cluster: existing infrastructure + infrastructure with FID status + infrastructure with non- FID status

With regards to infrastructure, the three years represent different gas infrastructure configurations which always cover the existing infrastructure and the planned infrastructure projects in accordance with their FID status. FID status has been identified as the most robust parameter for clustering planned infrastructure projects. All projects were considered eligible for modelling in the first year in which the capacity is available on 1 January 2013, 2017, 2022. Detailed description of those projects is available in Annex A.

The process is to first include only-FID projects in the modelling. Subsequently, the modelling of the same cases with the Non-FID Cluster shows how Non-FID projects could improve the level of Market Integration.

In the case of Network Resilience testing, modelling the two infrastructure clusters and comparing their results makes it possible to identify investment gaps and examine how Non-FID projects covered by TYNDP help to mitigate such gaps. The process ensures non-discriminatory treatment where multiple projects are able to produce such effect.

3.3. Demand situation

The different demand situation and their use in the modelling are summarized in the table below:

DEMAND SITUATIONS	NETWORK RESILIENCE / SUPPLY SOUNETRCE DEPENDENCE	SUPPLY EVOLUTION ADAPTABILITY / SUPPLY SOURCE DIVERSIFICATION
1-day Design-Case Situation	X	
1-day Uniform Risk Situation	X	
14-day Uniform Risk Situation	X	
1-day Average Situation	X	X

Table 3.1. Demand Situations

3.3.1. Demand under 1-day Design-Case Situation

The 1-day Design-Case Situation is the national peak demand per day as calculated by TSOs and laid down in National Development Plans and TSO capacity outlooks where existing. This demand is the demand included in the TSOs' investment calculations and therefore referred to as the Design-Case Situation. This Demand Situation is the most burdensome as it shows the effects on the European gas system under the occurrence of all national peak demands at the same time.

In addition to this situation, two Uniform Risk Demand Situations (as described below) were developed by ENTSOG upon specific request by ACER to develop a harmonised approach to demand. These situations shall be considered for comparison purposes.

3.3.2. Demand under 1-day Uniform Risk Situation

The starting point for ENTSOG was to develop a common demand situation in terms of the probability of uniform risk occurrence across Europe. Therefore ENTSOG has chosen to include a 1-day Uniform Risk Situation based on a common definition of climatic conditions. This common definition of climatic conditions consists in the harmonisation of the level of risk of climatic occurrence.

The climatic conditions are represented by the effective temperature, understood as the parameter correlated with increases in the demand level due to heating consumptions driven by weather conditions. The effective temperature keeps consistency with the formulas developed by some TSOs, considering the temperature heterogeneity within the country, the accumulative effect of cold days on consumers' behaviour in terms of gas demand, as well as any other factors related to gas consumptions as wind velocity.

The 1-day Uniform Risk Situation has been defined as described below, addressing a climatic occurrence close to 1-in-20 years:

- Period to be considered: minimum of 37 years (from 1 January 1975 to 31 December 2011). For those TSOs having no access to sufficient historical weather/temperature data through their own sources, daily average temperatures coming from a Commission's temperature database (average values by country and day) were used.
- Relevant daily temperatures to be considered: yearly minimum effective temperatures by calendar year.
- 1-day Uniform Risk temperature defined by the percentile 0.05 of the relevant daily temperatures.

It should be noted that not all TSOs have climatic demand models, meaning that it was not possible to apply the Uniform Risk Situations methodology perfectly.

In addition, climatic conditions have a direct effect on the heating driven gas demand; nevertheless this link cannot be extrapolated to gas demand from the electricity sector. This sector in general doesn't have a strong relationship with climatic conditions. Hence demand under the 1-day Uniform Risk Situation only provides harmonised definition for the heating-driven gas demand.

Moreover, in several not yet mature markets, the demand estimation depends not only on the climatic conditions assumptions but also on the assumptions regarding the penetration of gas in the various consumption sectors.

3.3.3. Demand under 14-day Uniform Risk Situation

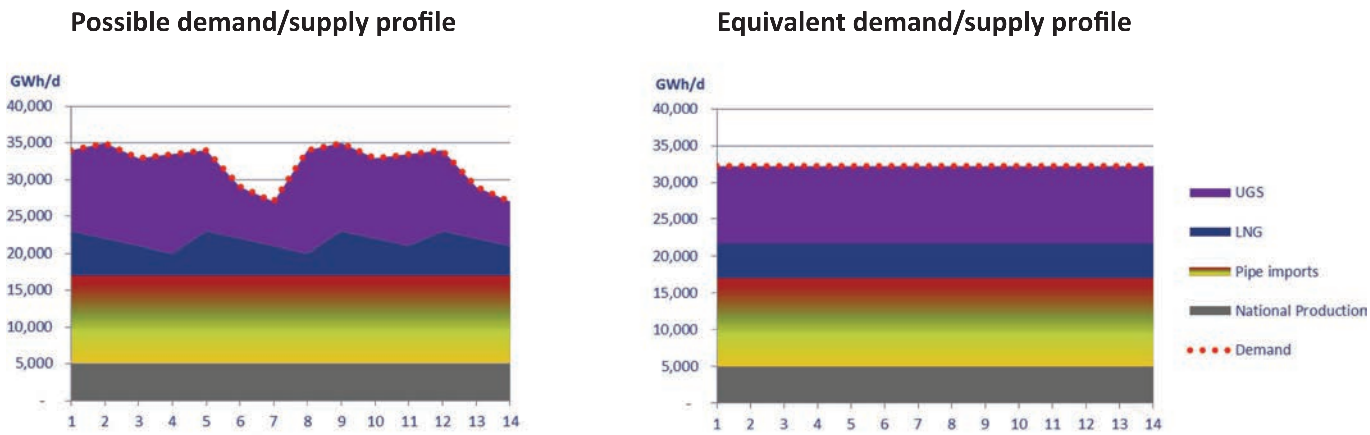
A 14-day Uniform Risk Situation has been included in the analysis in order to capture the volume effect such duration may have on supply, especially with regard to UGS and LNG terminals. The 14-day demand levels are considered through the assessment of the last day of such a period. This last day is the most stressful moment as the supply availability from the storage (UGS and LNG) at this point may be undermined by high deliverability in the previous 13 days following the high consumptions.

For consistency reasons, ENTSOG used the same statistical approach as for the 1-day Uniform Risk Demand Situation, replacing the daily effective temperatures by the 14-day average effective temperatures in the data set. The inclusion of two full weeks in the 14-day period doesn't take into account possible lower demand levels during weekends or holidays for the average demand on a 14-day period.

As noted above, considering the decreasing deliverability of UGS and LNG terminals on the period, for a given level of demand, the last day is the most stressful one. As the volume of supply used over the period is independent from the demand profile, a flat average demand profile has been considered.

The graphs below show the volume equivalence between a possible profile and its considered equivalent. This transformation makes it possible to limit modelling to the last day of the period.

Figure 3.4.
Illustration of the volume equivalence between a possible profile and its considered equivalent



3.3.4. Demand under 1-day Average Situation

There are certain types of cases that fit better with a lower demand level compared to the 1-day and 14-days situations. For that purpose a 1-day Average Situation has been included in order to simulate a yearly average situation. Demand on that day is defined as the ENTSOG annual volume demand scenario based on individual TSO data divided by 365. This Average Situation is used to assess the Supply Source Dependence and network adaptability to Supply Evolution and the Supply Source Diversification. The yearly average is considered as more suitable for such type of flexibility analysis. Moreover, if the analysis were carried out in connection with a high demand situation, the supply penetration assessment would be limited due to the consumption of the additional volumes in the region closest to the supply.

3.4. Supply situations

For each of the demand situations defined above, a supply situation has to be built in order to define how much gas is available and from which source. These levels and locations will influence transportation needs and hence infrastructure assessment.

The starting point in the analysis is always a specific Reference Supply Situation corresponding to the considered demand situation, as described below. Variations on these Reference Supply Situations are strongly correlated to the specific cases considered, and are further detailed in the next sub-chapter 4. on the European gas system and supply assessment.

The table below summarizes the setting of all supply sources in the Reference Cases. The period defined as last 3 years references supply in the years 2009, 2010 and 2011. Supply sources imported by pipe are Algeria, Azerbaijan, Libya, Norway and Russia.

Table 3.2. Supply Situations

Under every situation, aggregated National Production at European level is set in the 90-100% range of its maximum deliverability.

	SUPPLY SOURCES		
SITUATIONS	**PIPE IMPORTS**	**LNG**	**UGS**
1-DAY DESIGN-CASE	The maximum reached on one day during the last 3 years	Import component is equal to the Average Daily Supply based on the last 3 years plus 10% (to factor in the winter swing) The remaining send-out is used as last resort	Last resort supply
14-DAY UNIFORM RISK	The highest average of 14 consecutive days during the last 3 years	Import component is equal to the Average Daily Supply based on the last 3 years plus 10% (to factor in for the winter swing) Additional send-out based on the maximum use of stored LNG	
1-DAY AVERAGE	Average shares by source of the different supply import sources in the European yearly balance of last 3 years, applied to the required imports. When the supply coming from one source is limited by the Intermediate Potential Supply scenario, the corresponding missing volume, is divided between the remaining sources proportionally to their ability to increase their level i.e. how far they are from reaching their own Intermediate Supply Potential scenario.		Not used

3.4.1. Reference Supply under 1-day Design-Case and Uniform Risk Situation

From 2013 onward where there is no increase in imported pipeline capacity compared to 2009-2011 the supply assumption is set as the daily maximum achieved in the period 2009-2011. Where an infrastructure project increases the import capacity from one source, the supply from that source is increased proportionally. The supply through the new route is calculated first, as the average peak ratio of the other routes coming from the same source. This amount is subsequently added to the original daily maximum to determine the new total. Flows at import route level are kept as far as possible within a range defined by:

- The maximum reached through the route over 2009-2011, potentially increased pro-rata to consider the project increasing the route capacity
- The average flow through the route over the winters 2009-10 and 2010-11

LNG is first used as an import source at Average Daily Supply level, based on the years 2009-2010-2011, which is increased by 10% to consider the winter swing.

Demand is balanced using the remaining LNG send-out capacity (on top of import source use) and UGS deliverability. This is referred to as supply of last resort. In order to consider the influence of stock level on storage availability, UGS deliverability has been decreased by 3%. This decrease is consistent with the minimum stock level observed mid-January on the 2009-2011 period on the AGSI platform and the European aggregated UGS delivery curve as established by GSE.

3.4.2. Reference Supply under 14-day Uniform Risk Situation

Regarding each source imported through pipes, the same approach has been used as for the above 1-day Situation. The only difference is that the source and import route maximum has been observed on a 14-day rather than a 1-day period.

On a 14-day period, LNG terminals are not designed to be able to sustain maximum deliverability. A specific approach has been developed by ENTSOG based on a GLE study. For every LNG terminal, send-out is defined as the addition of 2 parameters:

- The downloading of ships linearized at Average Daily Supply level for the years 2009-2010-2011 increased by 10% to consider the winter swing
- The maximum use of LNG tank considering the initial and the usual minimum stock level as defined by GLE and LSOs

Demand is balanced using UGS as last resort supply. In order to consider the influence of stock level on storage availability, UGS deliverability has been decreased by 5%. This decrease is consistent with the minimum stock level observed at the end of January on the 2009-2011 period on the AGSI platform and the European aggregated UGS delivery curve as established by GSE.

3.4.3. Reference Supply situation under 1-day Average Situation

The Reference Case is based on the average shares by source of the different supply import sources (AZ, NO, RU, DZ, LY, LNG) in the European yearly balance of 2009-2010-2011. This average share is applied to the required imports (i.e. Demand minus National Production). Where the resulting supply volume required to come from each source exceeds the respective Intermediate Potential Supply scenario is used as an upper limit for the Reference Supply. The corresponding missing volume is allocated between the remaining sources in proportion to their ability to increase their level i.e. how far they are from reaching their own Intermediate Supply Potential scenario. Flows at import route level are kept in a ±10%

range around a reference value. This value is derived from the three-year historical average flow through the route. It is noted that storage supply is not considered in the cases pertaining to Supply Source Dependence, the network adaptability to Supply Evolution, and the Supply Source Diversification as it is considered neutral from the whole year perspective.

Image courtesy of Gasunie

ASSESSMENT OF THE EUROPEAN GAS SYSTEM

In addition to the Reference Cases, additional cases bringing more stress to the EU gas network have been defined. They define the scope of the sensitivity study of the assessment.This assessment is based on an analysis of the level of physical interconnection between different infrastructures to capture aspects of Security of Supply and Competition and, at the same time, assess the level of Market Integration.

4.1. Infrastructure Resilience assessment

The Infrastructure Resilience assessment looks at the ability of the infrastructure to transport large quantities of gas under high daily conditions (Supply Stress). This assessment is used for identification of investment gaps and potential remedies.

The Supply Stress cases defined are extensions of the Reference Cases covering 1-day Design-Case and 14-day High Risk Situations. By comparing these Supply Stress cases with the relevant Reference Cases, the effects of a specific disruption or Extreme LNG Minimisation are identified.

The considered supply stresses are:
Complete disruption of Norwegian supply to France (failure of Franpipe) – NO 1
Partial disruption of Norwegian supply to United Kingdom (failure of Langeled) – NO 2

- Complete disruption of Russian supply through Belarus - BY
- Complete disruption of Russian supply through Ukraine- UA
- Complete disruption of Algerian supply to Italy (failure of Transmed) – DZ 1
- Partial disruption of Algerian supply to Spain (failure of MEG) – DZ 2
- Complete disruption of Libyan supply to Italy – LY
- Extreme LNG Minimisation

In the network modelling, LNG is not considered to be disrupted, but minimisation is simulated. To define a realistic LNG disruption of European impact is difficult because globalisation and flexibility of the LNG chain allow for the rerouting of LNG ships, including between terminals, in response to price signals.This opens the possibility to replace a specific LNG source by another one. Due to the fact that it is impossible to determine what the reaction of the market will be in the long term and to determine how many cargoes would be replaced in an emergency event, ENTSOG investigates how far the LNG deliverability can be reduced without the occurrence of network congestion. This approach, for long term assessment under the infrastructure perspective, helps picture the level of dependence on this source for each country and/or how Europe could be impacted by a major move of global LNG supply to another region. It also pictures the impact of a technical disruption of an LNG terminal in a Zone having a single facility (e.g. Greece in 2013) or maritime conditions impacting all facilities of a given Zone (e.g. Fos Cavaou and Fos Tonkin located in GRTgaz South Zone).

The missing gas supply derived from the Supply Stress is managed by rerouting supply of the interrupted sources through alternative routes (if any) and, finally, as a last resort, by additional gas from UGS and LNG. For the 14-day case, the ability of LNG terminals to supply additional gas is made possible through the use of a lower minimum tank level compared to the Reference Case (such levels have been defined by GLE/LSOs).

This assessment results in the identification of the Remaining Flexibility of each Zone and of the different types of infrastructure located in the Zone. This indicator is defined according the below formulae:

Infrastructure level:

$$Remaining\ Flexibility = 1 - \frac{Flow}{Capacity}$$

Zone level:

$$Remaining\ Flexibility = 1 - \frac{\sum Entering\ Flow}{\sum Entry\ Capacity}$$

The indicator at Zone level considers both the gas staying in the Zone to face demand and the gas exiting to adjacent systems.

The identification of investment gaps is based on the level of the Remaining Flexibility at Zone level. Investment gaps are identified when the indicator is:

- below 5% under Reference Cases
- below 1% under Supply Stress cases as part of the flexibility has been used to face the Supply Stress.

Disruption scenarios simulated in the current TYNDP are assuming a lack of gas flows from the concerned supply source at the relevant EU borders. Capacity at EU cross-border IPs is considered technically available, although not always fully exploitable, taking into consideration the proximity of the IPs to the disrupted source and the underlying infrastructure. This is reflected in the model by the fact that, in case of a disruption, the use of Entry Capacity of each Zone is impacted by the flow decrease starting from the disruption and then spread according to transmission capacity level. After crossing a few Zones, the impact becomes strongly diluted.

Should the concerned disruption occur, flows actually transmitted at the concerned EU cross-border IPs could result in different Remaining Flexibility levels than those shown in the Report considering, among other reasons, the prevailing flow sources at those IPs, market dynamics or other SoS measures possibly undertaken under crisis conditions.

4.2. Supply Source Dependence assessment

Supply Source Dependence assessment aims at the identification of Zones whose balance depends strongly on a single supply source.

This assessment has been carried out under the 1-day Average situation in order to identify the strong dependence of some Zones on a single supply source throughout the year. This is achieved through the Full Minimisation of each supply source separately, and the replacement of the corresponding volume by the remaining sources.

The supply situation under the Full Minimisation cases reflects, source by source, the ability of the remaining sources to replace a specific supply. For that purpose each import source has been reduced alternatively down to the minimum required to balance each Zone. In order to identify the potential dependence of all Zones in a single modelling, no limit has been set to the alternative supply sources apart from their technical capacity as it is assumed that all Zones will not minimize the predominant supply at the same time. Indigenous production has been kept at Reference Case level and LNG terminal send-out limited to 80% of their capacity.
Zones requiring at least a 20% share of a given source are identified as source dependent.

4.3. Infrastructure Adaptability to Supply Evolution

The assessment of the Adaptability to Supply Evolution looks at the European infrastructure's ability to face very different supply mixes as resulting from short-term signals or long-term trends.

This assessment has been carried out under the 1-day Average demand situation in order to identify the ability to balance every Zone when one of the supply sources move from the Reference Supply to Maximum Potential supply or Minimum Potential Supply scenarios. Where no flow pattern enables to reach the Potential Supply scenarios, the limiting factor is identified.

4.3.1. Even Maximisation

The supply situation under the Even Maximisation cases reflects, source by source, the reach of the Maximum Potential scenario by each of the sources. In each case, the maximisation of one source up to its Maximum Potential scenario comes along with the reduction of the others proportionally to their shares in the Reference Case keeping them above the Minimum Potential scenario. In the Even Maximisation, the reduction of each route is done proportionally to its share in the Reference Case.

4.3.2. Even Minimisation

The supply situation under the Even Minimisation cases reflects, source by source, the ability of the remaining sources to replace a specific supply going down to its Minimum Potential scenario. The increase of the replacing sources has been approached through the Even Minimisation, where the increase of each supply source and import route are done proportionally to their shares in the Reference Case still being limited by their Maximum Potential scenario.

4.4. Supply Source Diversification

The assessment of the Supply Source Diversification at Zone level aims at determining the ability of each Zone to access each identified supply source. It has been

Image courtesy of Gasunie

carried out under the 1-day Average demand situation through Targeted Maximisation.

The supply situation under the Targeted Maximisation cases reflects, source by source, the geographical reach of the Maximum Potential scenario. In order to identify a flow pattern enabling the reach of Zones further downstream, more freedom has been given to the flow ranges authorized for each import route compared to the Even Maximisation. Therefore each case requires several simulations in order to test the supply reach in all directions at the level of 5% and 20% share of total supply (including indigenous production) in each Zone.

4.5. Import Route Diversification and Import Dependence indexes

This part of the assessment introduces indexes aiming at quantifying the diversification of routes bringing gas to a Zone, and a Zone's dependence on imports as compared to UGS and National Production.

ENTSOG had considered the development of a capacity-based indicator assessing the diversification of routes as mentioned in the draft Energy Infrastructure Guidelines. Such indicator should picture the ability of a Zone to substitute one route of gas by another one when facing some technical disruption for example.

The definition of the appropriate formula should value both the number of entry points and their relative weight, the best situation being when they all have the same capacity. First, the following formula had been considered (the lower the value, the better the diversification):

Where a specific entry capacity (%) represents the share of a specific entry capacity in the total Entry Capacity into the considered Zone. Each term corresponds to a single facility being a physical Interconnection Point with an adjacent Zone, a direct import point, a LNG terminal, a storage facility or a production facility.

$$\sum_l^{Xborder}\sum_k^{IP} \%\, IP_k\, Xborder_l^{\;2} + \sum_j^{Source}\sum_i^{IP}\left(\%\, IP_i\, from\ source_j\right)^2 + \sum_m (\%\, LNG\ terminal_m)^2 + \sum_n \left(\%\, UGS\ facility_n\right)^2 + \sum_p (\%\, NP\ facility_p)^2$$

Calculation of such formula is made challenging as capacity of single storage or production facility is often not available and capacity is only provided in an aggregated form. The same situation also occurs at the border between some Zones where virtual Interconnection Points have been introduced.

As the replacement of such individual values by aggregated ones would distort the formula it has been decided to define two indexes rather than one. The first Index captures the diversification of paths that gas can flow through to reach a Zone, the second Index captures the need of imports to balance demand throughout the year.

4.5.1. Import Route Diversification Index

Aggregated values are used directly for Interconnection Points between European Zones as those physical points are likely to largely depend on common infrastructure. Import points for non-EU gas are considered individually as upstream infrastructures are often much more independent.

This leads to the definition of an Import Route Diversification index:

$$\sum_{l}^{Xborder}\left(\sum_{k}^{IP} \%\, IP_k\, Xborder_l\right)^2 + \sum_{j}^{Source}\sum_{i}^{IP}\left(\%\, IP_i\, from\, source_j\right)^2 + \sum_{m}(\%\, LNG\, terminal_m)^2$$

4.5.2. Import Dependence Index

Aggregated shares of storage and National Production deliverability, expressed as a percentage of the Average Daily Demand of a Zone, are used to measure the dependence on imports (the 1+ term is introduced to obtain the value of 1 for a country completely dependent on imports throughout the whole year). A factor 0.5 has been introduced for the UGS component as it is assumed that storage has a neutral balance over the year. A Zone having enough National Production to cover exactly its demand will score 0.5.

Aggregated share of storage and National Production deliverability (expressed as a percentage of the Average Daily Demand of a Zone) are used to measure the dependence on imports (the 1+ term is introduced to obtain the value of 1 for a country completely dependent on imports all over the year). A factor 0.5 has been introduced for the UGS component as it is assumed that storage has a neutral balance over the year. A Zone having enough National Production to cover exactly its demand will score 0.5.

This leads to the definition of an Import Dependence index:

$$\frac{1}{1 + (\%\, National\, Production) + (0.5 \times \%\, UGS)}$$

4.6. List of cases defining the scope of the assessment

The table below gives an overview of all the cases that were modelled under the Infrastructure Resilience assessment (Reference Cases in **bold**).

Table 3.3.
Cases modelled under Infrastructure Resilience assessment
For Supply Stress definition, please refer to sub-chapter 4.1.

CASE	YEAR	INFRASTRUCTURE CLUSTER	DEMAND SITUATION		SUPPLY SITUATION	
			DURATION	OCCURENCE	SUPPLY STRESS	UGS DELIVERABILITY
1	2013 2017 2022	FID / Non-FID	1 day	Design-Case	**None (Reference Case)**	Not limited
2					NO 1	
3					NO 2	
4					BY	
5					UA	
6					DZ 1	
7					DZ 2	
8					LNG	
9					AZ	
10				Uniform Risk	**None (Reference Case)**	
11					NO 1	
12					NO 2	
13					BY	
14					UA	
15					DZ 1	
16					DZ 2	
17					LNG	
18					AZ	
19			2 weeks		**None (Reference Case)**	
20					NO 1	
21					NO 2	
22					BY	
23					UA	
24					DZ 1	
25					DZ 2	
26					LY	
27					LNG	
28					AZ	

The table below gives an overview of all the cases that were modelled under Supply Dependence assessment (Reference Cases in **bold**).

Table 3.4.
Cases modelled under Supply Dependence assessment

CASE	YEAR	INFRASTRUCTURE CLUSTER	DEMAND SITUATION		SUPPLY SITUATION	
			DURATION	OCCURENCE	IMPORT MIX	UGS DELIVERABILITY
1	2013 2017 2022	FID / Non-FID	1 day	Yearly average	**Reference Case**	Not used
2					Full Minimisation NO	
3					Full Minimisation RU	
4					Full Minimisation DZ	
5					Full Minimisation LY	
6					Full Minimisation LNG	
7					Full Minimisation AZ	

The table below gives an overview of all the cases that were modelled under the Infrastructure Adaptability to Supply Evolution assessment (Reference Cases in **bold**).

Table 3.5.
Cases modelled under Infrastructure Adaptability to supply evolution assessment

CASE	YEAR	INFRASTRUCTURE CLUSTER	DEMAND SITUATION		SUPPLY SITUATION	
			DURATION	OCCURENCE	IMPORT MIX	UGS DELIVERABILITY
1	2013 2017 2022	FID / Non-FID	1 day	Yearly average	**Reference Case***	Not used
2					Even Maximisation NO	
3					Even Maximisation RU	
4					Even Maximisation DZ	
5					Even Maximisation LY	
6					Even Maximisation LNG	
7					Even Maximisation AZ	
14					Even Minimisation NO	
15					Even Minimisation RU	
16					Even Minimisation DZ	
17					Even Minimisation LY	
18					Even Minimisation LNG	
19					Even Minimisation AZ	

The table below gives an overview of all the cases that were modelled under the Supply Source Diversification at Zone level assessment (Reference Cases in **bold**).

Table 3.6.
Cases modelled under Supply Diversification assessment

CASE	YEAR	INFRASTRUCTURE CLUSTER	DEMAND SITUATION		SUPPLY SITUATION	
			DURATION	OCCURENCE	IMPORT MIX	UGS DELIVERABILITY
1	2013 2017 2022	FID / Non-FID	1 day	Yearly average	**Reference Case***	Not used
8					Targeted Maximisation NO	
9					Targeted Maximisation RU	
10					Targeted Maximisation DZ	
11					Targeted Maximisation LY	
12					Targeted Maximisation LNG	
13					Targeted Maximisation AZ	

*Reference Case is identical to the one of the Supply Source Dependence assessment
**Targeted Maximisation; it may require multiple simulations for the assessment

Image courtesy of Swedegas

Supply and Demand

INTRODUCTION

This chapter provides an outlook for the gas demand of Europe as well as the potential European supply for the period 2013-2022. This chapter has two specific aims, the first to provide a supply adequacy outlook as stipulated in the 3rd Energy Package REG-715. The second aim is to provide the details of the supply and demand situations used for the network modelling.

DEMAND

Annual demand scenarios show the evolution of the gas demand on a yearly basis. Whilst this information is very interesting, from a network design and operation perspective it is hourly or daily demand that is required. Demand scenarios which show high levels of demand, either on a single day or over a sustained period, show what capability a system must be configured too. This information is vital for the safe and sustainable running of a transmission system.

ENTSOG has defined its demand scenario under a combined bottom-up and top-down approach. The introduction of a top-down methodology on a demand scenario created by the aggregation of the individual TSOs' scenarios has come through the use of a common methodology defining the risk levels on climatic occurrence.

2.1. Current state

During the last decade, European gas demand has not followed a clear trend, reaching its maximum annual consumption over the period in 2005 and generally remaining constant in the following years.

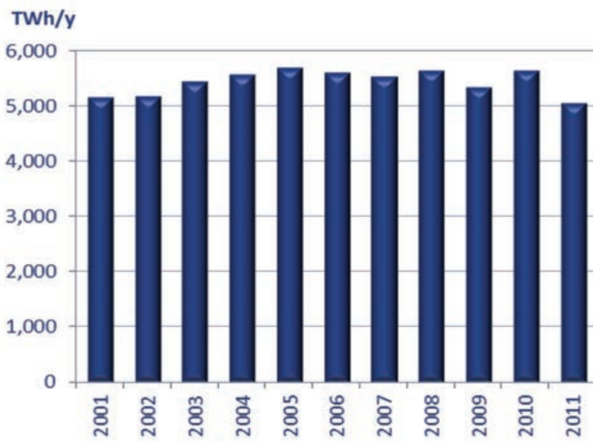


Figure 4.1.
Evolution of European gas consumption (Source: Converted from Eurostat figures)

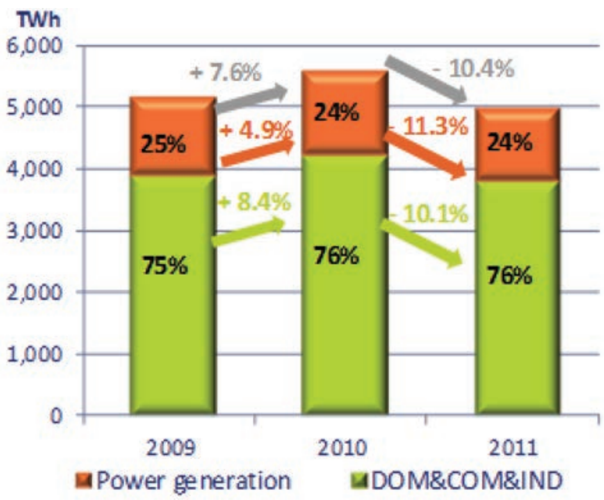


Figure 4.2.
Evolution of European yearly demand and its breakdown (Source: ENTSOG)

Yearly demand figures fluctuate mainly because of climatic conditions, due to the increased heating requirements during colder winters, and in some countries, to seasonal peaks of gas demand for electricity generation during warmer summers. The calendar year 2010 incorporated the main heating consumption periods of the gas years 09-10 and 10-11. Whilst in 2011, the main winter consumptions during the 10-11 winter was concentrated in December 2010, and the same instance happened in the winter of 11-12 when the main winter consumption occurred in early 2012. The above winter conditions resulted in a sharp demand increase in 2010, and then a subsequent decrease in 2011.

As showed by the graph below, the increase in yearly consumptions in 2010 and following decrease in 2011 was a general trend. Only Bulgaria, Croatia, Greece, Lithuania, Poland and Romania kept positive growth on the two consecutive years, the sustained growth in these markets was neutralised by significant demand decreases in bigger markets.

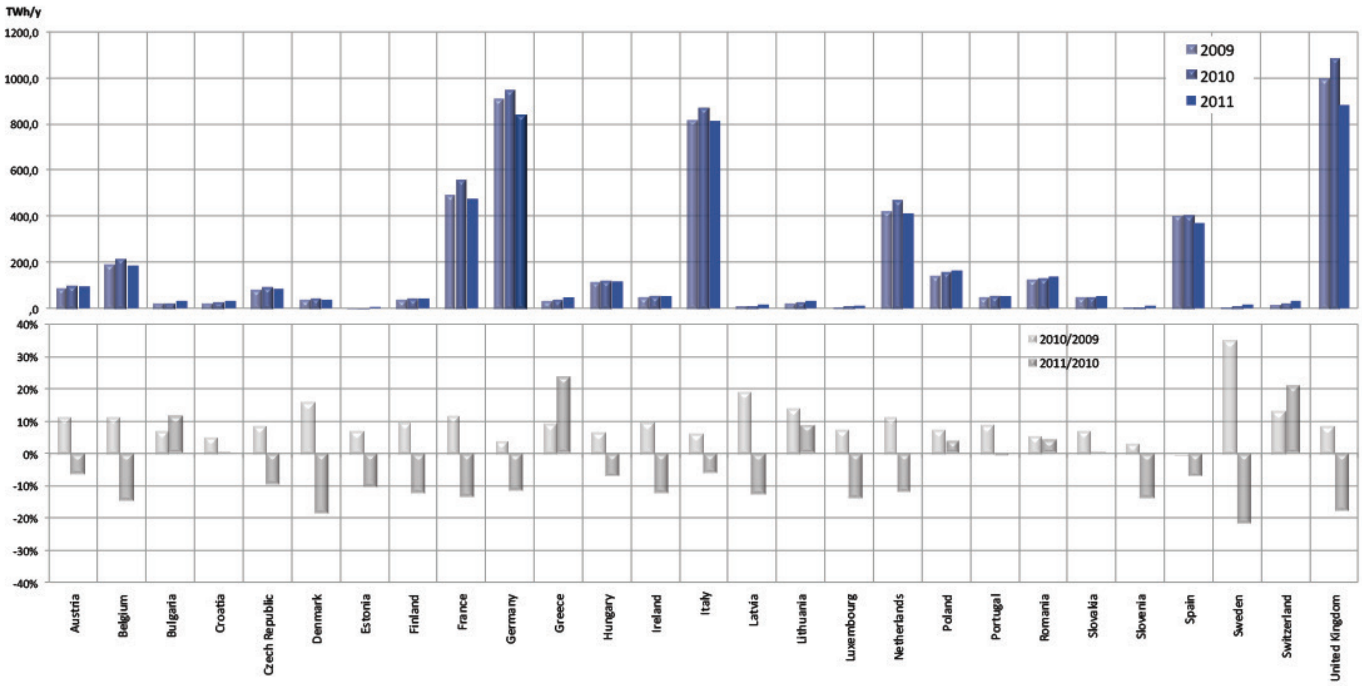


Figure 4.3.
Evolution of European yearly demand
by country and year on year percentage difference

The evolution of the power generation sector in gas consumption can be seen in figure 4.2; it shows a yearly swing of +4.9% and then -11.3%. The changes in power generation demand are due to the impact of climatic conditions as outlined above, along with changes in the power generation mix. There was a significant shift between coal and gas as base load technology due to the pricing differential.

Over the period from 2009 to 2011, power generation from non-fossil fuels slightly increased following the growth of new production renewable technologies. A significant decrease in gas generation came in 2011, derived from the relative increase of other fossil fuels.

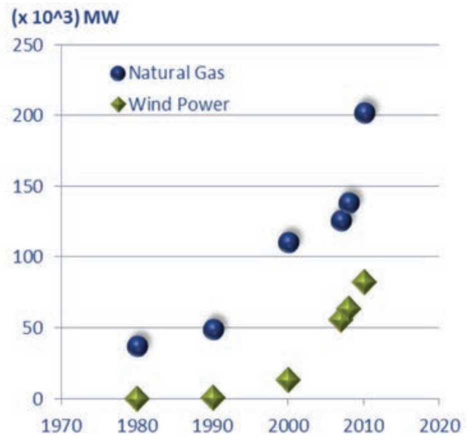


Figure 4.4.
Max net generating capacity by Natural gas and Wind power (Eurelectric 2012)

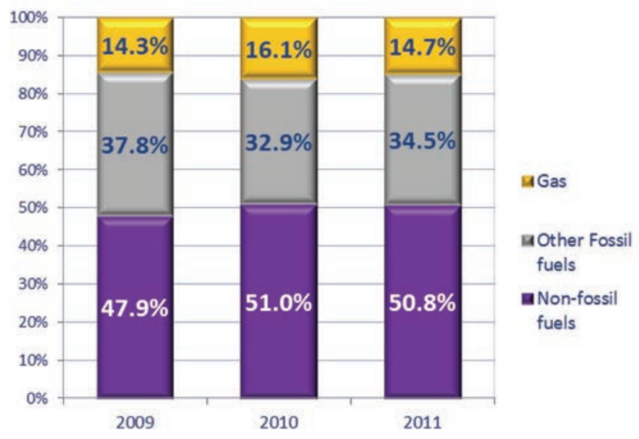


Figure 4.5.
The role of gas in electricity production (based on data provided by ENTSO-E)

The increase in the gas-fired installed capacities has come on-line during a period where there has been a significant development of intermittent renewables. The sharp increase in the installed capacity from gas experienced in 2011 was not followed immediately by a parallel development in the gas consumptions. Due to the spread in the gas-coal prices and low carbon prices, the impact being that coal was the preferred base load generation technology resulting in lower gas use for power generation in 2011.

The operation of the system is mainly impacted by high levels of consumption. The day of highest consumption in the year, is a pillar for network design, and represents one of the most stressful situations to be covered by the gas transmission system. Nevertheless, it is not only the level of demand, but also the availability of supply sources which challenge system operation. This availability or lack of availability of supply is usually impacted by the duration for which high levels of gas consumptions are sustained. On this basis, ENTSOG has estimated a 14-day period as significant for the definition of a long period of high demand testing the resilience needs of the system.

The table below quantifies the high levels of demand during the day of highest consumption, and the 14-days with highest average consumption of the last three winters.

		Date	GWh/d
Day of highest consumption	Winter 2009/10	26.01.10	27,431
	Winter 2010/11	17.12.10	27,091
	Winter 2011/12	07.02.12	29,141

		Date	GWh/d
14-day period of highest average consumption	Winter 2009/10	(03/01/10 - 16/01/10)	24,645
	Winter 2010/11	(09/12/10 - 22/12/10)	24,633
	Winter 2011/12	(31/01/12 - 13/02/12)	27,644

Figure 4.6.
High daily and 14-day consumptions

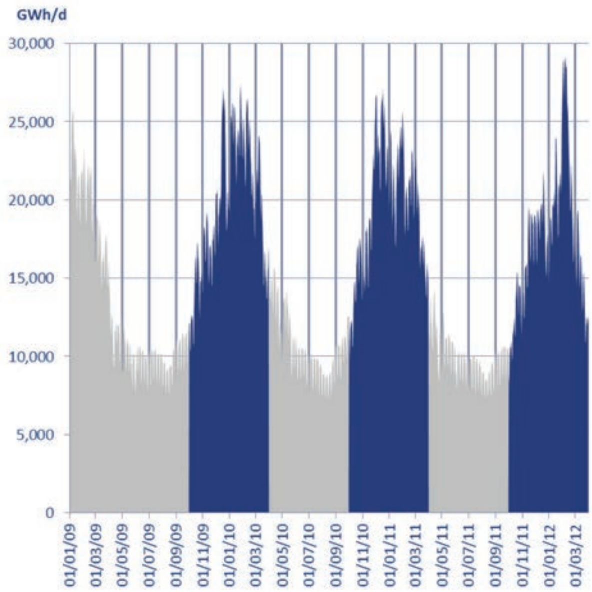


Figure 4.7.
Yearly modulation

The Figure 4.6. shows the evolution of the day of highest consumption in the last three years, describing a maximum for almost every country in 2010, followed by a significant reduction in 2011 that is explained by the fact that highest consumptions in the two winters of 2011 (winter 10-11 and 11-12) took place in the months outside of the year (Dec 10 and Feb 12).

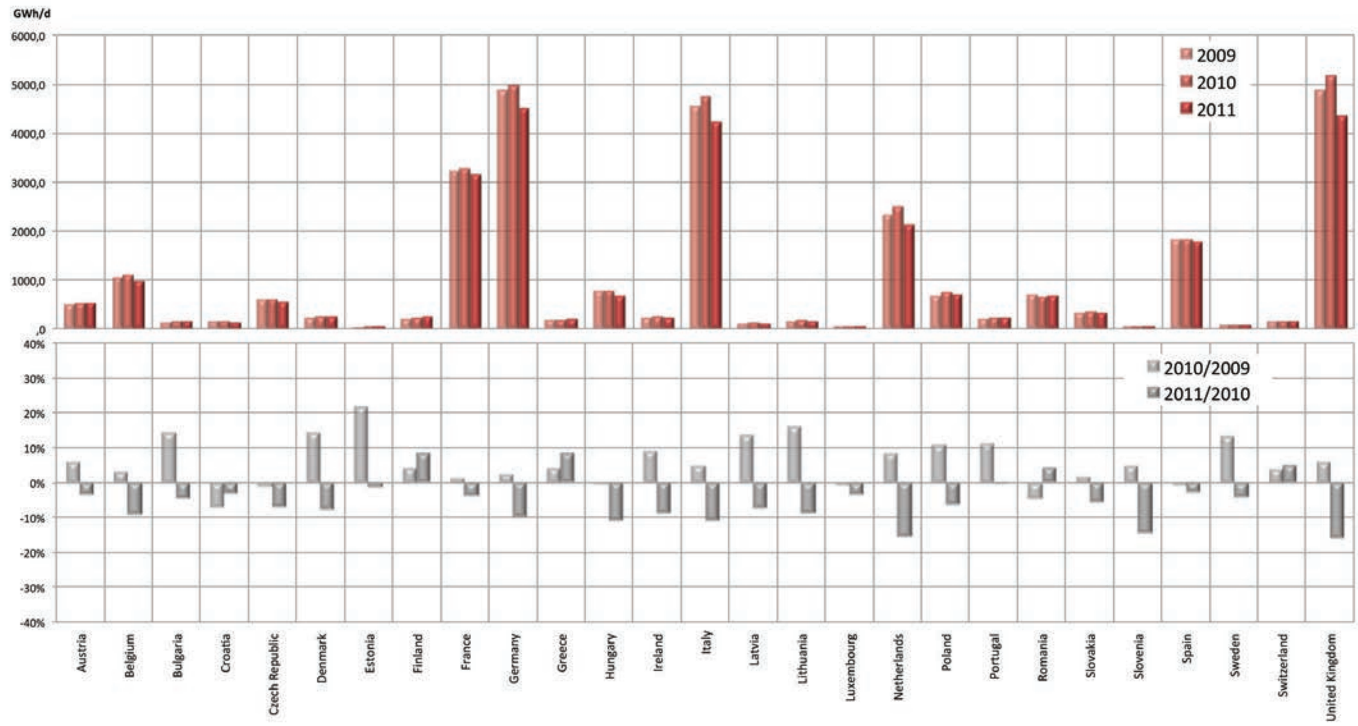


Figure 4.8.
Day of the highest consumption and year on year percentage difference

2.2. Demand scenarios and cases

2.2.1. Underlying assumptions

The assumptions considered in the scenario definition are independently defined at country level by the responsible TSO or relevant national authority. Considerations regarding GDP, population, other input parameters with repercussion on gas demand, as well as the detail on the definition of the level of risk and other considerations on power generation are detailed in Annex C.

2.2.2. Annual demand

The yearly gas demand is expected to grow on an average rate of 1% in the 10-year horizon. This growth will come mainly from gas consumptions from power generation, this sector increases by 31% over the 10-year period. Actual volumes of residential, commercial and industrial consumptions are expected to remain at current levels in the EU as a whole, although differences are foreseen in individual countries.

In addition, ENTSOG considers other demand scenarios to assess the supply-demand balance on an annual basis. Assumptions underlying these scenarios are given below.

- Eurogas Baseline and Eurogas Roadmap (Eurogas, 2010)
  The Eurogas Baseline Scenario determines the development of the EU energy system under current trends and policies based on the historic trends observed in the past 20 years, while the Eurogas Roadmap describes how the different sectors can contribute to reaching the 80% greenhouse gas reduction target. It does not follow the historic trends but presents a pathway based on sensitivity analyses.

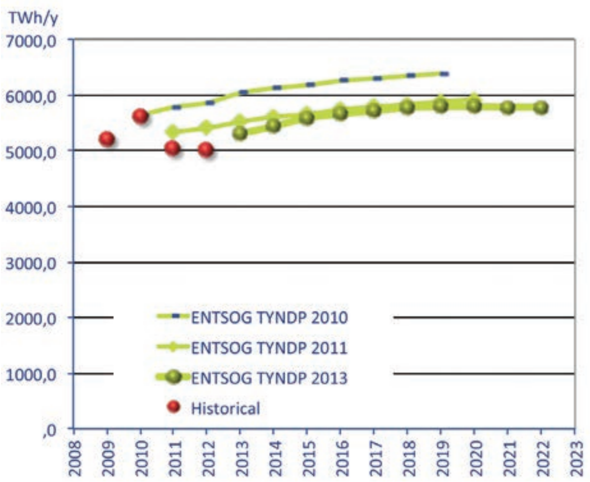


Figure 4.9.
Comparison of ENTSOG TYNDP annual forecasts

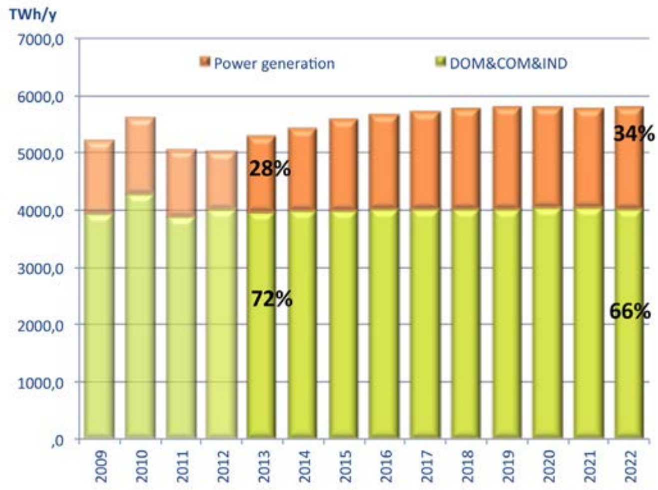


Figure 4.10.
Yearly demand, evolution and breakdown
Note: On the date of publication of this Report, the definitive data for 2012 is not available.

Growth rate	2013	2014	2015	2016	2017	2018	2019	2020	2021	Avarage
Gas demand	2.6%	2.7%	1.3%	1.0%	1.0%	0.3%	0.0%	-0.2%	0.1%	**1.0%**
Powergen	9.0%	8.5%	4.0%	3.7%	2.4%	1.1%	-0.3%	-0.6%	0.5%	**3.1%**
DOM & COM & IND	0.4%	0.4%	0.2%	-0.1%	0.1%	-0.1%	0.2%	-0.1%	-0.1%	**0.1%**

Figure 4.11.
Yearly growth by sector

- IEA New Policies, Current Policies and 450 Scenario (IEA, 2012)
  The New Policies Scenario takes into account broad policy commitments and plans that have already been implemented to address energy related challenges as well as those that have been announced, even where the specific measures to implement these commitments have yet to be introduced.

- The Current Policies Scenario embodies the effects of only those government policies and measures that had been enacted or adopted by mid-2012. Without implying that total inaction is probable, it does not take into account any possible, potential or even likely future policy actions.

- The basis of the 450 Scenario is different. Rather than being a projection based on past trends, modified by known policy actions, it deliberately selects a plausible energy pathway. The pathway chosen is consistent with actions having around a 50% chance of meeting the goal of limiting the global increase in average temperature to two degrees Celsius (2°C) in the long-term, compared with pre-industrial levels. (IEA, 2012)

- Commission Roadmap 2050 (Commission, 2011)
  The Commission's Roadmap 2050 describes different evolutions in the energy mix allowing the targeted reduction of CO_2 emissions up to 80-95% by 2050. For comparison purposes only two roadmap scenarios, (High Energy Efficiency

and High Renewable Energy sources) covering the minimum and maximum gas consumptions during this period, have been considered.

The following graph shows the comparison between the ENTSOG scenario and the different scenarios mentioned above. The ENTSOG scenario is towards the middle part of the range. In the comparison of those scenarios driven by environmental targets (Eurogas Roadmap, IEA 450 Scenario, and Commission Roadmap), significant differences appear before the end of the period. The Eurogas Roadmap shows a demand scenario that achieves the environmental targets, which converges with ENTSOG's scenario for the last years of the horizon.

*The gas demand figures have been calculated in TWh (Gross calorific basis) from gas data expressed in mtoe or ktoe (on net calorific basis) assuming that net calorific value is 10% less than gross

Figure 4.12.
Comparison with other outlooks

2.2.3. Gas-fired power generation

The following graph shows the evolution of gas-fired power generation installed capacity, comparing ENTSOG´s scenario (see Annex C) with the two capacity scenarios covered in ENTSO-E´s Scenario Outlook and Adequacy Forecast (SO&AF) 2012 which were considered in ENTSO-E's TYNDP (Scenario B and Scenario 2020)2. During the first three years, ENTSOG´s scenario is in between the two ENTSO-E scenarios, converging with Scenario B after 2015. It should be noted that ENTSO-E's SO&AF details the installed capacity from gas for the years: 2012, 2015, 2016 and 2020 in the case of the Scenario 2020, and 2025 in the Scenario B. Capacities in the missing years have been calculated by linear interpolation.

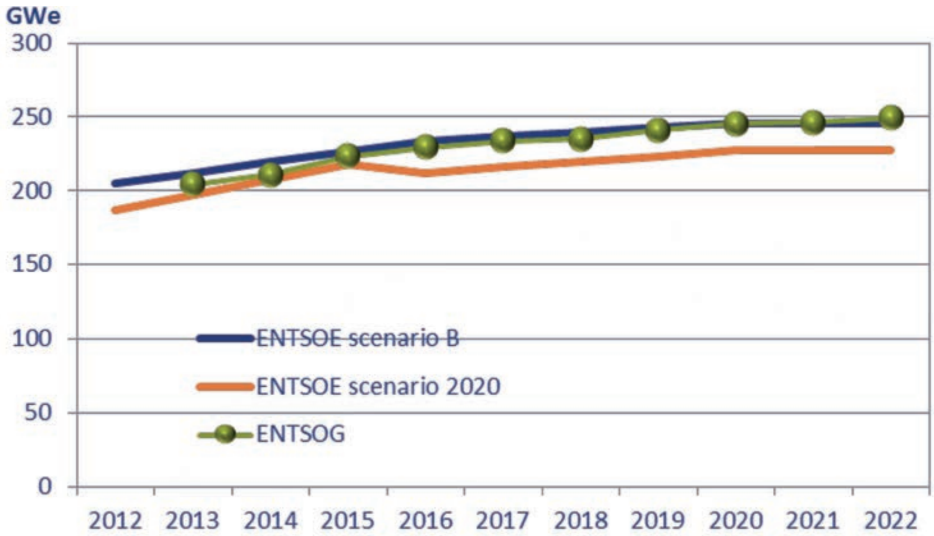


Figure 4.13.
Gas-fired power generation. Installed capacities.

The increase of gas-fired capacity is followed by expected growth in gas consumption for power generation, both in the yearly and in the peak figures, as seen in figure 4.13. The peak factor is defined as the ratio between daily peak and daily average. The peak factor oscillates between 1.9 and 2 during the period, meaning an increase in gas consumption in the peak day between 90% and 100% over the average consumption.

This reduction in the share of gas within the total installed capacity for the second half of the decade is the result of the significant growth of the future installed capacities of renewable technologies.

[2] The Scenario EU 2020 has been built top-down, based on the European 20-20-20 objectives and the NREAPs. The Scenario B extrapolates information from market players'present investments perspectives in a bottom-up approach.

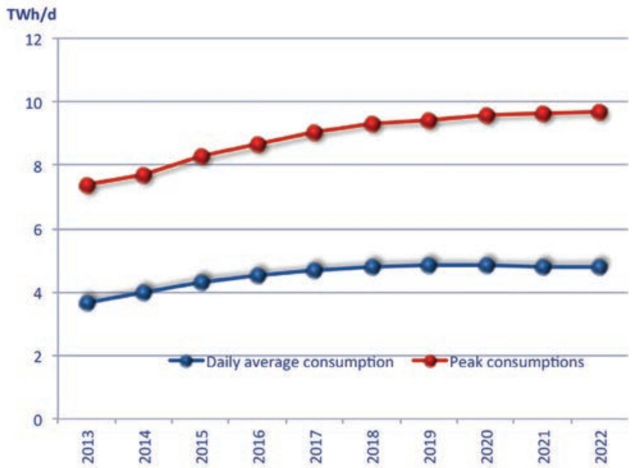


Figure 4.14.
Gas consumption for power generation.
Daily average vs. Peak day

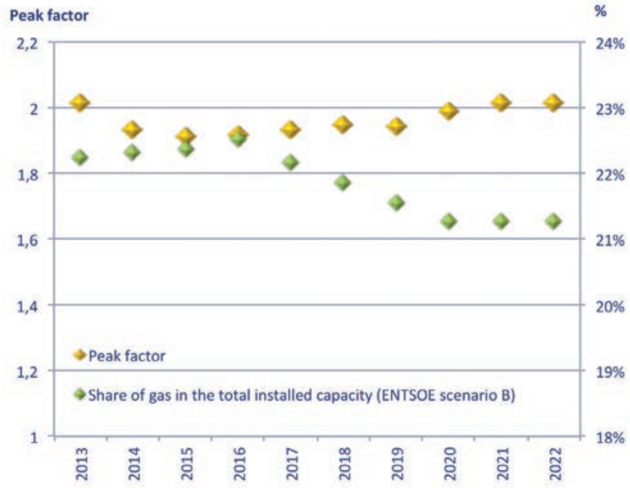


Figure 4.15.
Peak ratio and share of gas
in the total installed capacity

ENTSOG has considered a conservative estimate of 47% efficiency rate for the different generation technologies which reflect the expected utilisation. The load-factors defined in figure 4.16 show the ratio between capacity use and the installed capacity. These gas consumption figures would indicate yearly load-factors around 40%, and daily (peak) load-factors close to 75%, as seen in the following graph:

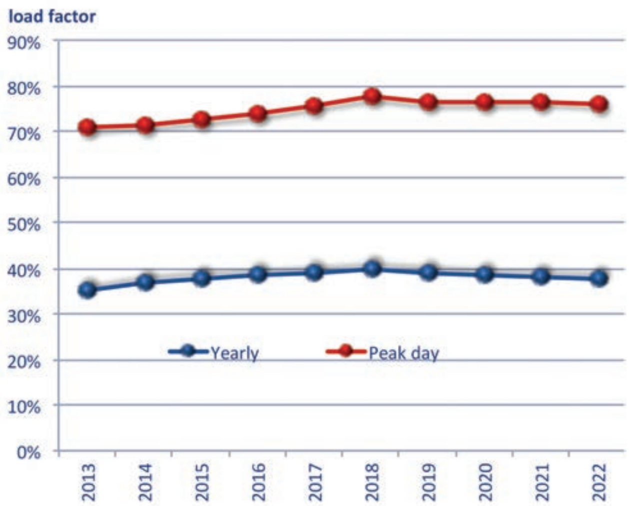


Figure 4.16.
Evolution of load-factors

Yearly loadfactor = yearly consumption / (8,760 hours of nominal consumption)

Peak loadfactor = peak day consumption / (24 hours of nominal consumption)

ENTSOG's scenario of gas demand for power generation has been compared with the results of the market studies run by ENTSO-E within their TYNDP 2012. In these market studies ENTSO-E modelled the behaviour of the power system in 2020 at hourly granularity under two scenarios: Scenario B and Scenario 2020. For this comparison the figures on electricity production from gas have been transformed into gas consumption using average efficiencies (47% for CCGT and 30% for OT). The graph below shows the differences between the scenarios, these differences can be explained by the different modelling methodologies (see annex C).

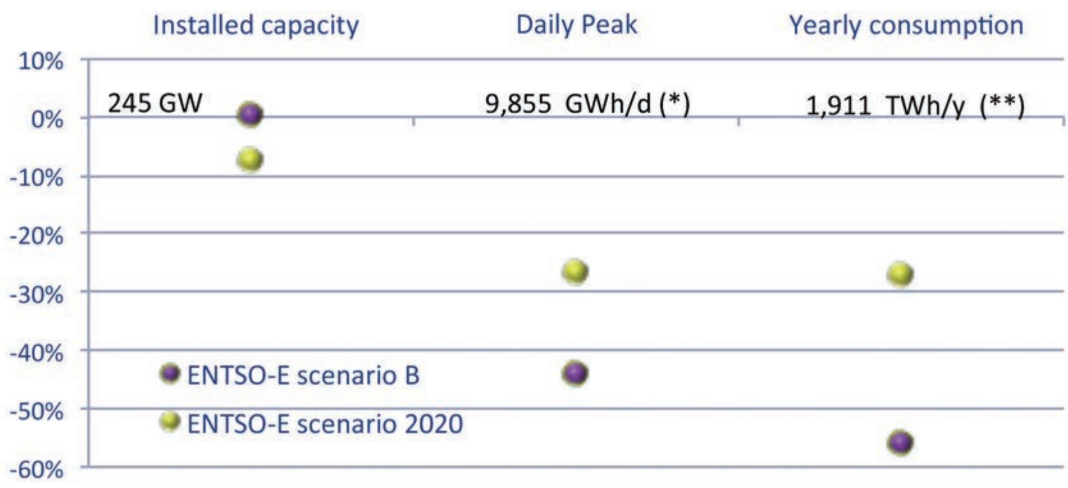


Figure 4.17.

Comparison between ENTSOG´s and ENTSO-E´s scenarios. Year 2020

* 9,855 = 9,418 (ENTSOG scenario) + 437 (replacement data)

** 1,911 = 1,759 (ENTSOG scenario) + 152 (replacement data)

The resulting chart shows the scenarios differ significantly. The consumption levels are difficult to predict in the long-term, because they are derived from market conditions defining the electricity generation mix (relative cost of coal and gas generation) which are not considered at this stage by ENTSOG. Besides, the very recent changes in the subsidy policies of Member States, with potential effect on the RES development may not have been completely factored into the scenarios.

In any case the discrepancies in the consumption values between ENTSO-E and ENTSOG scenarios should not detract from the broad consistency in the capacity figures. The differences in the peak consumptions figures should be seen in conjunction with different under-lying assumptions associated with each data set. The peak figures included in the ENTSOG scenario are defined under a higher level of risk, whilst the gas consumption figures in ENTSO-E's scenarios have been estimated from average efficiencies. It is also important to realise that the highly intermittent regimes on which gas-fired power generation may be operating introduces significant uncertainty in these values.

These differences will be investigated as part of ENTSOG R&D plan starting in 2013.

2.3. Demand Situations

2.3.1. Yearly Average Situation

The yearly average is calculated by dividing the annual volumes as described in section 2.2.2. Annual Demand by 365.

2.3.2. The Design-Case Situation

The Design-Case Situation refers to the sum of the high daily demand in each country as described in the Methodology chapter. The following graph and table show the evolution of the Design-Case in the 10-year range.

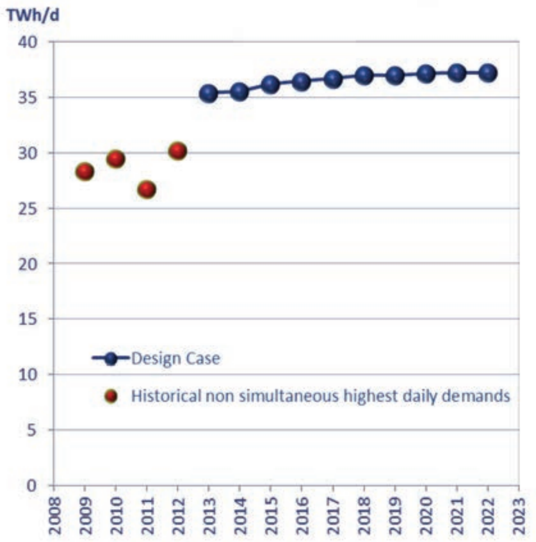


Figure 4.18.
Design-Case Situation. Evolution of total gas demand.

Growth rate	2013	2014	2015	2016	2017	2018	2019	2020	2021	Avarage
Gas demand	0.4%	1.7%	0.8%	0.7%	0.7%	0.0%	0.4%	0.2%	0.0%	**0.6%**
Powergen	4.4%	7.1%	4.3%	4.5%	3.1%	0.9%	1.8%	0.7%	0.4%	**3.0%**
DOM & COM & IND	-0.7%	0.1%	-0.3%	-0.6%	-0.1%	-0.3%	-0.1%	0.1%	-0.2%	**-0.2%**

Figure 4.19.
Design-Case Situation. Yearly growth rate.

2.3.3. Uniform Risk High Daily Demand Situation

As described in the Methodology chapter (3.3.2.), the Uniform Risk High Daily Demand Situation refers to the sum of the high daily consumption forecasts for each country, based on a common definition of climatic conditions. The following graph shows the evolution of the Uniform Risk High Daily Demand Situation in the 10-year range, being on average a 3% lower than the Design–Case Situation.

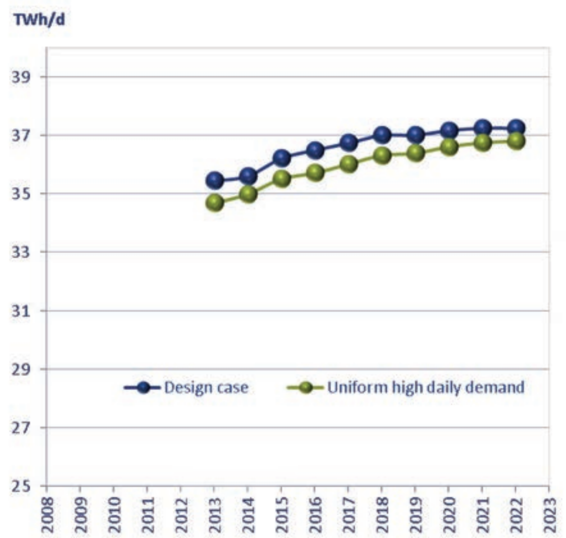
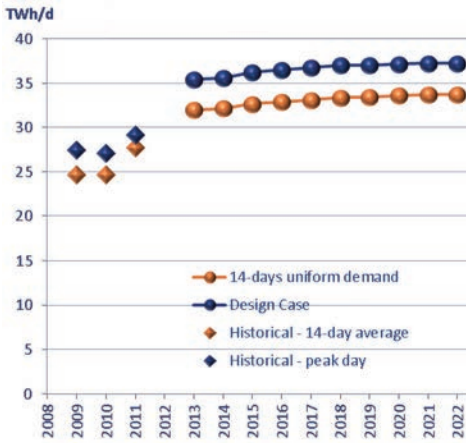


Figure 4.20.
Uniform Risk High Daily Demand Situation. Evolution of total gas demand

2.3.4. Uniform Risk High 14-day Demand Situation

The Uniform Risk High 14-day Demand Situation describes the sum of the Average Daily Demand during a 14-day period of high gas consumption in each country. As a continued cold climatic event is the most likely cause of a 2-week period of sustained high demand, the Uniform Risk High 14-day Demand Situation has been estimated following a defined level of risk based on climatic occurrence, as explained in the methodology chapter.

The following graph compares the Uniform Risk High 14-day Demand Situation with the Design-Case Situation, where there is an average difference of 10%.



4.21.
Uniform Risk High 14-day Demand Situation

2.3.5. EU-27 Simultaneity Assessment

It may seem that the addition of the high levels of demand for each country could lead to the overestimation of European gas demand, as all countries may not be reaching these levels of demand on the same day across Europe. Nevertheless, the limited amount of good quality data available does not allow for a simultaneity assessment to be completed on consumption figures. If it is assumed that a significant share of gas demand is correlated with climatic conditions, this assessment can be based on temperatures.

ENTSOG has carried out an assessment on the simultaneity of cold climatic conditions, comparing the European demand-weighted average temperature with the temperatures at country level, based on a data set of temperatures from the last 35 years. The results show a daily simultaneity index of 96% for the day, and 99% for the 14-days average. These values are fully consistent with the simultaneity observed in the peak gas consumptions during the last three years.

2.4. Political scenarios and the future beyond 2023. Natural gas and the environmental targets

The network assessment within this TYNDP is limited, by definition, to a ten-year horizon. Nevertheless, the investment in gas infrastructure requires long-term pay-backs, usually between 25 and 40 years. For this reason, the evolution of gas demand in the long-term is key for decision makers.

The following graphs summarise the long-term perspective for gas consumption as outlined by the Communication "Energy Roadmap 2050". It should be noted that the 5 alternative decarbonisation scenarios in the Roadmap represent 5 divergent options for the achievement of the 2050 target (a reduction of CO2 emissions up to 80-95% from 1990 levels). In a similar exercise, Eurogas Roadmap depicts an alternative energy scenario, where the 2050 reduction targets are achieved with an important contribution from gas.

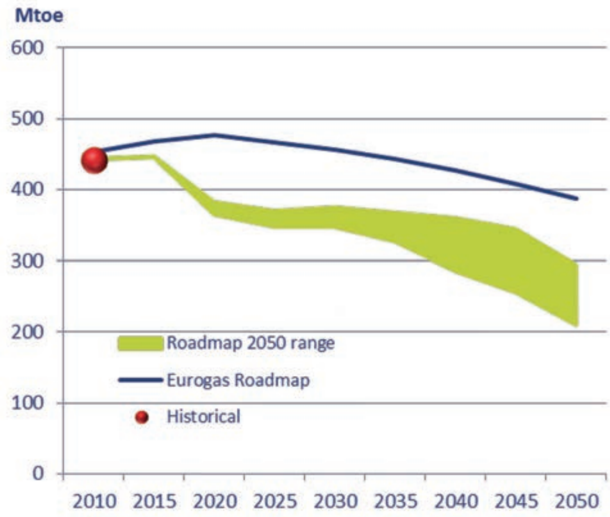


Figure 4.22.
Natural gas in primary energy consumption

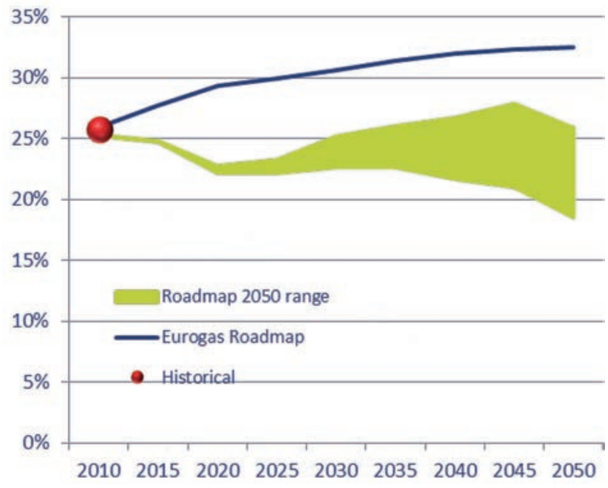


Figure 4.23.
Share of gas in primary energy

The energy consumption scenario outlined by the Eurogas Roadmap contemplates a substantial improvement in the sustainable use of natural gas in the long-term. This may be achieved with the development of Carbon Capture and Storage and the increase in the use of natural gas as fuel for transportation. The replacement of diesel by natural gas, particularly for heavy duty trucks and shipping, implies a significant reduction in the disperse emissions for transportation uses that are not currently practical for electrification. The graph below shows the development of natural gas consumption for the transport sector as considered by Eurogas Roadmap.

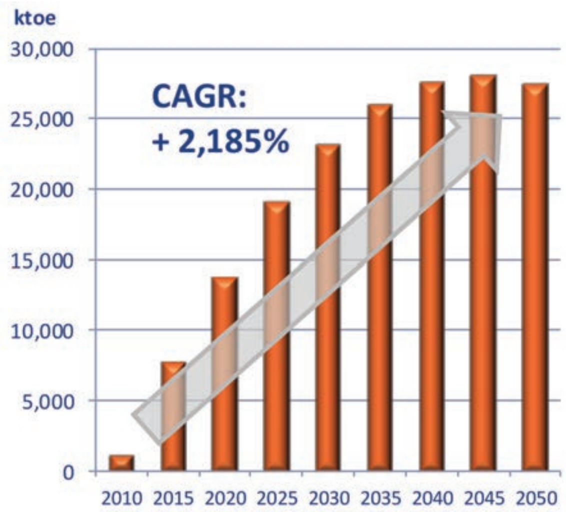


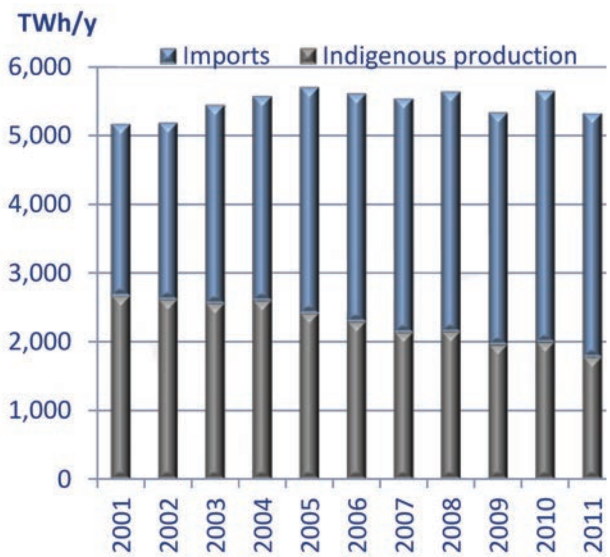
Figure 4.24.
Consumption of natural gas in transport sector.
Eurogas Roadmap

SUPPLY

ENTSOG would like to note that most TSOs have a very limited access to supply data as it exceeds their area of responsibility within the gas chain. Most supply data was collected from public sources and as such ENTSOG cannot be held responsible for the accuracy of this data.

3.1. Current state

In the last 10 years European indigenous production has steadily declined, this has been reflected in the European gas supply mix, where in 2011 indigenous production only accounted for about 30%. The decrease in indigenous production has been compensated by an increase in imports from outside Europe.



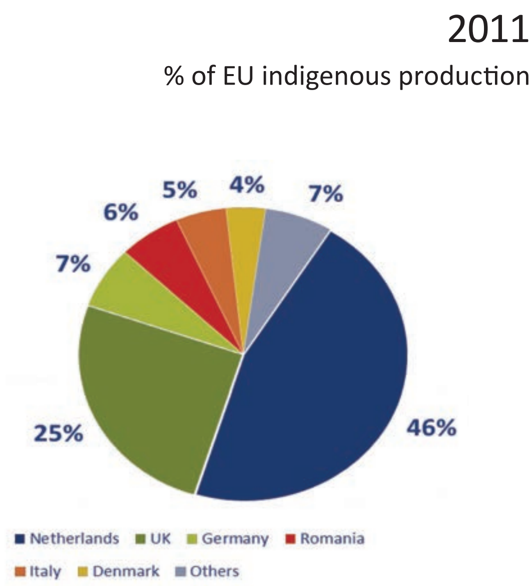


Figure 4.25.
Evolution of Indigenous production vs. Imports

Figure 4.26.
Indigenous production in 2011

In 2011, following a decrease in overall gas demand, both indigenous production and imports were reduced; however the effect on indigenous production was more pronounced.

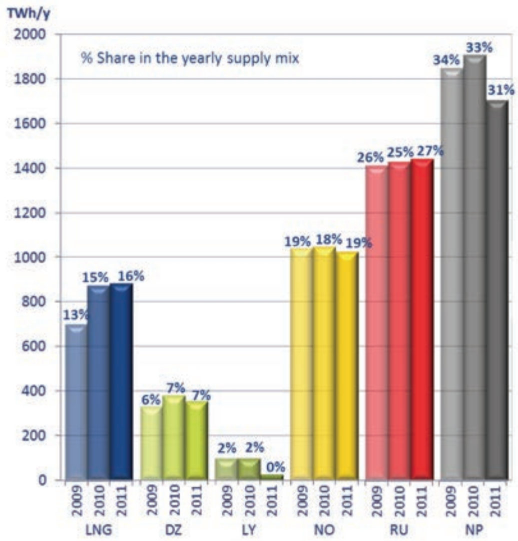


Figure 4.27.
European Supply Mix

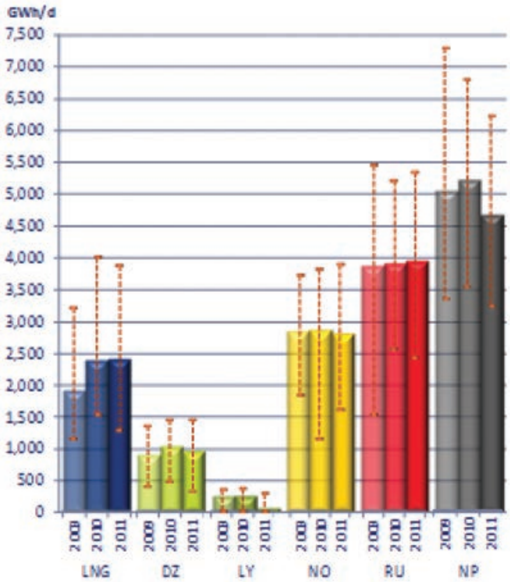
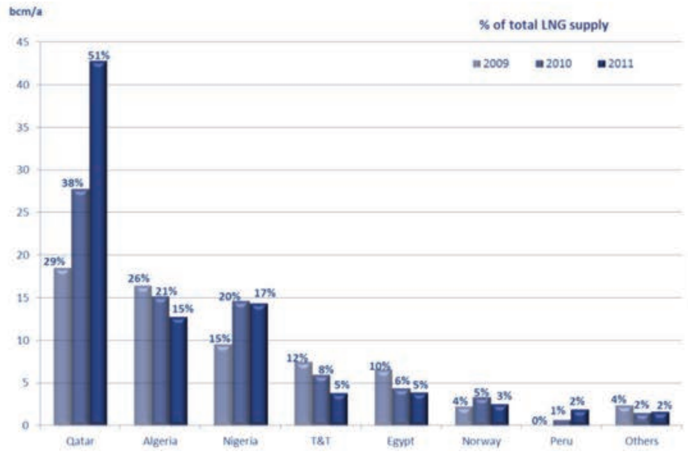


Figure 4.28.
Daily flexibility (max, average, min)

The maximum daily deliverability by each supply source occurred in the period of peak consumption registered in the corresponding years. The maximum daily deliverability of indigenous production shows a clear downward trend from 2009 to 2011, this is consistent with the yearly reduction observed. The maximum daily flexibility by supply source is however influenced by the decisions of the markets and the availability of gas in the storages.

LNG plays an important role within the European gas supply mix, accounting for 16% of overall supply in 2011. LNG offers the European market a considerable amount of supply diversification; however the overall diversity of LNG supplies to Europe was reduced in 2011 with the growing dominance of Qatar in the European LNG supply portfolio.



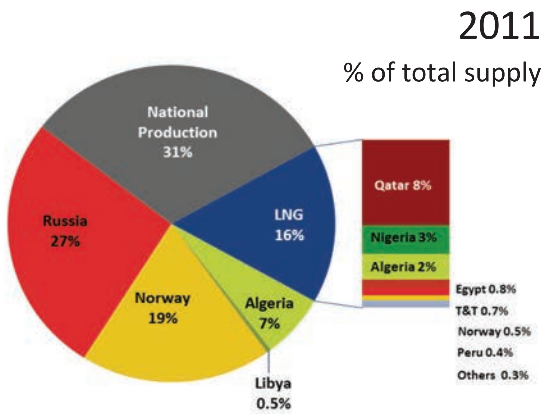


Figure 4.29.
LNG Supplies

Figure 4.30.
Diversification of Supply

3.1.1. Supply Scenarios

As it can be clearly seen in the previous section, the majority of gas supply mix is from countries outside the EU. In addition to that fact, ENTSOG being an association of unbundled TSOs, has no particular information on supply beyond what can be found in common industry publications. Nevertheless, supply scenarios are the base for any supply adequacy outlook and a necessary input for any network assessment. For the purpose of this TYNDP, ENTSOG has defined a range of Potential Supply scenarios for each of the import sources. This range has been delimited by a maximum and a minimum scenario representing limits for the amount of gas available from a gas producer for the European market on annual basis according to the available information. In between this maximum and minimum, an intermediate scenario has been outlined. For indigenous production only one supply scenario has been considered, as this is the best estimate by TSOs.

3.1.1.1. Indigenous production

The Supply Potential of indigenous production from the European countries covered in this Report shows a slow decline over the 10-year period, based on the information provided by TSOs.

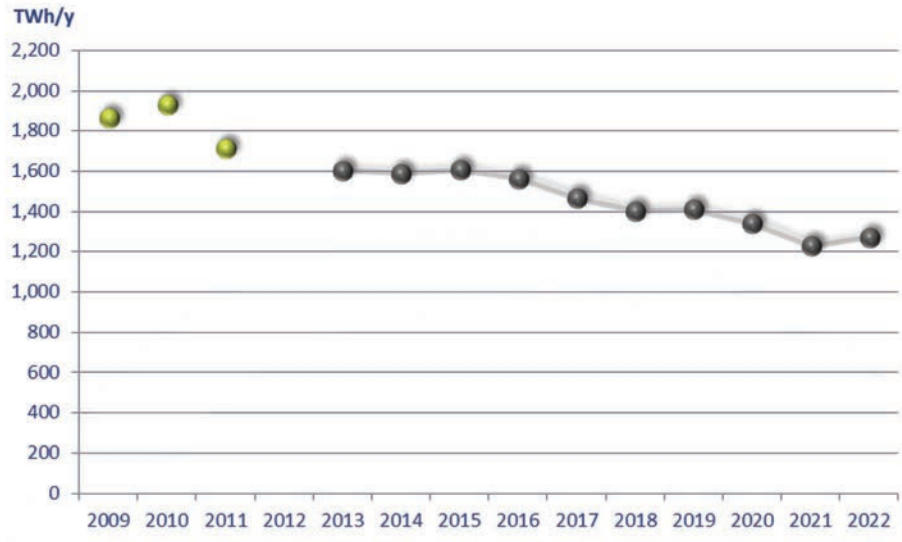


Figure 4.31.
European Indigenous production

The development of alternative local sources of gas should be considered as an option to the increase of gas imports in the substitution of the declining production. In this context, an increase in the volumes injected to the system of either shale gas or gases coming from renewable sources is expected.

According to the scenarios covered by the IEA, the development of unconventional gas in the European Union could be up to 7% of the total indigenous production by 2020, while a large growth could come after this year, with a potential production of 77 bcm by 2035. Nevertheless these figures describe the IEA 'Golden Rules Case' in shale gas development; however the IEA 'Low Unconventional Case' offers an alternative scenario where there is no development of these sources.

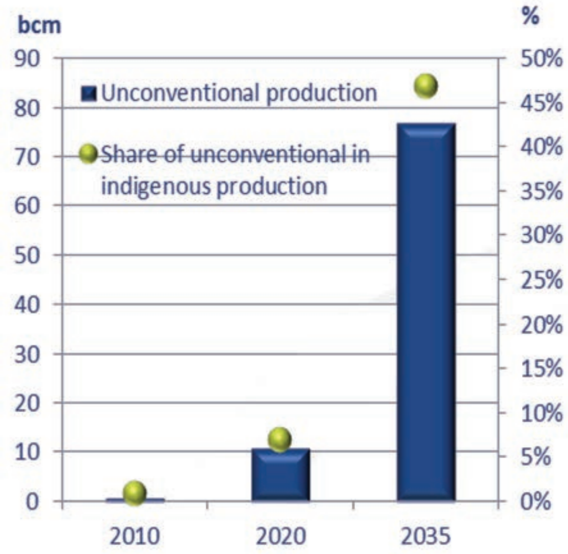


Figure 4.32.
Unconventional production in the European Union. Golden Rules Case (Source: IEA Golden Rules for a Golden Age of Gas)

The potential reserves of unconventional gas in Europe are believed to be large, particularly in certain countries like Poland, however exploration activities are at an early stage and therefore the exact values of recoverable reserves are not currently available. Moreover, the development of unconventional sources will depend on how the regulatory, social and economic aspects are treated.

Due to the current level of uncertainty with regards to unconventional production, only a limited number of TSOs have provided data on this subject. Therefore the chart below can only be seen as an initial insight into this potential source of gas. Based on the figures received the development of these techniques will not have a significant impact in the overall European supply mix in this period, however the impact could be important locally.

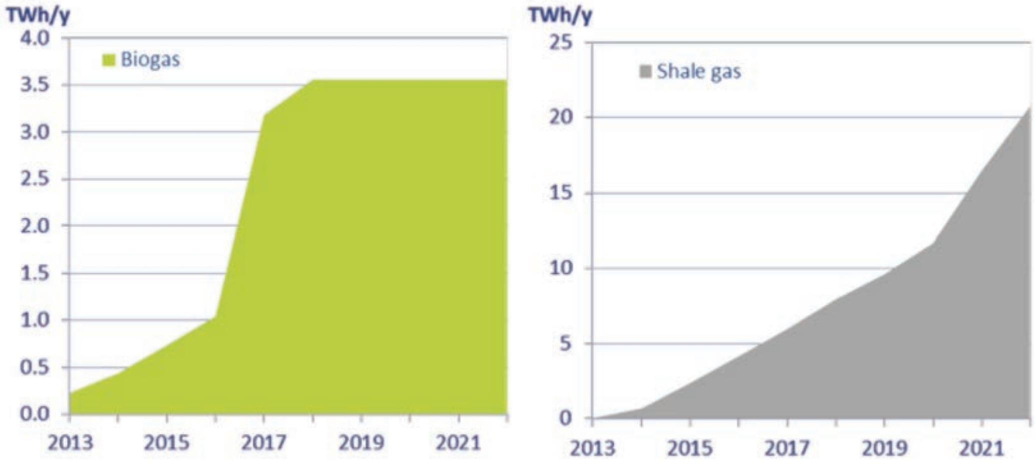


Figure 4.33.
Biogas and Shale gas supplies - TSOs own estimations

The injection of methane from sustainable sources contributes to the reduction of the overall impact of greenhouse gas emissions[3]. In this sense, the development of biogas could foster the exploitation of indigenous energy sources like urban waste or biomass. Nevertheless, the scope of biogas suits local consumption, or the injection in to distribution systems, as the limited size of the biogas production facilities does not fit well with the equipment required to increase its pressure for entry to the transmission system. The local consumption of biogas or its injection in the distribution system should still be considered as it may reduce the demand on the transmission system.

There is also the potential for different gases to come from renewable processes such as methanation or hydrogenation, associated with storage of electricity. These future developments may have an impact on the supply mix in the long term, but these technologies are still being investigated (feasibility studies and pilot projects) and for that reason, are not for further consideration in this Report.

There is a considerable amount of potential for these new sources of gas in the future, however with the current high uncertainty levels in their development, this Report favours the limitation of their contribution in the supply mix to the best estimation of TSOs (ref. Figure 4.31.).

[3] If methane is not captured and used as a fuel thus converted to CO_2 and H_2O, it will be released in the atmosphere where its Global Warming Potential (GWP) is much higher than that of the same mass of CO_2 (72 times in a 20 years time horizon, 25 times in a 100 years time horizon and 7.6 times in a 500 years time horizon)

3.1.1.2. Norway

Norwegian gas production activity is mature, with significant infrastructure in areas of the North Sea where the geology is often well known, therefore large new discoveries are less likely than before in these areas.

Norwegian supply scenarios are based upon ranges of expected gas sales from the Norwegian Petroleum Directorate / Ministry of Petroleum and Energy, and figures provided by GASSCO.
The potential range of Norwegian supply has been estimated as follows:

- The lower line (minimum scenario) is defined by the minimum values for the Norwegian gas sales as forecasted by the Norwegian Petroleum Directorate.
- The upper line (maximum scenario) is defined by the Norwegian potential pipeline exports as estimated by GASSCO.
- The Intermediate Potential Supply scenario has been calculated as the average of the maximum and minimum ones defined above.

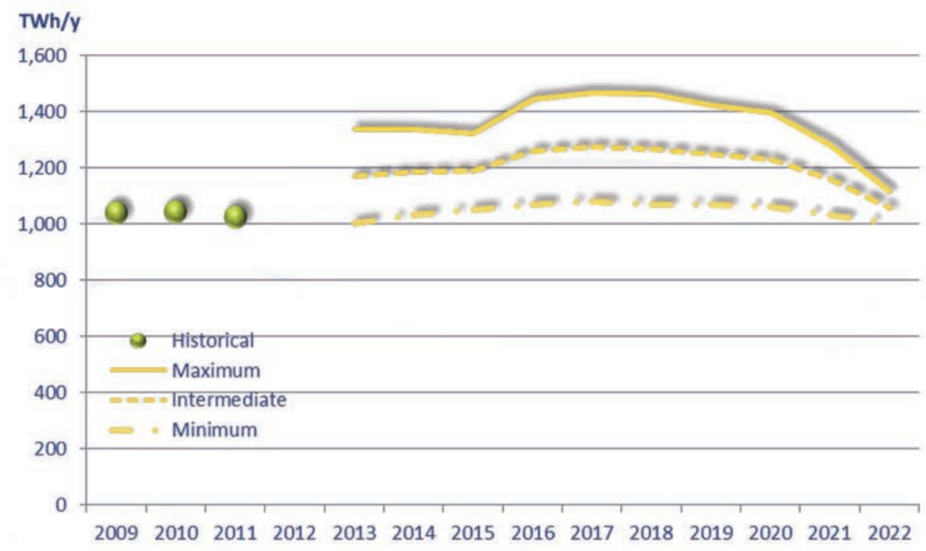


Figure 4.34.
Norwegian potential supply

3.1.1.3. Russia

The Supply Potential of Russian gas is based on the export values given in the Energy Strategy of Russia for the period up to 2030 (published in 2010).

To define a range for Russian exports, two gas balances for the total pipeline exports were calculated:

- Maximum scenario: low exports to Turkey and CIS countries and to Asia were considered, leading to the higher exports for EU-27.
- Minimum scenario: defined by the upper limits for the exports to Turkey and CIS countries and to Asia.
- The Intermediate Potential Supply scenario has been calculated as the average of the maximum and minimum scenario defined above.

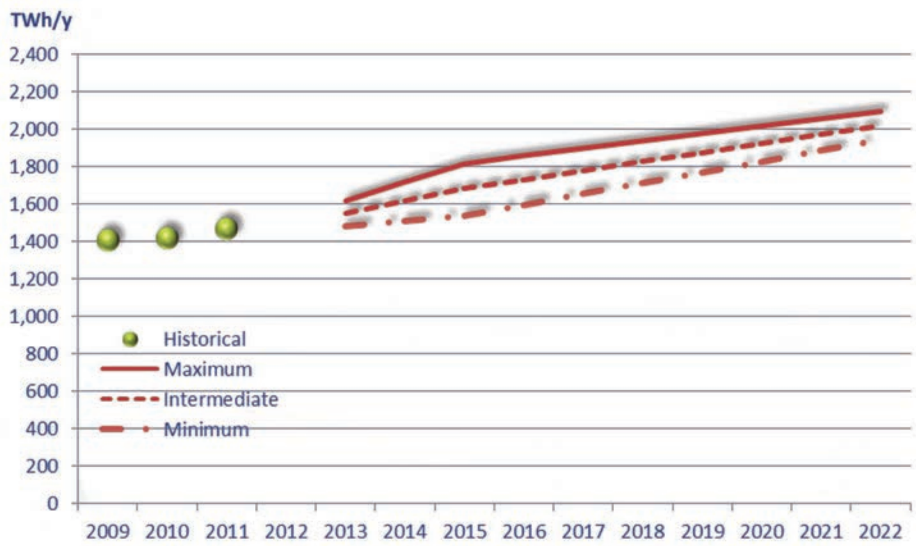


Figure 4.35.
Russian potential supply

3.1.1.4. Algeria

The Supply Potential from Algeria is based on the "Gas Export Availability" data from Mott MacDonald's report: Supplying the EU Natural Gas Market (September 2010) which was ordered by the European Commission, and includes a Low, a High and a Base case for Algerian exports.

- The minimum scenario is based on the Low case
- The maximum scenario is based on the High case
- The Intermediate Potential Supply scenario is based on the Base case

To determine what portion of these exports corresponds to piped gas, ENTSOG based the estimation of the exports on the existing LNG liquefaction capacity. ENTSOG has updated the Mott MacDonald scenarios changing the starting point to reflect the actual values from the years following its publication. From this year on, the trend followed by each of the scenarios is the one coming from Mott MacDonald, as yearly variation.

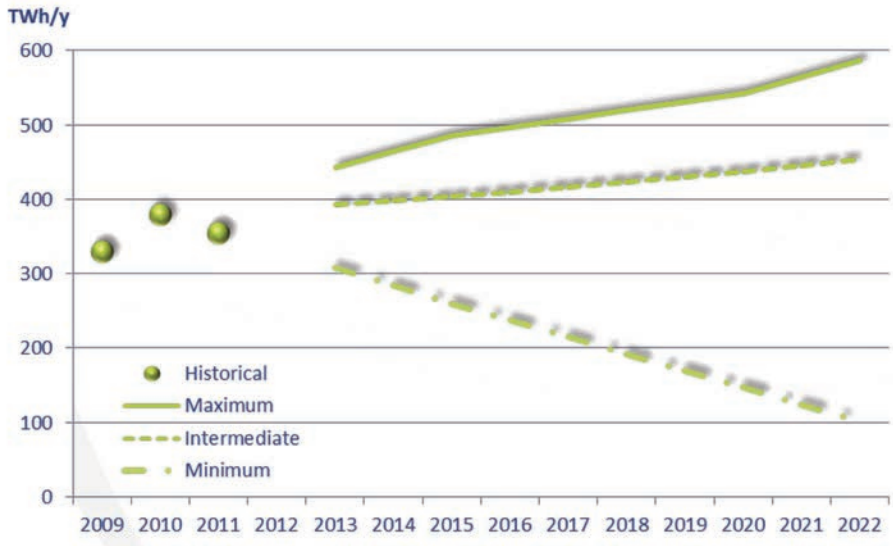


Figure 4.36.
Algerian potential pipeline supply

3.1.1.5. Libya

The potential supply range from Libya has been defined as follows:

- Maximum scenario: assuming a load factor of 95% on the import transmission capacity
- Intermediate scenario: assuming a load factor of 85% on the import transmission capacity.
- Minimum scenario: the minimum scenario has been estimated combining parameters from the Mott MacDonald analysis, taking the lowest values for gas production (pessimistic scenario for the export potential) and lowest values of local demand (more optimistic scenario for exports).

The different approach followed in the estimation of Libyan potential supplies, comes from the will of keeping the potential range within reasonable limits as, according to different data sources the potential export scenarios ranges from zero to 433 TWh/y, which was considered as too extreme.

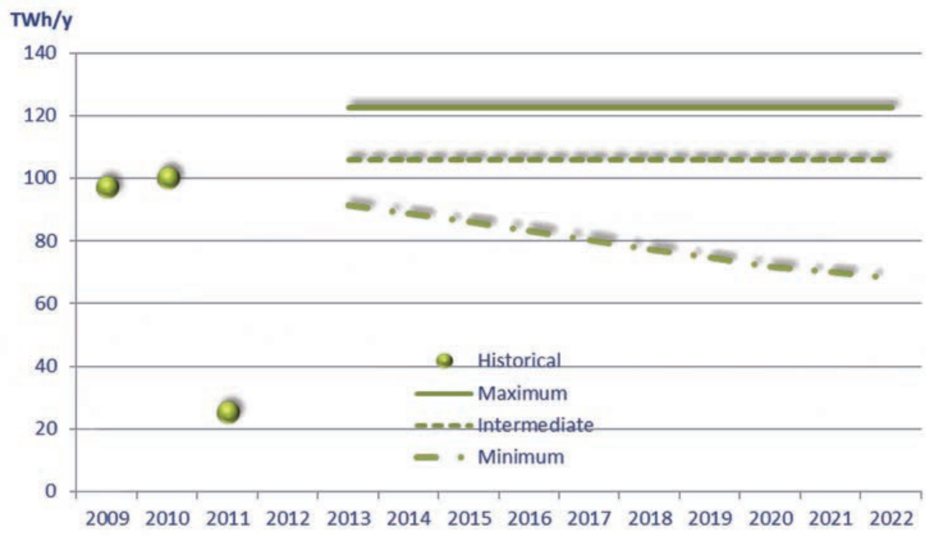


Figure 4.37.
Libyan potential pipeline supply

3.1.1.6. LNG

There is considerable uncertainty regarding the level of LNG supplies that will reach the European market in the future. There are many reasons for this, which include:

- The potential for significantly increased global liquefaction capacity going forward, for example the facilities under construction in Australia, proposals to export US gas as LNG and possible new LNG from Africa (Mozambique) and Russia
- Higher global LNG demand, particularly in the Far East
- Possible commissioning delays in both LNG liquefaction and regasification facilities
- Reduced production from existing LNG liquefaction facilities due to maintenance or potential supply shocks
- Lower LNG demand in other markets, for example in the US
- Inter-regional price variations. In some instances traded LNG would flow towards higher priced markets. Nevertheless, the continuity of some LNG flows to the original markets should be ensured by:
- the cost of shipping
- some need of the supplier to maintain diversity in the portfolio of customers
- contractual obligation in the short and long term
- Increasing volumes of gas traded internationally, both LNG and pipeline gas
- In the short term, uncertainty regarding LNG demand in Japan due to the level of nuclear generation returning.

The uncertainty regarding LNG supplies going forward is encapsulated in the changing US supply-demand position. Only a few years ago, with domestic gas production in decline, the US was predicted to be a significant importer of LNG in the future. Now, with developments in hydraulic fracturing and horizontal drilling, shale gas production has increased so significantly that the US could potentially become a significant exporter of LNG over the next decade and beyond. It is important that the scenarios show a broad range of supplies to reflect this ongoing uncertainty in LNG supply.

The approach taken was mixed:

The Minimum and Intermediate scenarios were calculated based on the aggregate load factors of send-out capacity for all LNG terminals within Europe based on the last three years of daily historical data and selecting the 20th and 50th percentiles. Clearly there is significant variation in the load factors between terminals and indeed from one year to the next, and future performance may be very different from that seen in the past.

- For the Minimum scenario, the 20th percentile load factor of LNG terminals for the period 2009 to 2011 (33%) is applied to the future send-out capacity for regasification projects with FID only.
- For the Intermediate scenario, the 50th percentile load factor of LNG terminals for the period 2009 to 2011 (39%) is applied to the future send-out capacity for regasification projects with FID and Non-FID.

For the Maximum scenario, ENTSOG has based the analysis on the Liquefaction capacity and the analysis of the LNG market, adopting the following formula:

Total Liquefaction Capacity by Basin x % Liquefaction Capacity Utilisation x % LNG coming from each Basin destined for the EU.

Applied parameters:

- Total Liquefaction Capacity by Basin: as detailed in "LNG journal June 2012"
- Shares of each Basin's production (for the EU):
  - Atlantic Basin: 60 %
  - Middle East: 35 %
  - Pacific Basin: 1%
- Liquefaction Capacity Utilisation: The utilisation factor of the liquefaction terminals was reduced to 80-85% in those years with a sharp increase in liquefaction capacity, recovering a common utilisation factor of 95% later on.

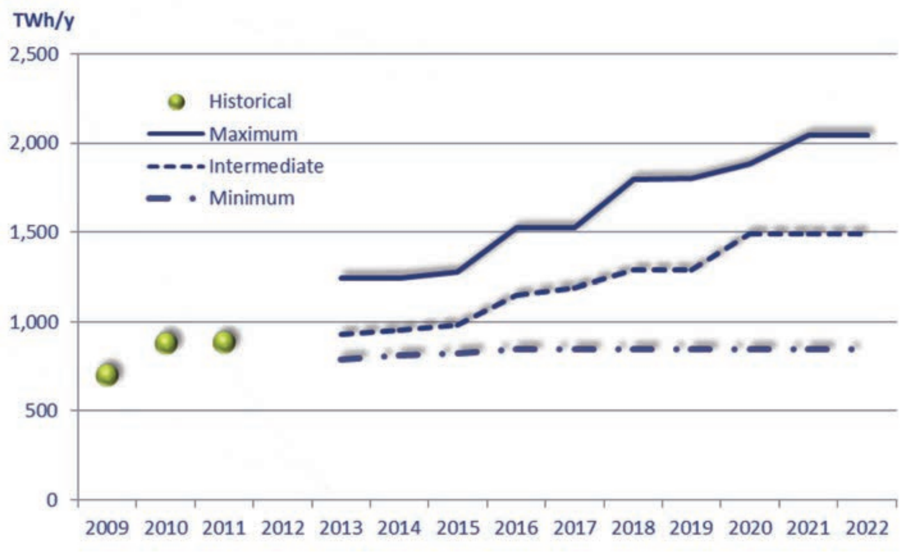


Figure 4.38.
LNG potential supply

3.1.1.7. Azerbaijan

ENTSOG considers only Azeri gas coming from Shah Deniz II. According to the provisions of the Intergovernmental Agreement (IGA) between Turkey and Azerbaijan signed on 7 June 2010 regarding the supply of gas to Turkey as well as transit of Azeri gas through Turkey, out of the 16 bcm yearly available from Shah Deniz II, 10 bcm would be allocated to Europe and 6 bcm for Turkey.

Nevertheless, part of the 6 bcm assigned to Turkey could end up in EU-27, therefore ENTSOG has defined the Maximum Potential Supply scenario as 16 bcm/y, keeping 10 bcm/y as the intermediate scenario, and considering the potential delay or cancelation of the project the minimum scenario has been classified as zero, given that Shah Deniz II has not taken the FID by the date of publication of this Report.

With regards to the date of commissioning, first gas could be available by the end of 2017 according to the information provided by the project promoter. ENTSOG has defined a ramp-up phase based on own estimations, having the project reaching the targeted volumes in 2020.

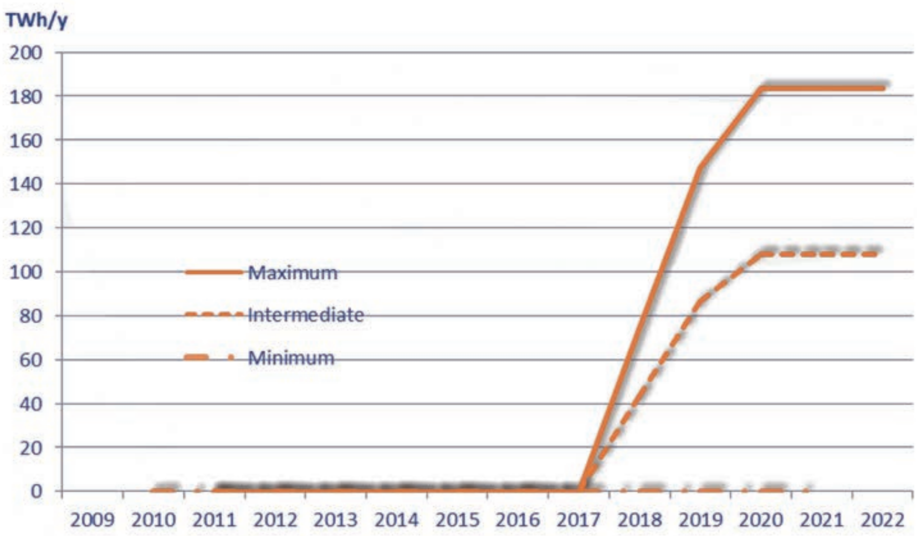


Figure 4.39.
Azerbaijan potential supply

3.1.2. Aggregate Supply Potential to Europe

The following graph shows the Intermediate Supply Potential for Europe based on the scenarios defined above. Based on the estimated scenarios the decrease in the indigenous production and the potential Norwegian imports are likely to be replaced by Russian supplies and LNG.

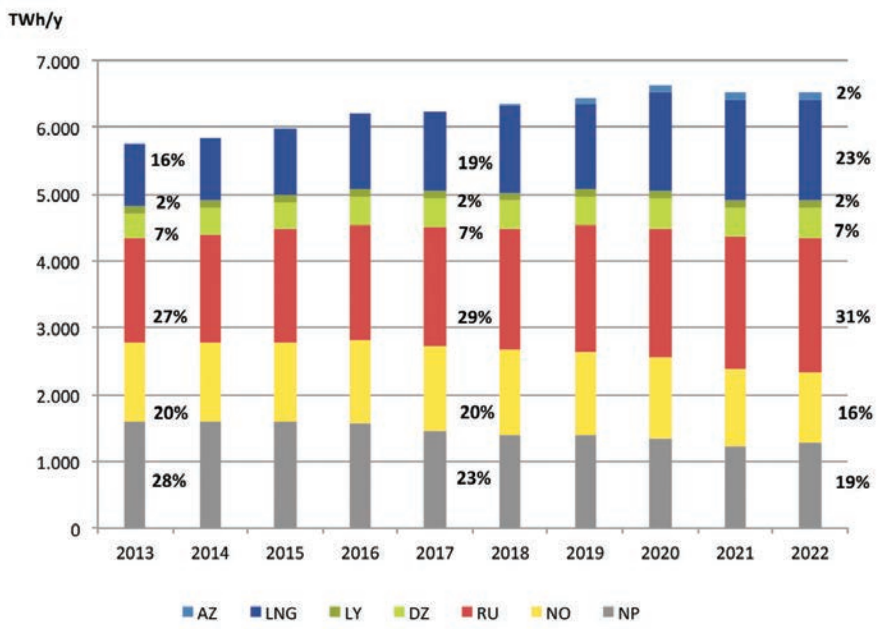


Figure 4.40.
Intermediate Supply Potential for Europe

The graph below shows the evolution of the spread between the Minimum and Maximum Potential Supply scenarios, highlighting the uncertainty in the LNG supply scenarios.

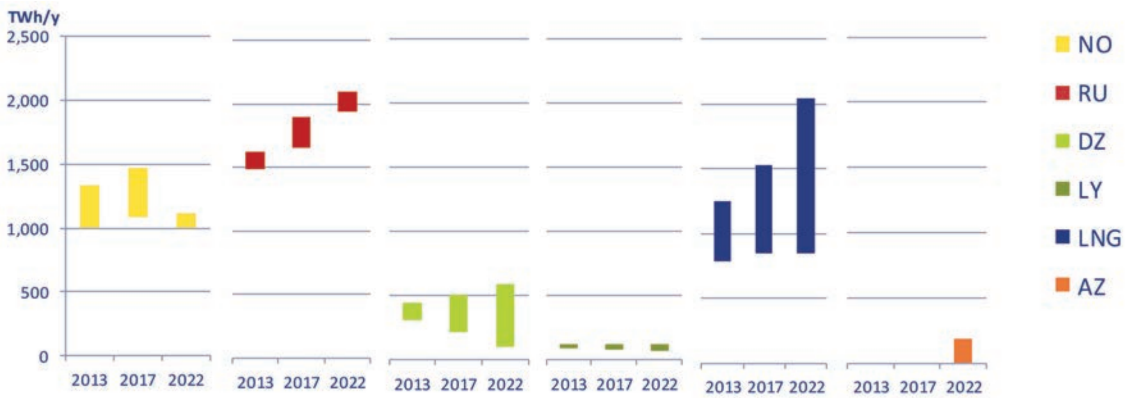


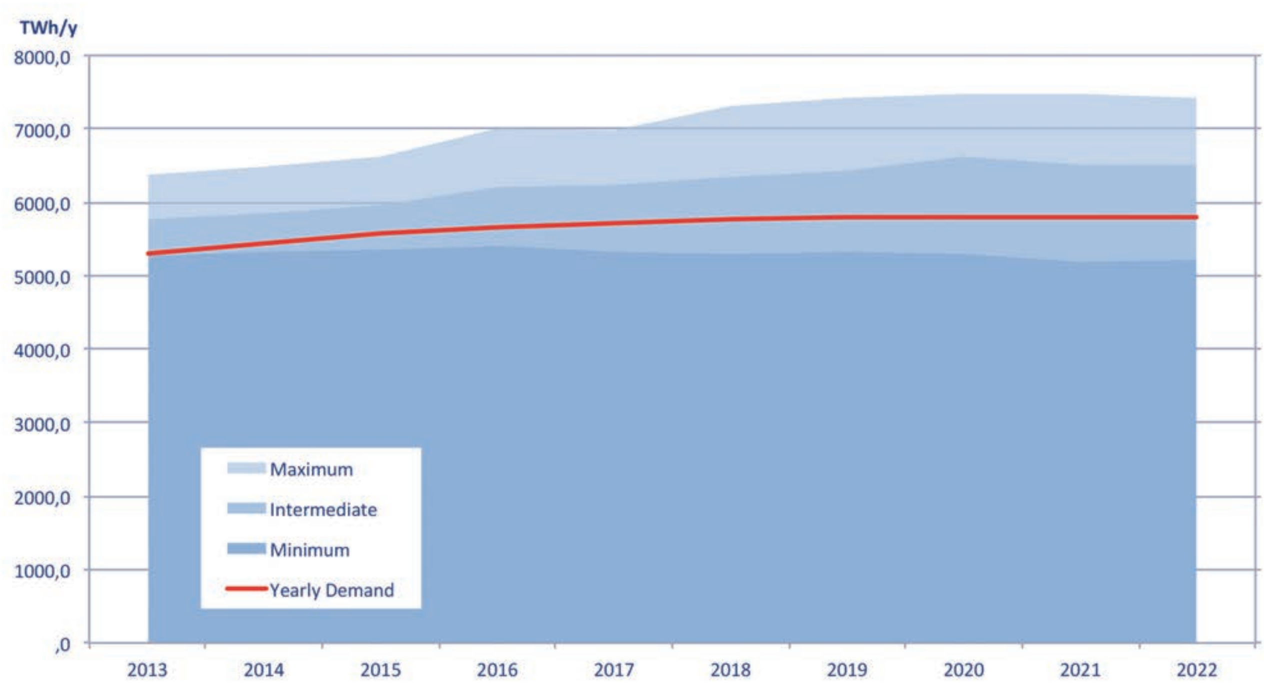
Figure 4.41.
Evolution of supply ranges – Spread between Maximum and Minimum potential scenarios by source

SUPPLY ADEQUACY OUTLOOK

The graph below presents the comparison of the three Potential Supply scenarios with the ENTSOG demand outlook.

The figures show that there may be significant supply flexibility, while the level of supply will depend on how the Supply Potential of the different sources is or is not developed. The evolution of this Supply Potential will be strongly influenced by the trend followed by the demand.

The balance as showed by this graph represents the yearly adequacy of the supply and demand scenarios. However, these figures must be translated into daily values to assess how this Supply Potential may get adapted to the seasonal modulation required for the demand coverage.



NOTE

Minimum: Aggregation of each minimum potential scenario by source (simultaneity of minimums)

Intermediate: Aggregation of each intermediate potential scenario by source (simultaneity of intermediates)

Maximum: Aggregation of each maximum potential scenario by source (simultaneity of maximums)

Figure 4.42.
Supply Adequacy Outlook 2013--2022

Assessment Results

GENERAL CONSIDERATION ON MODELLING RESULTS

ENTSOG has modelled the European gas system against various levels of supply and demand, and two different infrastructure clusters across the 10-year range. A full description of the cases considered can be found in the Methodology chapter (4.6.). Based on the resulting flow patterns, and as part of the Network Resilience assessment, ENTSOG has identified investment gaps which could have a negative impact on the ability of the respective Zones' infrastructure to sustain the supply-demand balance. Potential remedies mitigating those gaps have been identified where possible.

ENTSOG has tested the European gas system under various types of cases to analyse the Network Resilience, Supply Source Dependence, Infrastructure Adaptability to Supply Evolution and Supply Source Diversification, and give an indication of the level of Market Integration as enabled by gas infrastructure.

The modelling has been carried out using Entry/Exit Zones as basic blocks and cross-border capacity as the basic links between these blocks. Therefore the assessment is at cross-border level together with UGS and LNG terminals aggregated at Zone level. The gas infrastructure assessments included within this TYNDP, should be seen as a top-down European level assessment. Gas Regional Investment Plans (GRIPs) and National Plans can provide an additional level of detail, whilst consistent with the European assessment, they are able to identify additional investment needs considering regional specifics and within Zone networks.

INFRASTRUCTURE RESILIENCE ASSESSMENT

This part of the analysis focuses on testing the ability of the infrastructure to transport large quantities of gas under severe climatic conditions. In such situations, it is vital that high-level of supply is available on a short-term basis and the necessary infrastructures are in place to deliver the gas to the relevant markets.

This assessment is used for identification of investment gaps and potential remedies.

ENTSOG has defined two short periods of high daily demand conditions.

- a single day: in order to capture the situation of highest transported gas quantity (Design-Case Situation for consistence with National Plans and Uniform Risk Situation for a common occurrence)
- a 14-day period: in order to capture the impact of a multiple-day period on supply availability (mostly UGS and LNG terminals) and potential changes in required flow patterns (14-day Uniform Risk Situation).

For both periods, the assessment has first been carried out under Reference Case conditions, which means normal availability of supply sources and deliverability of gas infrastructures. The stress induced by the high level of demand has led to the identification of some investment gaps. Subsequently, as part of the sensitivity analysis, the European gas system has been assessed under Supply Stress conditions, namely a supply disruption or LNG minimisation on top of the Reference Case situations. These extreme cases resulted in additional investment gaps being identified.

As analysed in the Supply and Demand chapter (2.3.2. / 2.3.3.), demand levels of 1-day Design-Case and 1-day Uniform Risk Situations are very close. Following stakeholder feedback, both situations have been modelled on test cases. Strong similarity in the outputs had led ENTSOG to the decision to carry out the complete assessment only under the 1-day Design-Case and the 14-day Uniform Risk Situations as capturing a sufficient range of situations.

The identification of remedies, being infrastructure projects mitigating the found gaps, is done through the comparison of the assessments carried out on the FID Cluster and Non-FID Cluster cases under the same conditions.

2.1. Identification of investment gaps and remedies

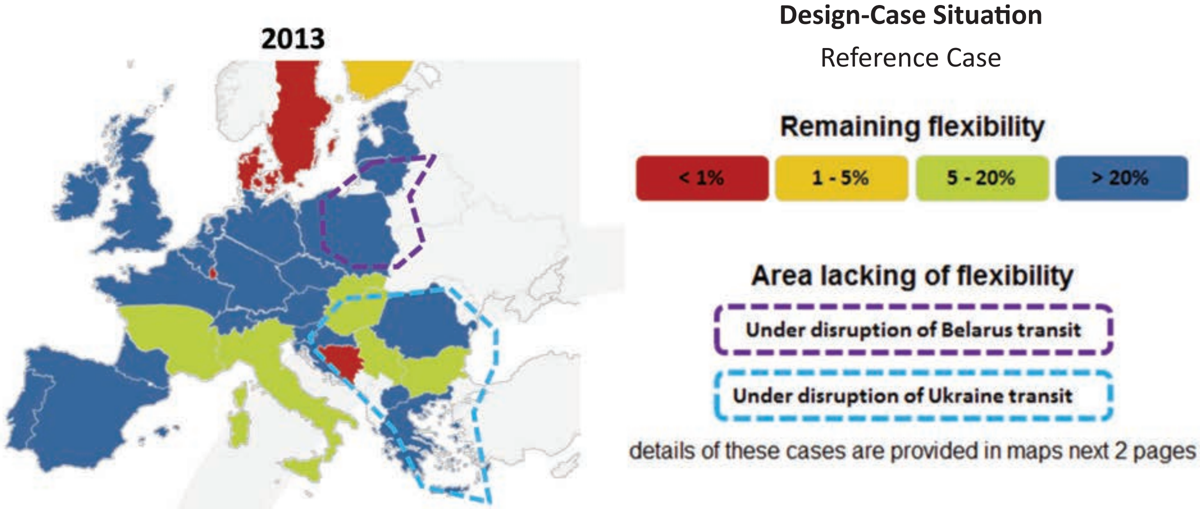
The following maps and tables identify investment gaps based on the areas lacking network flexibility when covering high demand situations. The Zones are defined according to the level of Remaining Flexibility (see Methodology chapter; 4.1.). For each Zone, the results are shown through a range of Remaining Flexibility, and, if applicable, the uncovered demand and the congested infrastructures. For the Non-FID cluster, the list of infrastructure projects helping mitigate the investment gap is also provided in a non-discriminatory way.

It should also be noted that compared to the ENTSOG Winter Supply Outlook 2012-13 released in November 2012, some Zones have slightly lower Remaining Flexibility as the deliverability of UGS has been reduced as explained in the Methodology chapter (4.1.).

Image courtesy of GASCADE

Figure 5.1. Infrastructure Resilience under Design-Case Situation

Reference Case



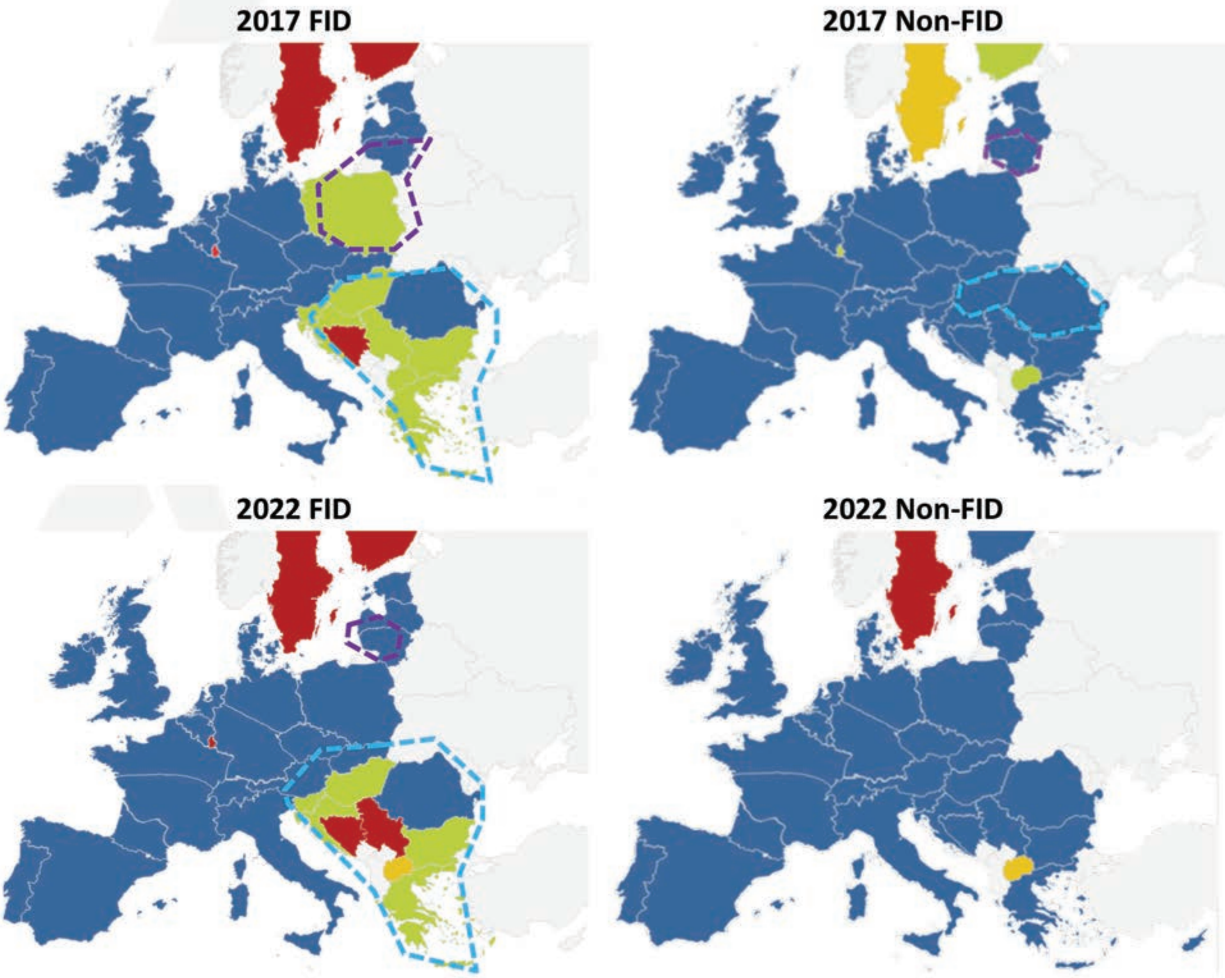
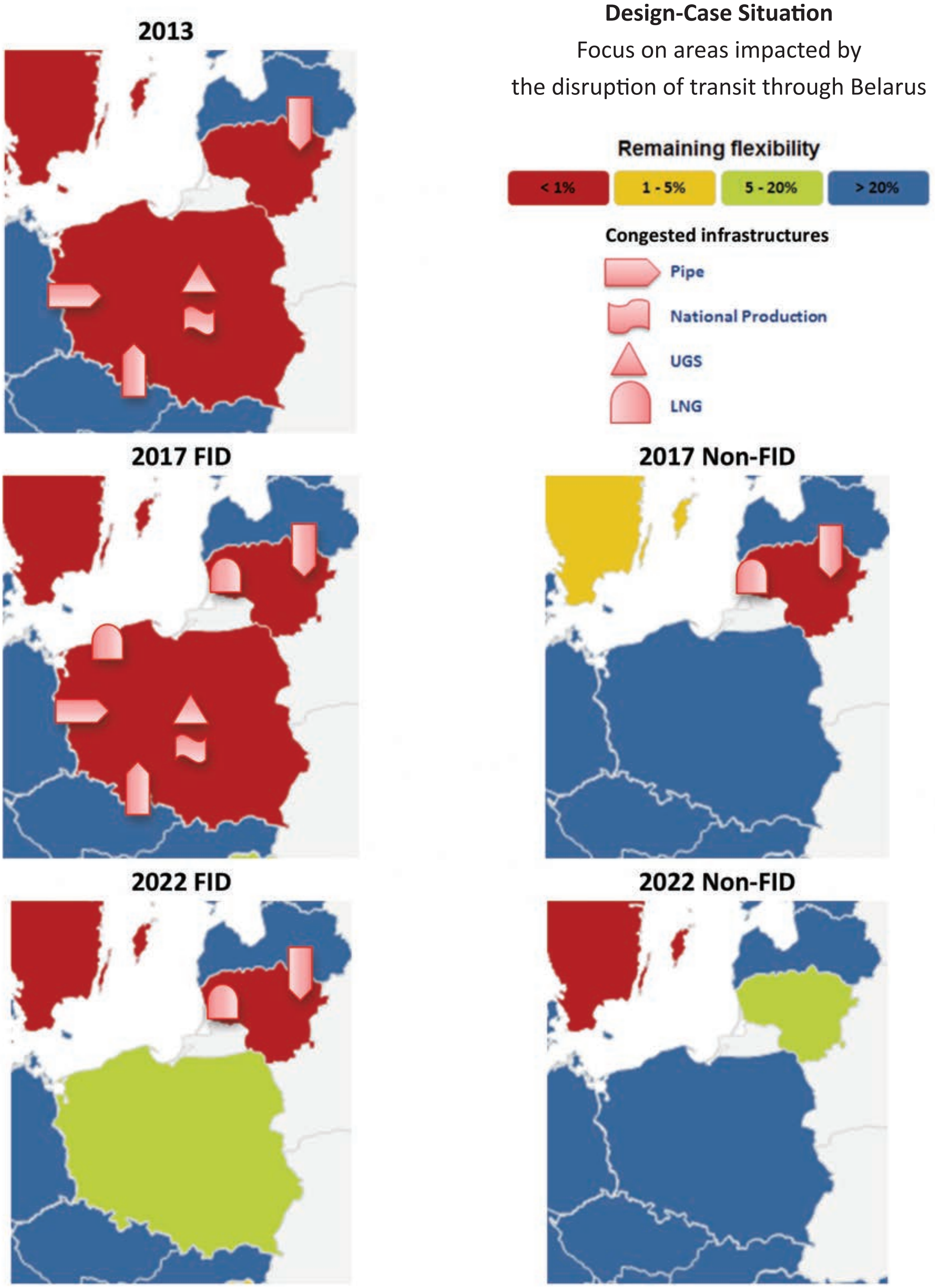


Figure 5.2. Infrastructure Resilience under Design-Case Situation

Focus on areas impacted by
the disruption of transit through Belarus



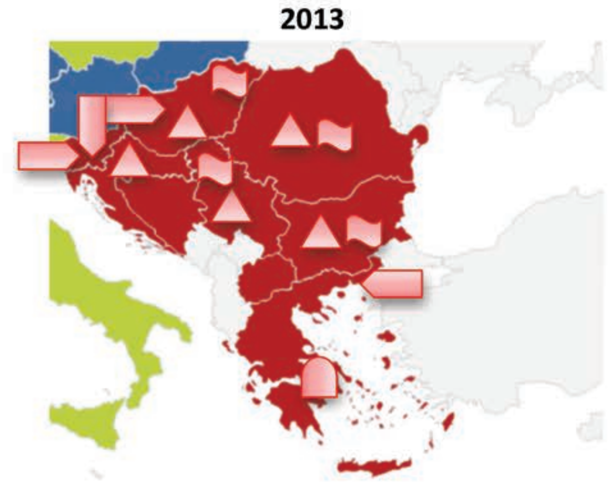
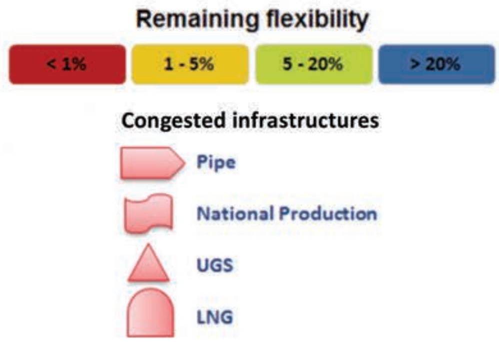
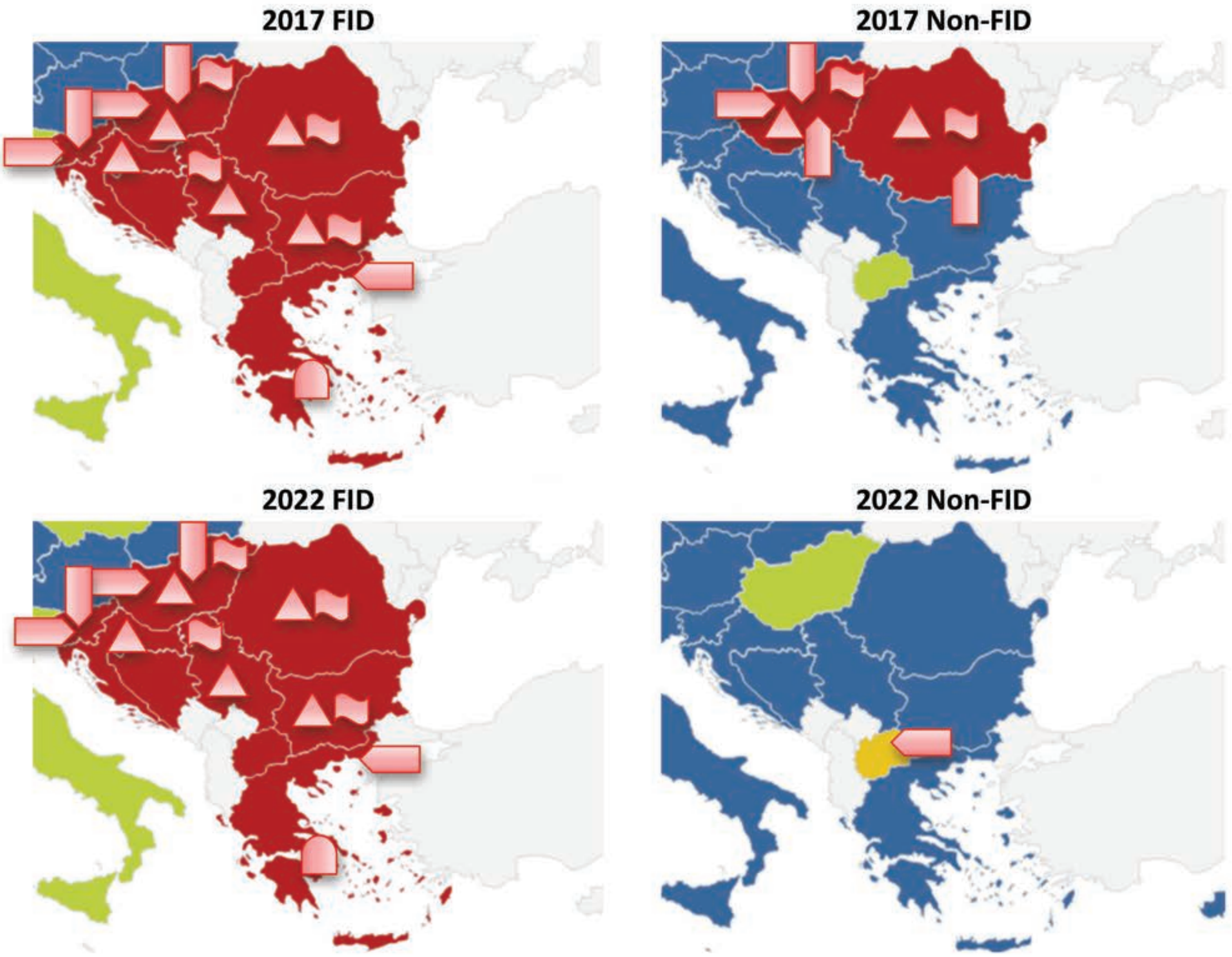


Figure 5.3. Infrastructure Resilience under Design-Case Situation

Focus on areas impacted by
the disruption of transit through Ukraine

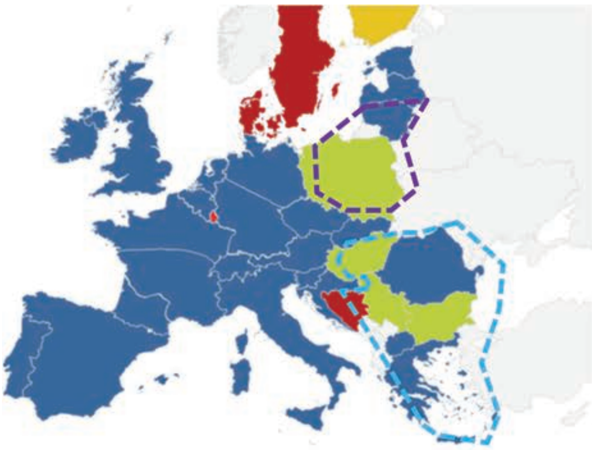


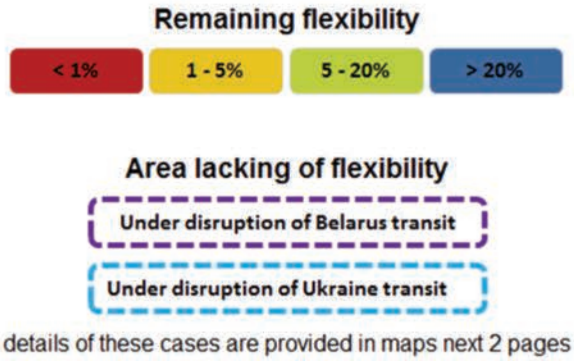


2013

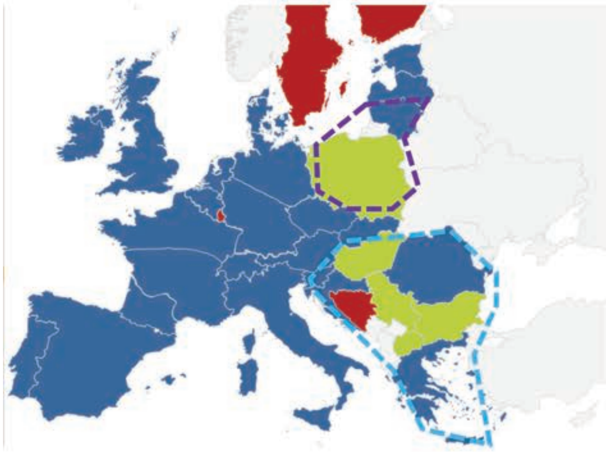
Figure 5.4. Infrastructure Resilience under 14-day Uniform Risk Situation

Reference Case

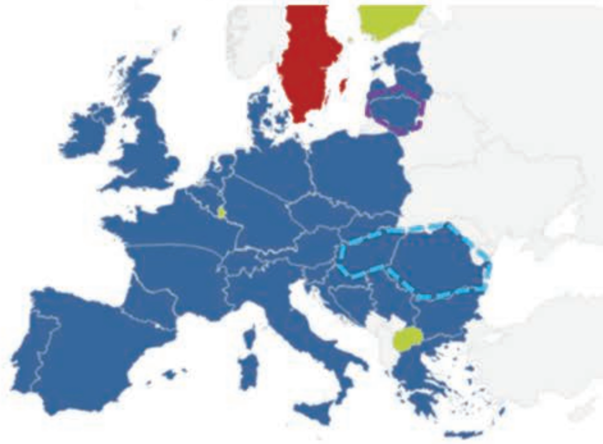




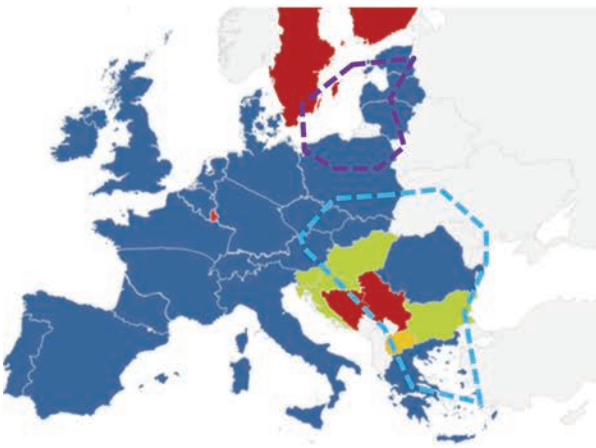
2017 FID



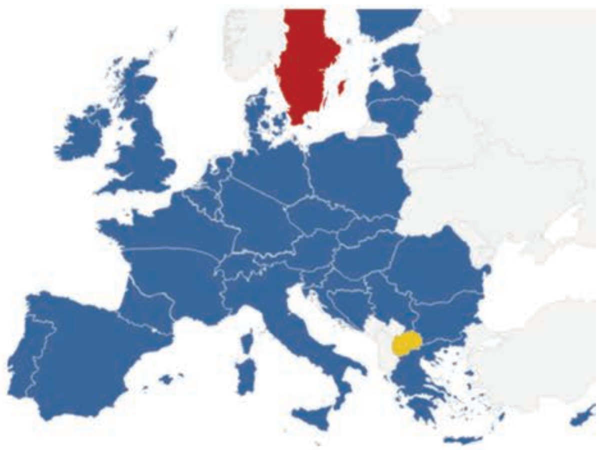
2017 Non-FID



2022 FID



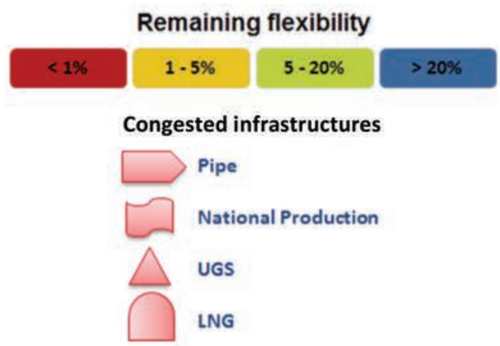
2022 Non-FID

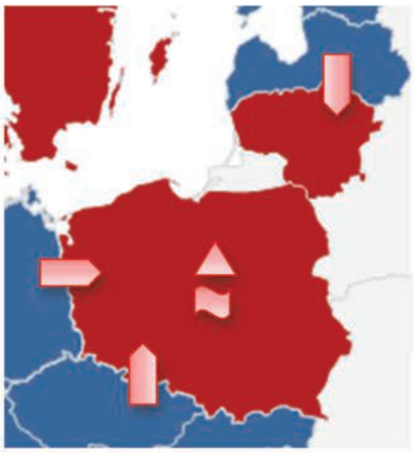


2013

Figure 5.5. Infrastructure Resilience under 14-day Uniform Risk Situation

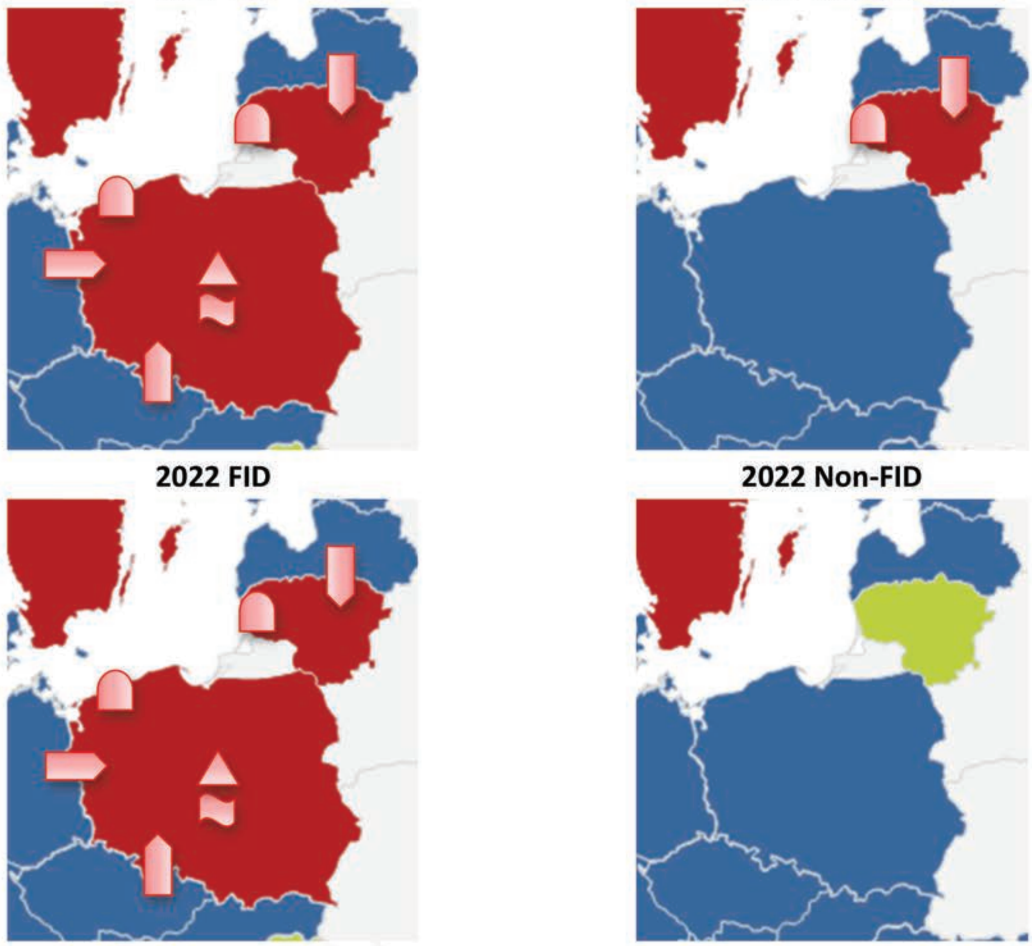
Focus on areas impacted by the disruption of transit through Belarus





2017 FID

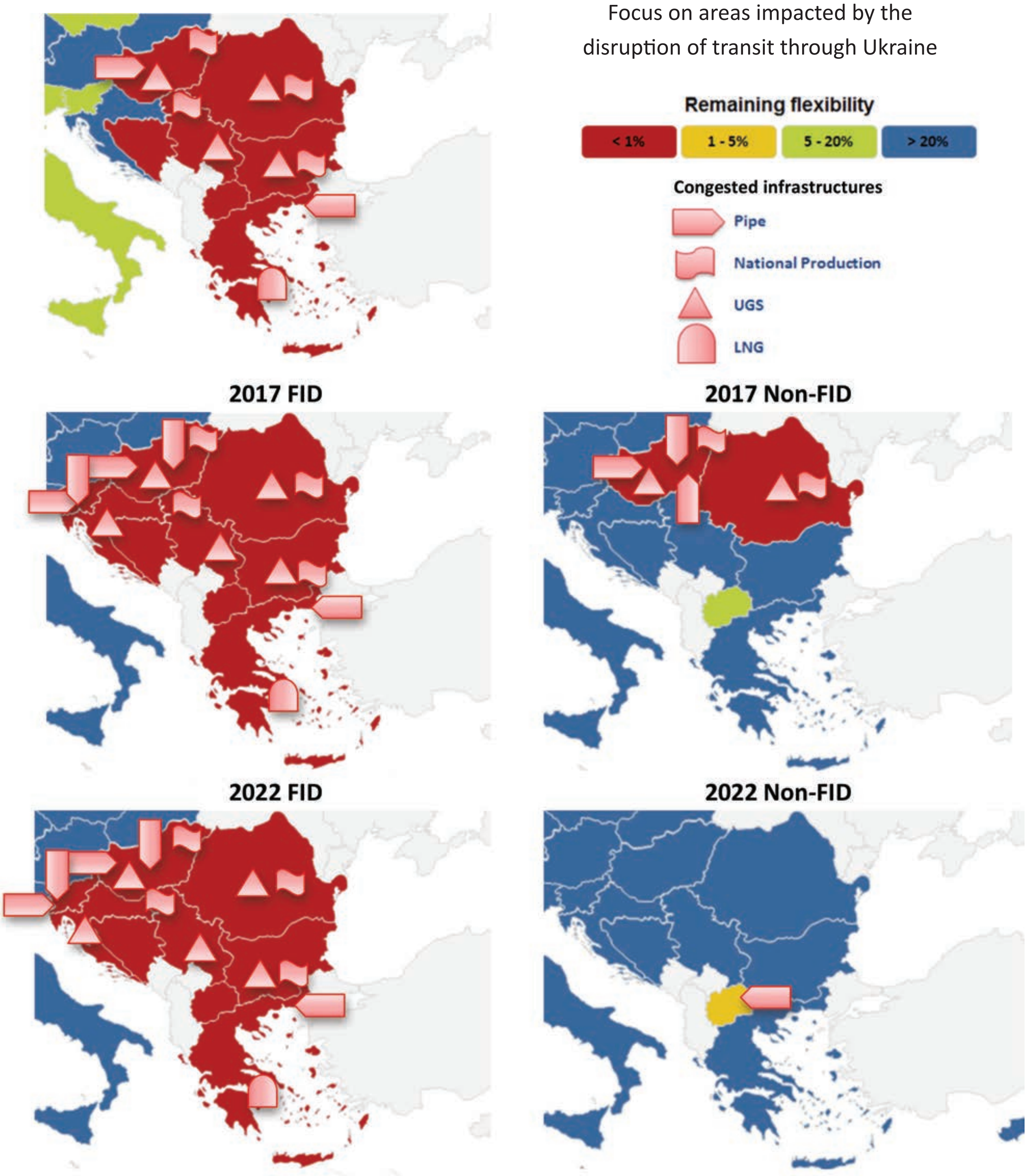
2017 Non-FID



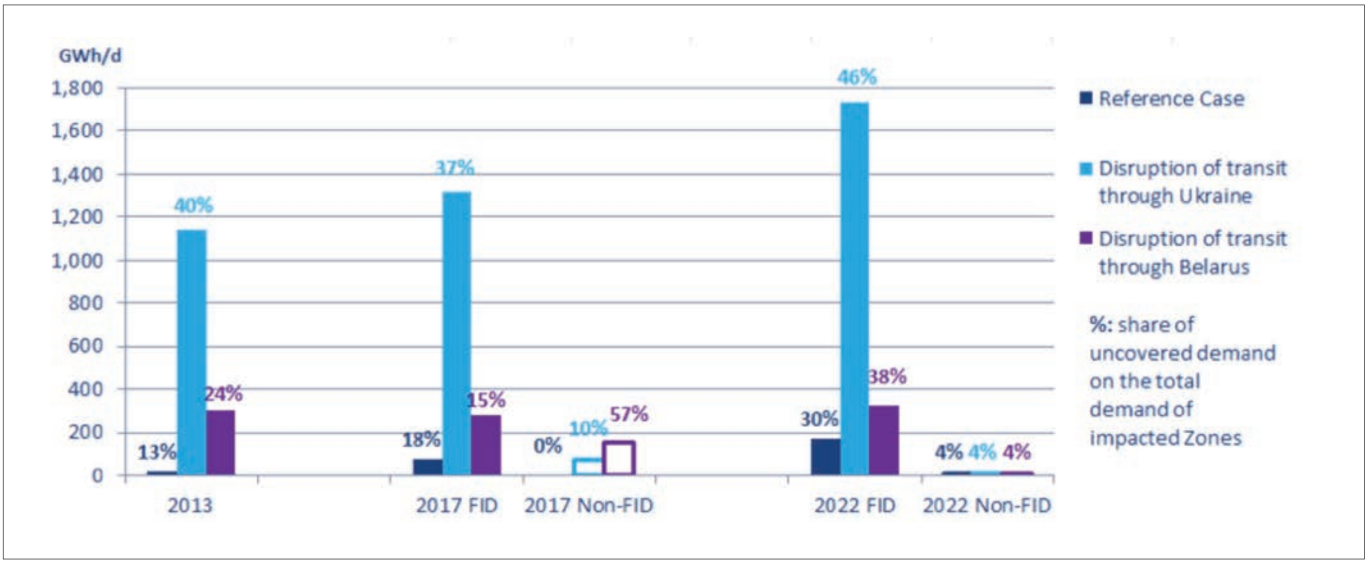
2013

Figure 5.6. Infrastructure Resilience under 14-day Uniform Risk Situation

Focus on areas impacted by the disruption of transit through Ukraine



The following graphs provide the aggregated amount of unfulfilled demand under the different cases and its relative share compared to the total demand of the impacted Zones. The FID projects are not sufficient to mitigate the parallel effect of gas demand increase and National Production decrease in the concerned Zones. The disruption of gas transit through Ukraine stays by far the supply event impacting the most on the European gas system. Such impact may be strongly mitigated by the implementation of Non-FID projects.

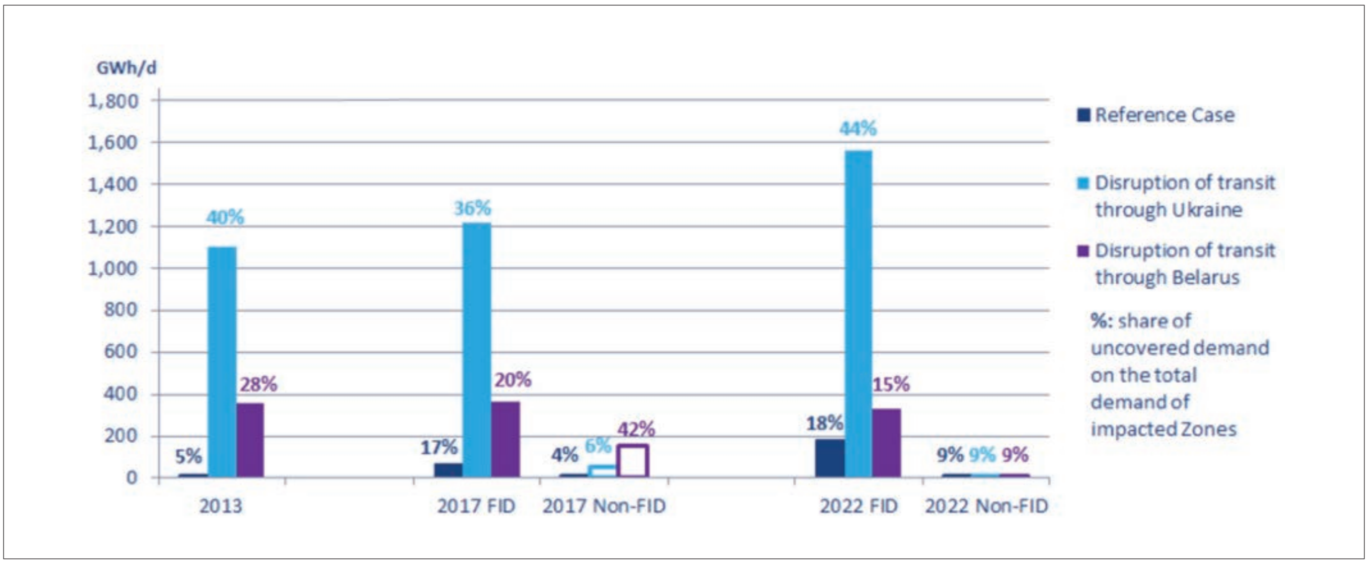


Impacted Countries

Cases	2013		2017 FID	2017 Non-FID		2022 FID	2022 Non-FID
Reference Case	BH, DK, SE & LU		BH, FI, SE & LU	None		BH, FI, SE, LU & RS	SE
UA disruption	Ref. Case + BG, MK, GR, HR, HU, RO, RS & SI		Ref. Case + BG, MK, GR, HR, HU, RO, RS & SI	Ref. Case + HU & RO		Ref. Case + BG, MK, GR, RO, HR, HU & SI	Ref. Case
BY disruption	Ref. Case + PL & LT		Ref. Case + PL & LT	Ref. Case + LT		Ref. Case + LT	Ref. Case

Figure 5.7.
Uncovered demand under Design-Case Situation

For example, in 2013 Reference Case, impacted countries are Bosnia-Herzegovina, Denmark, Sweden and Luxembourg whose overall demand amounts to 166 GWh/d and uncovered demand amounts to 21 GWh/d, which is 13% of the total demand of those countries.



Impacted Countries

Cases	2013		2017 FID	2017 Non-FID		2022 FID	2022 Non-FID
Reference Case	BH, DK, SE & LU		BH, FI, SE & LU	SE		BH, FI, SE, LU & RS	SE
UA disruption	Ref. Case + BG, MK, GR, HU, RO & RS		Ref. Case + BG, MK, GR, HR, HU, RO, RS & SI	Ref. Case + HU & RO		Ref. Case + BG, MK, GR, RO, HR, HU & SI	Ref. Case
BY disruption	Ref. Case + PL & LT		Ref. Case + PL & LT	Ref. Case + LT		Ref. Case + PL & LT	Ref. Case

Figure 5.8.
Uncovered demand under 14-day Uniform Risk Situation

In parallel to the above maps and graphs, the tables below identify investment gaps and the potential remedies from all the Non-FID infrastructure projects submitted to ENTSOG (Annex A) and their impact on Remaining Flexibility.

Gaps and remedies are first identified under the Design-Case Situation and then under the 14-day Uniform Risk Situation for both Reference Case and Supply Stress cases.

The focus is on direct remedies increasing the cross-border capacity of impacted Zones (from another European Zone or directly from a supply source), and UGS and LNG facilities directly connected to these Zones. Other projects, not directly connected to the impacted Zones, may also increase the potential offered by existing infrastructures and direct remedies.

The identification of projects shall not be considered as any kind of selection as individual impacts are not measured. Infrastructure project codes refer to the code given to projects in Annex A.

Table 5.1.

Investment gaps and the potential remedies and their impact on Remaining Flexibility in Design-Case Situation

DESIGN-CASE SITUATION

2013

Zones	FID Cluster		Non-FID Cluster	
	Rem. Flex.	Congested infrastructures	Projects contributing to gap mitigation	Rem. Flex.
Reference Case				
BH	<1%	RS>BH		
DK	<1%	DEg>DK, DEn>DK & DK>SE		
SE		UGS>DK, SE		
FI	1-5%	RU>FI		
LU	<1%	BE>LU & DEn>LU		
Additional investment gaps under Supply Stress RU-BY				
LT	<1%	LV>LT		
PL	<1%	DEg>PL, CZ>PL UGS>PL LNG>PL		
Additional investment gaps under Supply Stress RU-UA				
BG	<1%	AT>HU, AT>SI, IT>SI, TR>GR		
MK				
GR		UGS>HR, HU, RO, RS & BG		
HR				
HU		LNG>GR		
RO				
RS				
SI				

2017

Zones	FID Cluster		Non-FID Cluster	
	Rem. Flex.	Congested infrastructures	Projects contributing to gap mitigation	Rem. Flex.
Reference Case				
BH	<1%	RS>BH	TRA-N-066 (HR) & 187 (S. Stream)	>20%
FI	<1%	RU>FI	TRA-N-023 & 072 (EE)	5-20%
LU	<1%	BE>LU & DEn>LU	TRA-N-206 (BE)	5-20%
SE	<1%	DK>SE	LNG-N-032 (SE)	<1%
Additional investment gaps under Supply Stress RU-BY				
LT	<1%	LV>LT LNG>LT		<1%
PL	<1%	DEg>PL & CZ>PL UGS>PL LNG>PL	TRA-N-190 & 275 (SK), 274 (DEg) & 276 (Yamal)	>20%
Additional investment gaps under Supply Stress RU-UA				
BG	<1%	AT>HU, AT>SI, IT>SI, SK>HU & TR>GR UGS>HR, HU, RO, RS & BG LNG>GR	TRA-N-140 (TR>BG), 187 (S. Stream>BG), 107 (IT-SI) TRA-N-137 (RS-BG), 149 & 188 (BG-GR), 126 & 132 (RO-HU), 090 (HR-SI), 098 (HU-SI) UGS-N-138 (BG), 209 (HU), 234 (HU) & 233 (RO) LNG-N-062 (GR), 082 (HR) & 129 (GR)	>20%
MK				5-20%
GR				>20%
HR				>20%
HU				<1%
RO				
RS				>20%
SI				>20%

2022

Zones	FID Cluster		Non-FID Cluster	
	Rem. Flex.	Congested infrastructures	Projects contributing to gap mitigation	Rem. Flex.
Reference Case				
BH	<1%	HU>RS	TRA-N-066 (HR), 187 (S. Stream) & 068 (IAP)	>20%
RS		RS>BH	TRA-N-00 (BG, South Stream)	>20%
FI	<1%	RU>FI	TRA-N-023 & 072 (EE) LNG-N-024 (FI)	>20%
MK	1-5%	BG>MK		1-5%
LU	<1%	BE>LU & DEn>LU	TRA-N-013 (FRn), TRA-N-206 (BE)	>20%
SE	<1%	DK>SE	LNG-N-032 (SE)	<1%
Additional investment gaps under Supply Stress RU-BY				
LT	<1%	LV>LT LNG>LT	TRA-N-131 (LV) & 212 (PL) UGS-N-034 (LT) & 219 (PL)	5-20%
Additional investment gaps under Supply Stress RU-UA				
BG	<1%	AT>HU, AT>SI, IT>SI, SK>HU & TR>GR UGS>HU, RO, BG, HR & RS LNG>GR	TRA-N-140 (TR>BG), 187 (S. Stream>BG), 078 (Nabucco), 128 (TR>GR), 054 & 189 (CY>GR), 010 (Poseidon), 051 (TAP), 053 (W. Stream), 068 (IAP), 107 (IT-SI) TRA-N-137 (RS-BG), 149 & 188 (BG-GR), 126 & 132 (RO-HU), 090 & 101 & 114 (HR-SI), 098 (HU-SI) UGS-N-138 (BG), 209 (HU), 234 (HU), 233 (RO), 076 (GR) & 080 (GR) LNG-N-062 (GR), 082 (HR) & 129 (GR)	>20%
GR				>20%
RO				>20%
HR				>20%
HU				5-20%
SI				>20%

Table 5.2.
Investment gaps and the potential remedies and their impact on Remaining Flexibility in 14-day Uniform Risk Situation

14-DAY UNIFORM RISK SITUATION

2013

Zones	FID Cluster		Non-FID Cluster	
	Rem. Flex.	Congested infrastructures	Projects contributing to gap mitigation	Rem. Flex.
Reference Case				
BH	<1%	RS>BH		
DK	<1%	DEg>DK, DEn>DK & DK>SE		
SE		UGS>DK, SE		
FI	1-5%	RU>FI		
LU	<1%	BE>LU, DEn>LU		
Additional investment gaps under Supply Stress RU-BY				
LT	<1%	LV>LT		
PL	<1%	DEg>PL, CZ>PL UGS>PL		
Additional investment gaps under Supply Stress RU-UA				
BG	<1%	AT>HU & TR>GR		
MK				
GR		UGS>HU, RO, RS & BG		
HU				
RO		LNG>GR		
RS				

2017

Zones	FID Cluster		Non-FID Cluster	
	Rem. Flex.	Congested infrastructures	Projects contributing to gap mitigation	Rem. Flex.
Reference Case				
BH	<1%	RS>BH	TRA-N-066 (HR) & 187 (S. Stream)	>20%
FI	<1%	RU>FI	TRA-N-023 & 072 (EE)	5-20%
LU	<1%	BE>LU & DEn>LU	TRA-N-206 (BE)	5-20%
SE	<1%	DK>SE	LNG-N-032 (SE)	1-5%
Additional investment gaps under Supply Stress RU-BY				
LT	<1%	LV>LT LNG>LT		<1%
PL	<1%	DEg>PL, CZ>PL UGS>PL LNG>PL	TRA-N-190 & 275 (SK), 274 (DEg) & 276 (Yamal)	>20%
Additional investment gaps under Supply Stress RU-UA				
BG	<1%	AT>HU, AT>SI, IT>SI, SK>HU & TR>GR UGS>HR, HU, RO, RS & BG LNG>GR	TRA-N-140 (TR>BG), 187 (S. Stream>BG), 107 (IT-SI) TRA-N-137 (RS-BG), 149 & 188 (BG-GR), 126 & 132 (RO-HU), 090 (HR-SI), 098 (HU-SI) UGS-N-138 (BG), 209 (HU), 234 (HU) & 233 (RO) LNG-N-062 (GR), 082 (HR) & 129 (GR)	>20%
MK				5-20%
GR				>20%
HR				>20%
HU				<1%
RO				
RS				>20%
SI				>20%

2022

Zones	FID Cluster		Non-FID Cluster	
	Rem. Flex.	Congested infrastructures	Projects contributing to gap mitigation	Rem. Flex.
Reference Case				
BH	<1%	HU>RS RS>BH	TRA-N-066 (HR), 187 (S. Stream) & 068 (IAP)	>20%
RS	<1%		TRA-N-00 (BG, South Stream)	>20%
FI	<1%	RU>FI	TRA-N-023 & 072 (EE) LNG-N-024 (FI)	>20%
MK	<1-5%	BG>MK		<1-5%
LU	<1%	BE>LU & DEn>LU	TRA-N-013 (FRn), TRA-N-206 (BE)	>20%
SE	<1%	DK>SE	LNG-N-032 (SE)	<1%
Additional investment gaps under Supply Stress RU-BY				
LT	<1%	LV>LT LNG>LT	TRA-N-131 (LV) & 212 (PL) UGS-N-034 (LT)	5-20%
PL	<1%	DEg>PL, CZ>PL UGS>PL LNG>PL	TRA-N-190 & 275 (SK), 274 (DEg) & 276 (Yamal), 271 (DK), 136 & 273 (CZ) UGS-N-219 (PL) LNG-N-272 (PL)	>20%
Additional investment gaps under Supply Stress RU-UA				
BG	<1%	AT>HU, AT>SI, IT>SI, SK>HU & TR>GR UGS>HU, RO, BG, HR & RS LNG>GR	TRA-N-140 (TR>BG), 187 (S. Stream>BG), 078 (Nabucco), 128 (TR>GR), 054 & 189 (CY>GR), 010 (Poseidon), 051 (TAP), 053 (W. Stream), 068 (IAP), 107 (IT-SI) TRA-N-137 (RS-BG), 149 & 188 (BG-GR), 126 & 132 (RO-HU), 090 & 101 & 114 (HR-SI), 098 (HU-SI) UGS-N-138 (BG), 209 (HU), 234 (HU), 233 (RO), 076 (GR) & 080 (GR) LNG-N-062 (GR), 082 (HR) & 129 (GR)	>20%
GR				>20%
RO				>20%
HR				>20%
HU				>20%
SI				>20%

2.2. Reference Case results

The Design-Case Situation and 14-day Uniform Risk Situation produce very similar results in terms of investment gaps and remedies. Under both situations, the Reference Cases show the persistent effect of the lack of decided projects around the Baltic Sea (Sweden and Finland), the Balkans (Bosnia-Herzegovina, Serbia and FYROM) and in Luxembourg. For all countries except for Sweden and FYROM, Non-FID projects exist that completely mitigate the highlighted investment gaps.

As in ENTSOG TYNDP 2011-2020, under the Reference Cases for the FID Cluster, the overall Remaining Flexibility improves during the first 5 years. The difference compared to the last edition is that this improvement remains in the other 5 years due to more FID projects and lower demand.

2.3. Disruption Case results

The disruption of gas transit through Belarus impacted two countries (Poland and Lithuania), however the impact of gas transit through Ukraine has wider regional dimension. As in the previous ENTSOG TYNDP, sufficient number of Non-FID infrastructure projects has been submitted to ENTSOG to totally mitigate both disruptions (except for Lithuania where the situation is marginally improved).

The main differences identified under the 14-day Uniform Risk Situation compared to the Design-Case one are:

- Identification of investment gap in Poland under the disruption of gas transit through Belarus in the 2022 FID Cluster
- Mitigation of the Slovenian and Croatian investment gap under the disruption of gas transit through Ukraine in the 2013 FID Cluster

In the first case, the gap derives from the decreased deliverability of UGS and LNG terminal which are an important component of the Polish supply-demand balance. In the second one, the mitigation comes from the positive effect of lower demand levels in countries whose reliance on UGS is relatively low.

The other considered disruptions (Transmed, MEG, Langeled, Franpipe and Green Stream) do not lead to a significant decrease of Remaining Flexibility in any Zone compared to the Reference Cases (no additional Zones have their flexibility moving below 1%). Given the results of the Transmed disruption, the Green Stream one has not been modelled as its capacity is approximately three time lower.

2.4. Evolution of storage and LNG terminal use as last resort supply

The evolution of demand and supply over the 10 years impacts the quantity of gas required to come from the last resort supply (UGS and the storage component of LNG terminals).

The graphs below show the amount of gas needed from the supply of last resort (not considering the part of LNG considered as import which is determined as the Average Daily Supply based on the last 3 years plus 10% to factor in the seasonal (winter) swing). The graphs show the amount of gas required under the Reference Case and the additional amount of gas required under the largest disruption event compared against the total available infrastructure capacity.

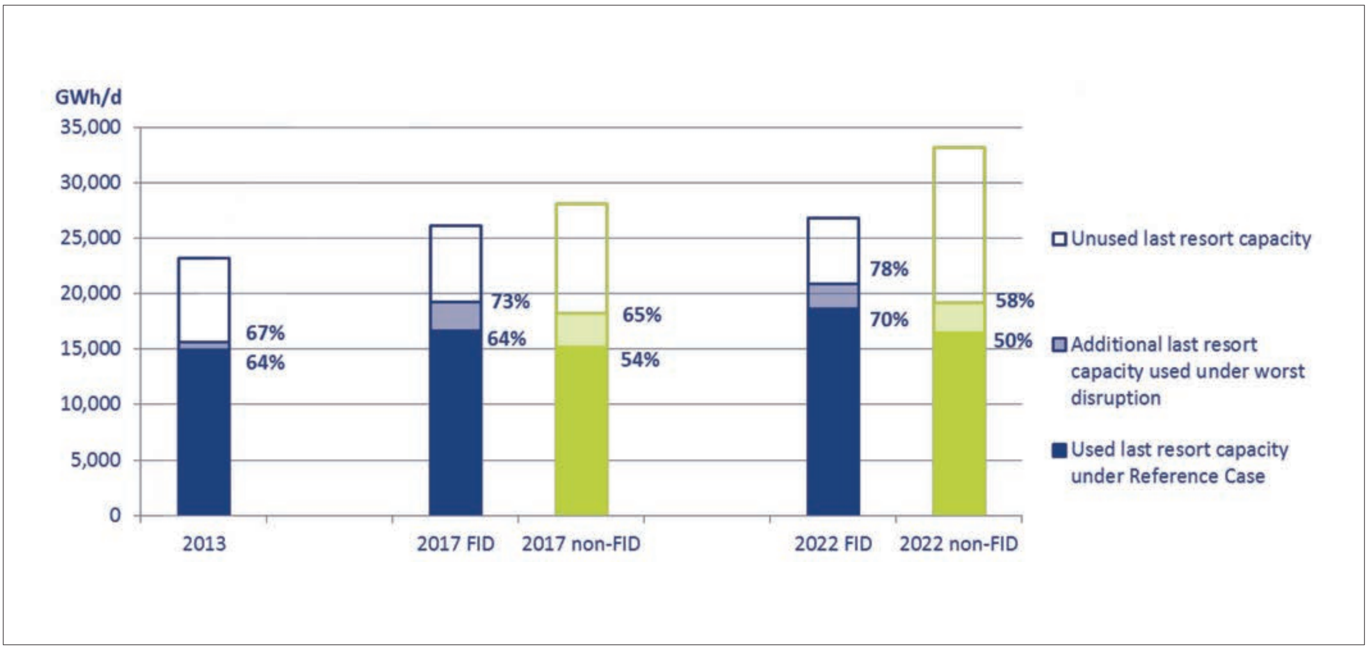


Figure 5.9.
The amount of gas needed from the supply of last resort under Design-Case Situation

Under Reference Case conditions for the FID Cluster, the future increase of demand is not fully balanced by additional imports, resulting in an increased use of last resort supply on the 10-year range both in absolute and relative terms. For the Non-FID Cluster, the situation differs with new import projects keeping the need of last resort supply stable in absolute terms. The commissioning of new UGS and LNG projects increase the total deliverability leading to a lower load factor requirement.

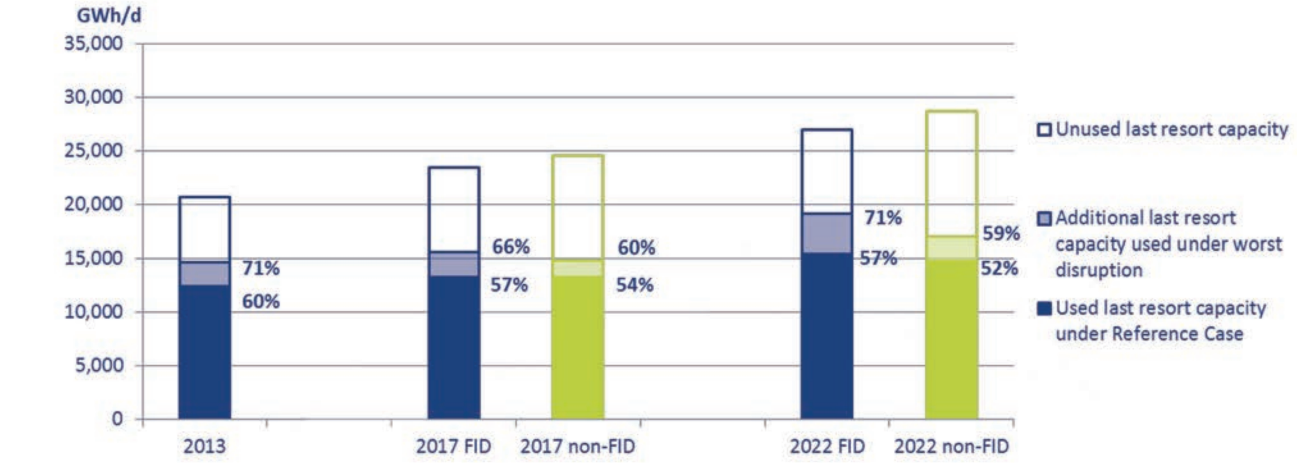


Figure 5.10.
The amount of gas needed from the supply of last resort under 14-day Uniform Risk Situation

In the 14-day Situations the overall demand is lower but so is the UGS and LNG deliverability. The overall evolution is similar to the Design-Case Situations but of a lower magnitude.

2.5. European resilience to low LNG delivery

Due to the globalised market place for LNG, ENTSOG has decided to provide a view of what the impacts would be if LNG were not to reach Europe. The maps below illustrate the minimum send-out of LNG terminals under Design-Case and 14-day Situations. Zones having direct access to LNG are identified with a specific pictogram. Such simulations also provide information on the impact of local events as the technical disruption of the single LNG terminal of a country impacting the send-out, or some climatic conditions impacting LNG delivery to the terminals.

Only four regions require an LNG send-out above 20% utilisation (considered as a lower technical limit):

- Iberian Peninsula; in order to supplement the maximum use of Algerian pipe supplies and interconnection with TIGF Zone
- Sweden; as capacity from Denmark and limited biogas production cannot match the demand
- Greece; in order to supplement the maximum use of Turkish pipe supplies and interconnection with Bulgaria
- Malta; as LNG is the only supply source

It can be concluded that the resilience of European gas system to low delivery of LNG is excellent and some transmission and UGS Non-FID projects should help improve it. Development of LNG terminals in Europe should not increase its dependency to this supply but rather offer alternative supply to face high daily demand situations.

Figure 5.11. Resilience to low LNG delivery under Design-Case Situation

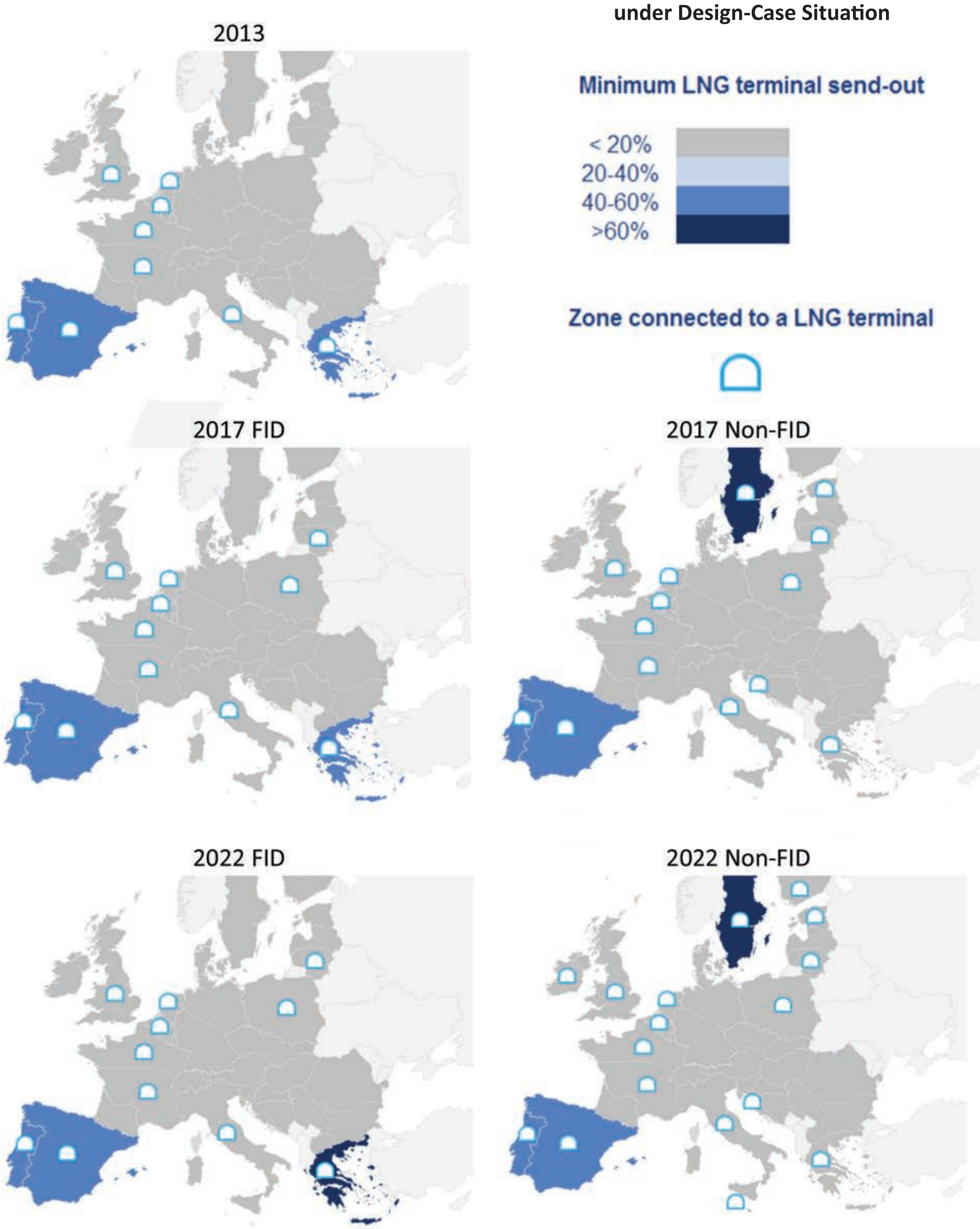
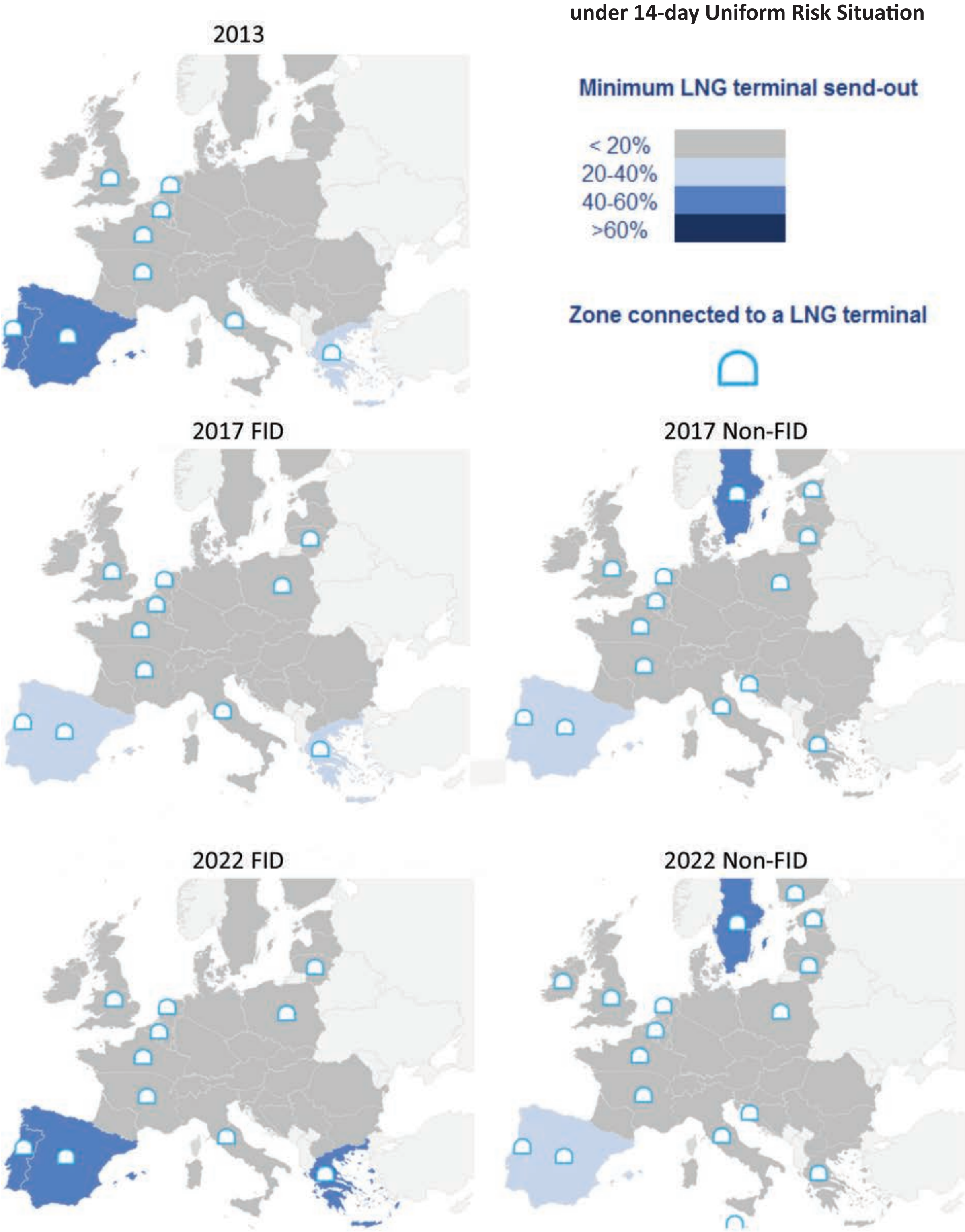


Figure 5.12. Resilience to low LNG delivery under 14-day Uniform Risk Situation



SUPPLY SOURCE DEPENDENCE ASSESSMENT

Supply Source Dependence assessment aims at the identification of Zones whose balance depends strongly on a single supply source. This is investigated under average demand conditions to capture the yearly character of the analysis.

This assessment is composed of:

- The identification of investment gaps persisting under Average Demand Situations
- The identification of Zones where balance relies strongly on a single source

3.1. Identification of investment gaps persisting under Average Demand Situations

Some investment gaps identified under High Daily Demand Situations persist under Average Daily Demand. Such gaps are given in the table below.

AVERAGE DAY – REFERENCE CASE

Zones	FID Cluster		Non-FID Cluster	
	Rem. Flex.	Congested infrastructures	Projects contributing to gap mitigation	Rem. Flex.
2013				
SE, DK	<1%	DEg>DK, DEn>DK & DK>SE		
2017				
BH	<1%	RS>BH	TRA-N-066 (HR) & 187 (S. Stream)	>20%
2022				
BH	<1%	RS>BH	TRA-N-066 (HR), 187 (S. Stream) & 068 (IAP)	>20%
SE, DK	<1%	DEg>DK, DEn>DK & DK>SE	TRA-N-218 (NO), 232 (DEg) and 271 (PL) LNG-N-032 (SE)	>20%

Table 5.3.
Investment gaps persisting under Average Demand Situation

It has to be noted that the balance of Denmark and Sweden is currently ensured through the interruptible and short -term firm capacity offered from Germany to Denmark.

3.2. Identification of Zones with strong reliance on a single supply source

This part of the assessment aims at identifying the Zones whose balance relies strongly on a given supply source. This dependency is measured as the minimum share of a given supply source required to balance the annual demand and exit flow of a Zone. This assessment is based on full supply minimisation modelling seeking for cases where a Zone will require a supply share of more than 20% from the minimized source.

The following maps identify the Zones that have a strong dependency on Russian and LNG gas, with different ranges depending on the minimum supply share of the predominant supply. There were no instances identified of a dependency on Algerian, Libyan, Norwegian and Azeri gas.

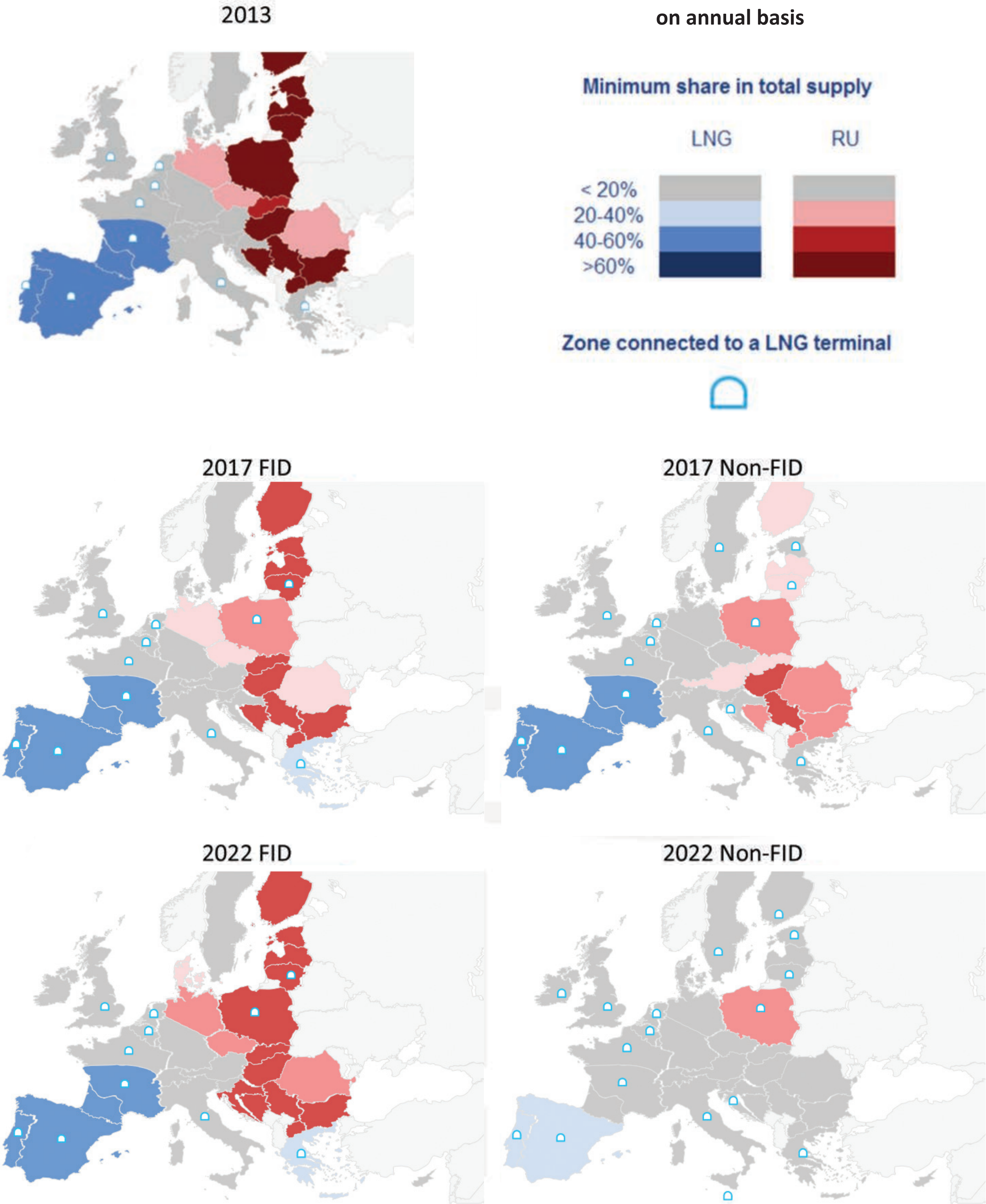
The supply dependence on Russian gas will increase when considering only the FID projects. This is due to the lack of appropriate infrastructure being available to bring other sources to compensate for the increase of gas demand and the decrease of National Production in the Eastern part of Europe. Dependence can be strongly reduced with the commissioning of Non-FID projects and especially if new sources of gas can be supplied to the South-East of Europe.

The dependence on LNG is more local and of a lower degree.

It should also be noted that LNG is by nature diversified in its potential origins. In any case, the dependence will decrease with the implementation of some FID projects and could be reduced further with the commissioning of Non-FID projects.


Image courtesy of DESFA

Figure 5.13. Supply Source Dependence on annual basis



ADAPTABILITY TO SUPPLY EVOLUTION ASSESSMENT

The assessment of the Adaptability to Supply Evolution looks at the European infrastructure's ability to face very different supply mixes as resulting from short-term signals or long-term trends. The ability to face large scale changes in supply shares resulting for example from a change in price signals is essential when considering the uncertainty of the supply evolution pictured by the increasing width of most Potential Supply scenarios.

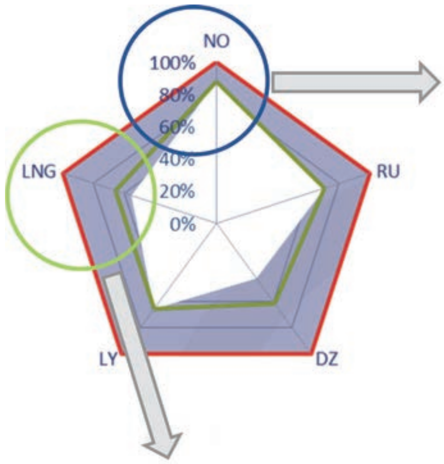
The graphs below indicate in relative terms:

- In blue, the range within which each supply source may vary according to the Maximum and Minimum Potential Supply scenarios (the latter given as a percentage of the first)
- In red, the actual maximum import from a source enabling the demand/supply balance in every zone as resulting from the Even Maximisation modelling
- In green, the actual minimum import from a source enabling the demand/supply balance in every zone as resulting from Even Minimisation modelling

When the red line or the green line are not at the outer or the inner limit, respectively, of the blue range, there is a limiting factor. Such limitation may derive from underdeveloped infrastructures or lack of alternative supply volumes. The picture below explains the graph interpretation:

Norwegian Maximum Potential Scenario daily value is 3,370 GWh/d (considered here as 100%)

Minimum Potential Scenario is 2,963 GWh/d (considered here as 2,963/3,370=88% of the Maximum Potential scenario)



The green arrow shows where to identify in relative terms the lowest possible import required to balance Europe compared to the Minimum Potential Scenario of the source (LNG is used as an example)

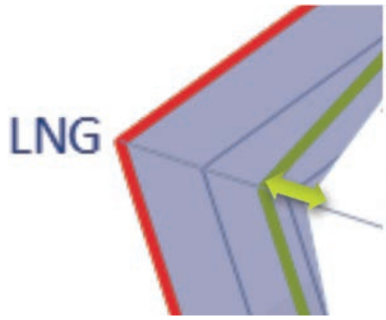
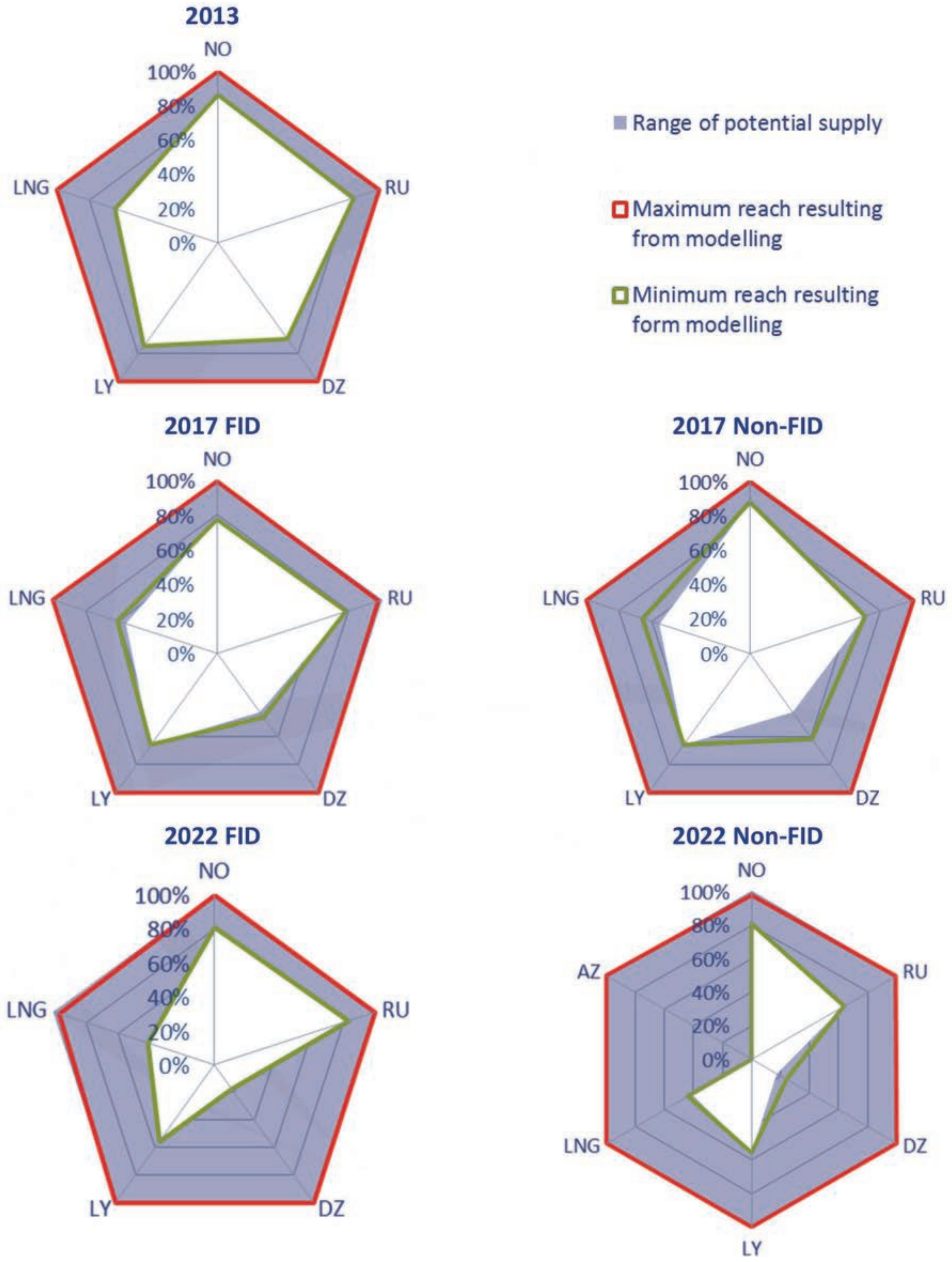


Figure 5.14.
Explanation of graph interpretation

Figure 5.15.
The adaptability of the European gas system to different supply mix



The ability of the European gas system to face very different supply mixes is high despite the increasing spread between the Minimum and Maximum Potential Supply scenarios of each source on the 10-year range.

Some of the targeted supply scenarios are not reached because of:

- The limited ability to decrease Russian supplies through Ukraine to Hungary and Romania due to the lack of interconnection of these countries with the rest of Europe. Such difficulties disappear with the commissioning of Non-FID projects in that region (being new sources or new routes)
- The limited ability to decrease LNG to Iberian Peninsula and South of France due to the lack of interconnection with Northern Europe (merger of GRTgaz North and South Zone and MidCat by 2022 will partially mitigate the issue for Portugal, Spain and TIGF Zones).
- The limited ability to decrease Algerian pipe supplies to Iberian Peninsula due to the lack of interconnection with Northern Europe.
- The reliance on LNG is also high for Poland in 2022.

4.1. Supply Source Diversification Assessment

The assessment of the Supply Source Diversification aims at determining the ability of each Zone to access each identified supply source. It is measured by the number of sources a Zone may have physical access to covering at least 5% or 20% of its total supply. This assessment is based on independent Targeted Maximisation simulations where each source is sent one by one in direction of a particular Zone in order to check source accessibility. This assessment does not cover the contractual access to a given source or specific market conditions which may be independent from physical access but have an impact on source accessibility.

Results of this assessment consist in the aggregation of several independent simulations for each source. A Zone may thus not achieve the limits of the different sources identified as accessible to it simultaneously and the accessibility of a given source at one moment in time by all reachable Zones may also not be possible. Moreover, the ability of one supply source to reach a high share of the supply of a Zone is linked to the size of both the source potential and the Zone demand.

4.1.1. Source accessibility details

The next tables provide, horizontally, the detail of source accessibility from a Zone perspective and, vertically, the spread of each supply source. In some cases, import supply shares may be limited by the fact that predominant supply is unlikely to be reduced by more than 50% compared to the Reference Case supply mix (e.g. role of indigenous production in The Netherlands). According to the methodology some of the Non-FID projects may also decrease the diversification of a Zone when the project increases the availability of the predominant supply, reducing the room for the others.

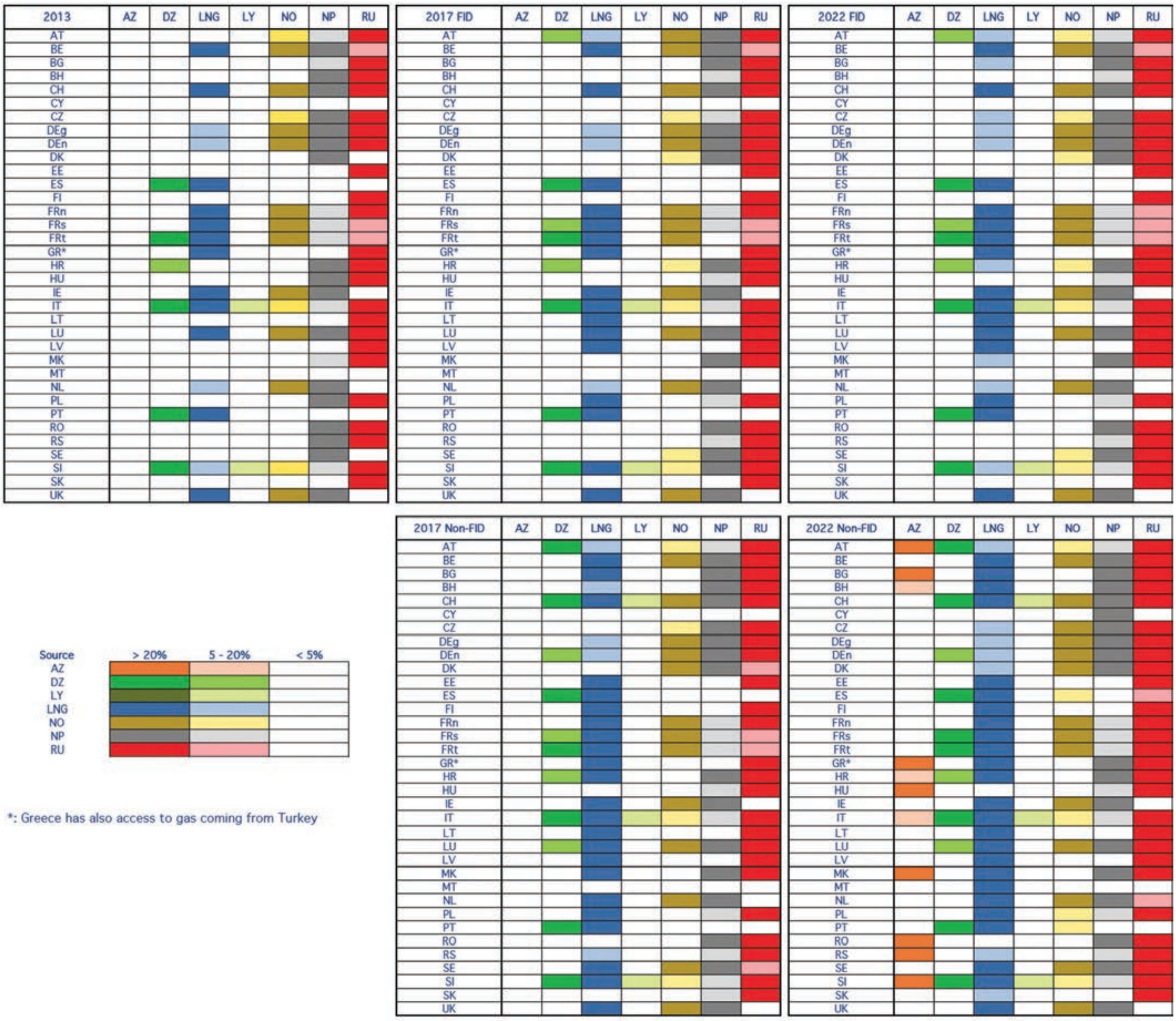


Table 5.4.

Overview of source accessibility from a Zone perspective

4.1.2. Diversification of Zones at 5% threshold

The following maps show the evolution of Supply Source Diversification from a Zone perspective according to the 5% limit. In order to let the reader apply its own value to the LNG embedded diversification, Zones reaching a 5% share of LNG are identified with a specific blue dot.

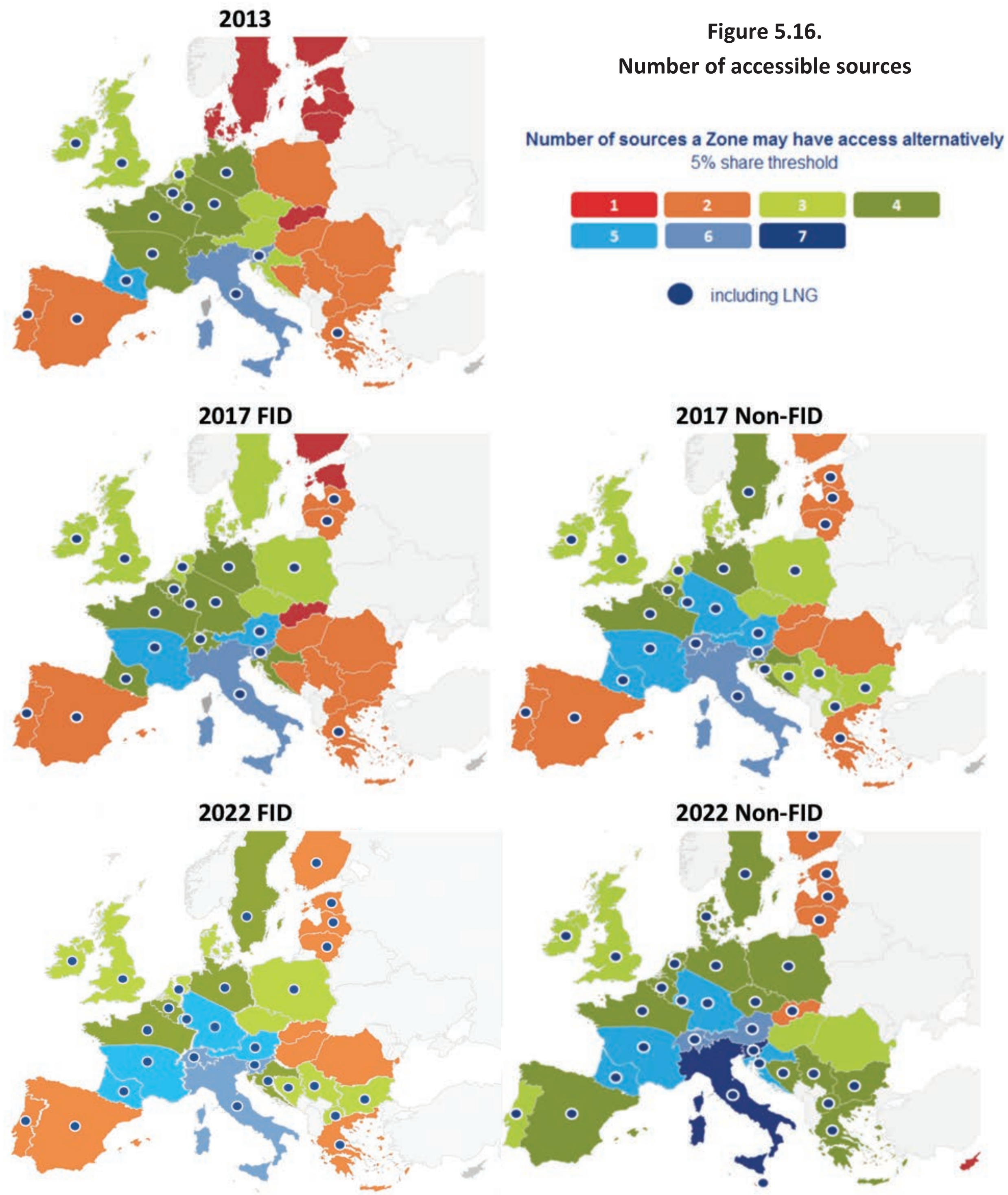


Figure 5.16.
Number of accessible sources

The average number of sources a Zone has access to moves up from 2.73 to 3.18 when FID projects are taken into account. The average goes up further to 3.83 when considering Non-FID projects too. Regarding the access to LNG, the situation worsens from 48% of the Zones having such access in 2013 to 73% in 2022 under FID Clusters, however accessibility goes up to 91% in 2022 with Non-FID projects included.

4.1.3. LNG embedded diversification

In TYNDP 2011-2020, the nature of sources a zone had access to was not clearly identified and LNG was considered as any other pipe gas source and not as coming from several countries of origin.

In this edition, the sources each Zone has access to are clearly identified, as well as their share (either more than 5% or more than 20%), in order to let the reader apply their own assumptions. In order to give context to the embedded diversification of LNG, the table and graph below provide the historical import basket of every receiving country and the European aggregated one for the period 2009 to 2011 (Source: BP2012).

SHARE OF LNG	UK	BE	FR	ES	PT	IT	GR	NL
in total Imports	33,8%	25,9%	28,7%	72,2%	60,2%	9,7%	27,1%	1,6%

Share of LNG source in total LNG supply	UK	BE	FR	ES	PT	IT	GR	NL
UAE (Abu Dhabi)	-	-	-	-	0,9%	-	-	-
Algeria	5,8%	0,4%	47,4%	18,2%	2,1%	31,1%	77,7%	24,2%
Australia	0,1%	-	-	-	-	-	-	-
Egypt	1,3%	1,3%	7,7%	11,6%	0,9%	9,2%	10,2%	-
Eq. Guinea	-	-	0,2%	-	1,1%	0,6%	0,9%	-
Libya	-	-	-	1,5%	-	-	-	-
Nigeria	3,2%	0,8%	22,9%	24,8%	84,2%	-	2,4%	24,2%
Norway	3,0%	1,3%	3,5%	5,5%	1,4%	2,3%	-	27,3%
Oman	-	-	-	2,1%	-	-	-	-
Peru	-	0,4%	-	3,3%	-	-	-	-
Qatar	76,6%	92,3%	14,1%	19,5%	2,8%	53,4%	5,1%	-
T&T	7,7%	1,7%	3,6%	12,8%	6,6%	3,4%	3,7%	24,2%
USA	0,5%	0,3%	-	0,4%	-	-	-	-
Yemen	1,8%	1,5%	0,6%	0,3%	-	-	-	-

Table 5.5.
Historical LNG import basket of every receiving country in Europe and of the European aggregated basket for the period 2009-2011

IMPORT ROUTE DIVERSIFICATION AND IMPORT DEPENDENCY: PILOT APPROACH TO INDEXES

The Remaining Flexibility of a Zone is the Entry Capacity still available once the Zone's demand has been met and the exit flows to other Zones have been considered. The Remaining Flexibility does not distinguish between the diversification of routes and sources of the gas. The diversification of sources is illustrated both by the Supply Source Dependency under High Daily Demand Situations (sub-chapter 2) and the Supply Source Diversification under Average Daily Demand Situations (sub-chapter 3).

The indicators included here are a first attempt to picture the possible diversification of supply routes for each Zone. While Remaining Flexibility and Supply Source Diversification focus respectively on the quantitative aspect of supply and their origin, the Import Route Diversification focuses on the paths that a supply can take to enter a Zone. The formulae of those indicators can be found in the Methodology chapter (4.5.).

The results should first be considered as enabling the stakeholders to provide feedback on the significance of such approach rather than comparing the mark of countries. As for all indicators, the main information is in the evolution of the situation of a given Zone along the 10-year range.

As for all indicators, the range of potential mathematical formulas is wide and the definition of the selected one is an empirical process. The background of the indicators is to be found in the Methodology chapter (4.5.).

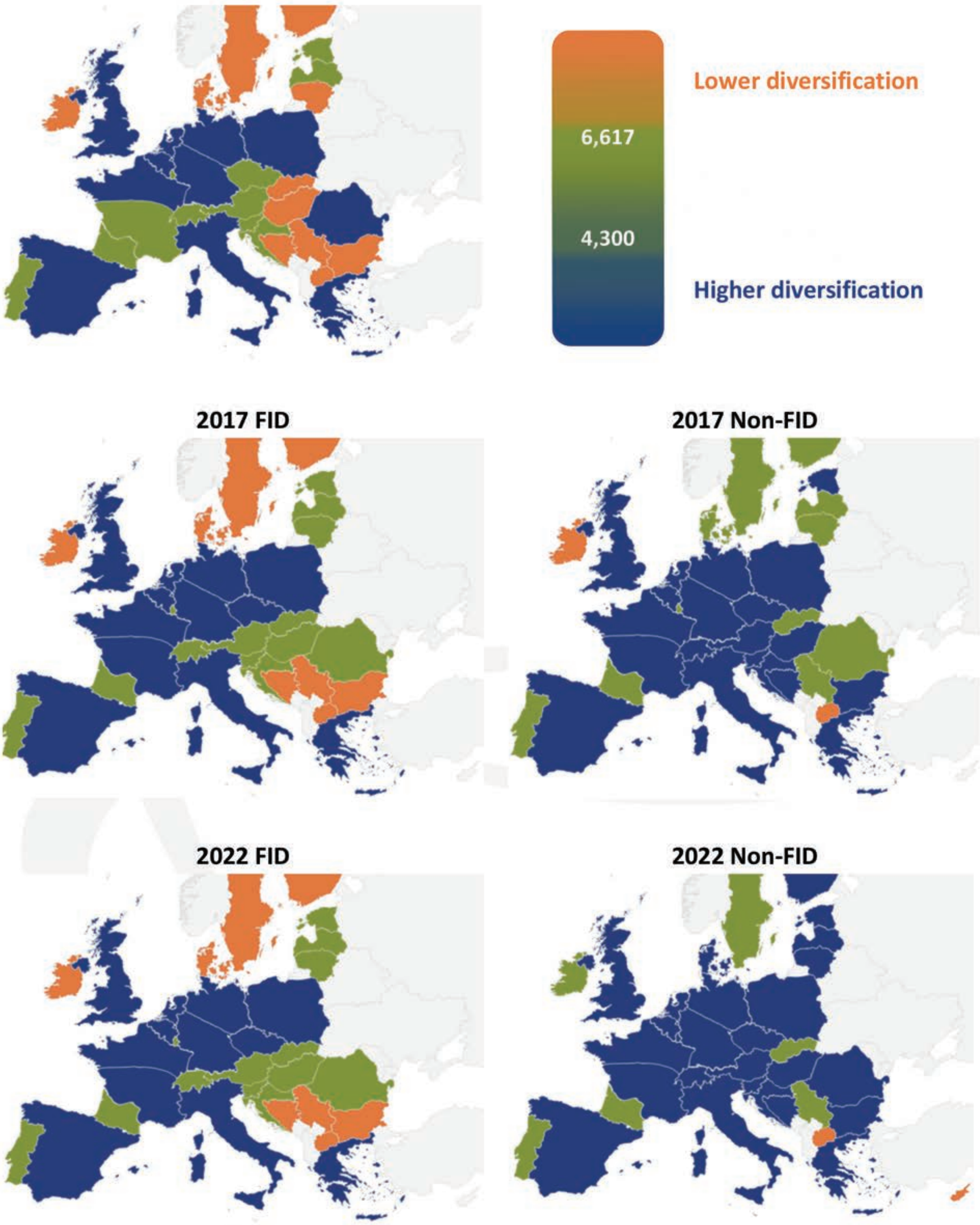
The following maps picture an indicator evolution on the 10-year range; Zones are clustered in three groups indicated by three colours. The limits between the groups have been defined by ranking the Zones according to the value of the indicators for 2013 and splitting them in 3 equal clusters. This approach is suitable as there is no definition of the targeted value of the indicators at this stage (the lower the figure, the better the situation) and as it enables to see the evolution of Zone scoring. A gauge at the right side of the 2013 map provides the highest and lowest value for the intermediate cluster.

ENTSOG welcomes any feedback on the definition of such indicators and on the targeted ranges.

From a first analysis the data show that the commissioning of FID projects by 2017 slightly improves the overall Import Route Diversification. The commissioning of Non-FID projects is required to further improve the diversification. The overall Import Dependency remains stable as UGS projects just compensate for both the increase in gas demand and the decrease of National Production. The situation could clearly improve only by 2022 with the commissioning of Non-FID projects.

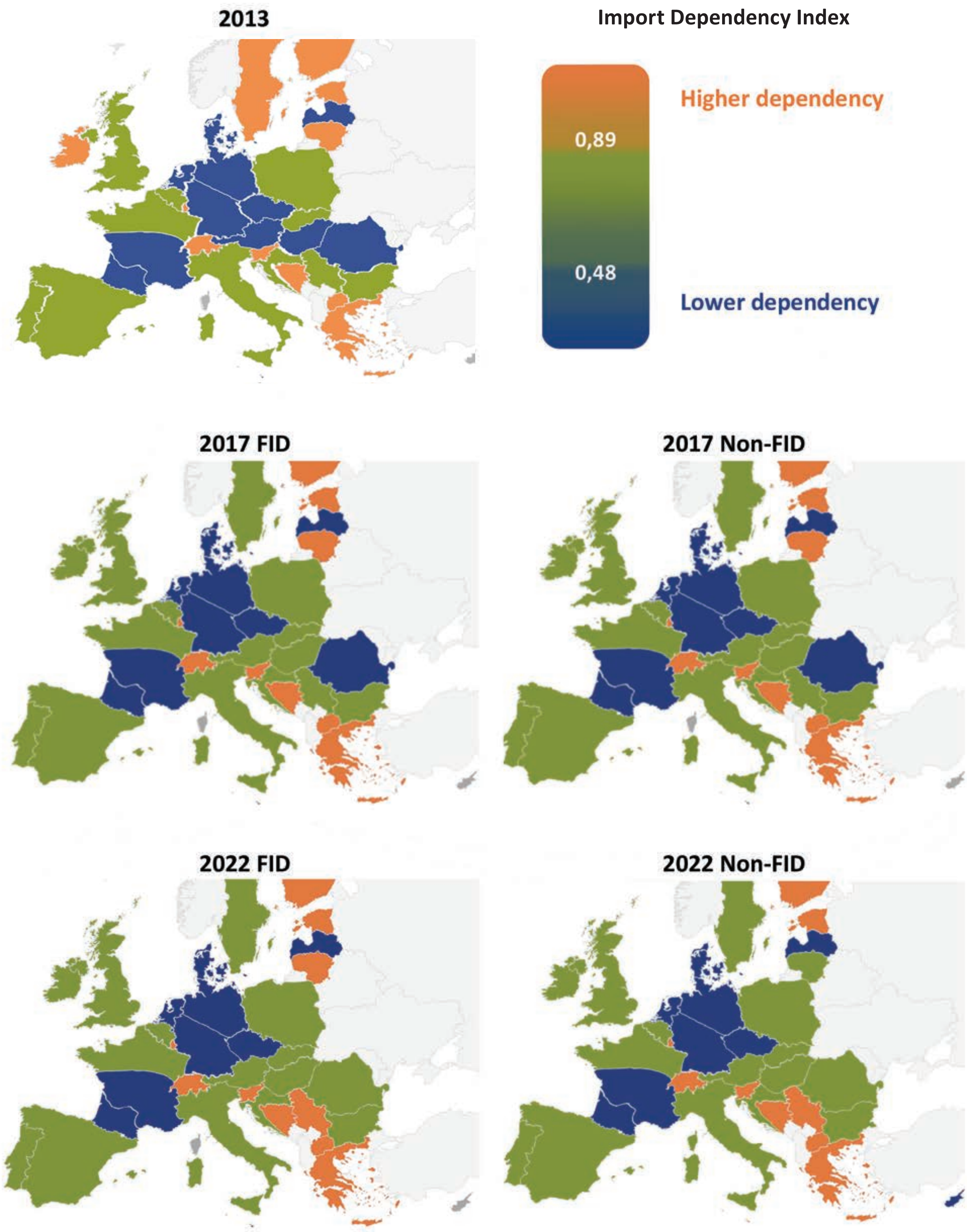
Figure 5.17.
Import Route Diversification Index

2013



2013

Figure 5.18.
Import Dependency Index



CONCLUSION ON ASSESSMENT RESULTS

TYNDP 2013-2022 shows very similar results in terms of Resilience assessment compared to the 2011-2020 edition. This illustrates the robustness of these findings considering the evolution of demand and supply scenarios and the improvement of the assessment methodology.

Resilience under High Daily Demand Situations remains an issue for Denmark, Sweden, Luxembourg, Bosnia-Herzegovina and FYROM (although to a lower extent and only in 2022 for FYROM). Apart for Sweden and FYROM Non-FID projects exist that could close the gaps. Among the considered disruptions only the interruption of gas transit through Belarus or Ukraine leads to the identification of additional Zones not able to cover their gas demand. In both cases, Non-FID projects submitted to ENTSOG are sufficient to close these gaps.

Such results are in line with the rest of the assessment highlighting the strong dependency of Eastern Europe on Russian supply on an annual basis. This assessment also illustrates the strong reliance of Iberian Peninsula on LNG and Algerian pipe gas due to a limited access to gas coming from the rest of the continent.

The assesment, based on the results of the simulations, shows a significant use of Non-FID projects in many cases. It should be noted that projects are assessed all together, other flow patterns exist and occurrence of cases is not defined. This statement is therefore not a forecast of potential utilization of such infrastructures.

As for previous TYNDP, the assessment results depend both on the inputs (demand, supply and infrastructure) and methodology. The improvement considered in this edition goes in the direction of a more robust assessment. Nevertheless this top-down assessment considers neither contractual limitations nor the bottlenecks within some Zones that could hinder the range of possible flow patterns.

Barriers to Infrastructure Investments and Potential Solutions

INTRODUCTION

This TYNDP focuses on existing and planned (FID and Non-FID) infrastructure projects, and how they could impact the European gas system over the next ten years. Nevertheless, infrastructure projects will only come on-line if there is a stable and attractive investment climate. Therefore it is vital that the market and legislative policy makers understand the potential risks and barriers to future investment in gas infrastructure.

This chapter explores different reasons why planned investment in the gas infrastructure could fail to materialise and identifies potential solutions.

Investment in natural gas infrastructure is a capital intensive exercise. A stable and attractive regulatory regime is essential to support natural gas infrastructure investment as most projects have lengthy payback periods. There are experiences with regulatory regimes, appropriately coupling framework stability with attractiveness of returns, enabling TSOs to enhance their system with positive effects for end-consumers, both in terms of efficiency, Security of Supply, Market Integration and end user system tariffs.

Conversely, regulatory uncertainty can represent a major barrier to investment. In general, companies evaluate potential investment opportunities based on the risks involved and the expected returns and the regulatory regime underpinning that investment is considered as a key aspect. Short term regulatory focus on tariff reduction or frequent policy changes could lead to delayed investments or under-investment, with negative effects for end-consumers.

The degree of market development and the structure of natural gas transmission systems vary considerably within Europe. This results in various needs throughout the different European countries. There are countries with mature markets and well developed transmission systems, equipped with a diversified portfolio of supplies and a liquid trading hub. Conversely there are countries with underdeveloped transmission systems which are dependent on a single source of supply, lacking the interconnectivity with their neighbouring states and gas markets. Therefore, regulatory regimes should put in place measures tailored to the specific investment needs which different systems have throughout their evolutions. It is important to state that the barriers highlighted below are not an exhaustive list, each infrastructure project faces its own set of obstacles it has to overcome be they national, regional or global. The barriers and potential solutions have been grouped under the following five sub-headers, National Regulatory Framework, Permit Granting, Market, Financing and Political.

NATIONAL REGULATORY FRAMEWORK

2.1. Low Rate of Return

The vast majority of investments in gas infrastructure across Europe are subject to the national regulatory tariff regimes. The Regulatory frameworks in place should encourage long term investment with reasonable returns for efficient gas infrastructure, which will ultimately be of benefit to the European end consumer. If the rate of return is too low or subject to high uncertainty, then this strangles new investment in gas infrastructure and may hinder the benefits of the European energy market from materialising.

2.2. Low/Zero Priced Short Term Capacity

Each country within Europe has its own specific national regulatory framework. On a European level, however, there seems to be a tendency to offer short term capacity products at extremely low or even zero reserve prices which brings about a real risk of under-recovery, at least in the short-term. This may lead to an unstable tariff regime and the potential occurrence of cross-subsidies and 'double' capacity payments by those users that planned ahead. This consequently results in users being charged twice for booking long-term and again under the allowed revenue recovery mechanism.

Short term capacity products should be priced in line with the value they have for users in providing them with flexibility in terms of associated profiling possibilities. If short term products are priced too low and cause a flight to short term bookings by users, this is likely to have a detrimental effect on long term capacity bookings which signal to the TSOs the future peak requirements of the system. This could result in congested Interconnection Points increasing the barriers between national markets.

The introduction of a revenue equivalence principle when setting short term pricing could mitigate against some of the potential issues outlined above. This principle puts flat bookings and profiled bookings on an equal footing and allows for capacity usage across all time frames, thereby minimising cross-subsidies. Essentially, the revenue equivalence principle balances long and short term system usage. It allows network users to procure capacity as they identify a need, without incentivising capacity hoarding or a flight to short term capacity bookings. Therefore, it has the least distortionary effect and optimises both long and short term efficiency.

2.3. Capacity Quotas

The Commission proposal for the Capacity Allocation Mechanism Network Code introduces the concept of reserving 20% of newly built capacity for medium and short-term use. This could result in an over-investment as there is no proof of upfront demand. Capacity quotas could distort the process for creating new capacity. The efficient investment in gas infrastructure should primarily be market-based.

Image courtesy of National Grid

2.4. Retrospective Cost Treatment

Retrospective cost treatment in a regulated tariff regime disincentives the construction of gas infrastructure even when the investment signals have been adequately met. Treatments resulting in detrimental and perhaps arbitrary correction measures should be specifically prohibited. The fear that efficiently built infrastructure meeting the criteria of the day may get financing retrospectively taken away years down the line has a negative impact on the perception of the investment climate.

2.5. Lack of Proper Transposition of European Union Directives

European Union directives require transposition into national law. If an EU Directive clearly places an obligation on a TSO to 'develop under economic conditions secure, reliable and efficient transmission to secure an open market', it is of fundamental importance that the investment costs implied by this obligation can be recovered through the national regulatory regime. If the necessary rules are not properly put in place, that is clear barrier for investment, and negates the spirit of the European legislation.

PERMIT GRANTING

Lengthy permit granting procedures across Europe have delayed and some cases caused the termination of projects when they have been in their pre-investment phase. A simplification of permitting procedures should be promoted across Europe and clear political support for infrastructure projects should be given towards the public, in particular in concerned local communities. The streamlined permit granting introduced by the Energy Infrastructure Guidelines for Projects of Common Interest (PCI) is a concrete step in the right direction. The swift implementation of the guidelines is imperative to ensure that PCI projects are brought on line in a timely manner. It is recommended that the streamlined permit granting is applied to other infrastructure projects of national and regional importance.

MARKET

4.1. Non Market Based Projects

There may be certain instances in some markets or situations whereby long term contracts for an infrastructure project cannot be agreed, yet the development of the project could still result in the significant improvement of the national or European internal market. Projects especially associated with Security of Supply and/or any other projects needed to complete the European Internal Gas Market, may not always be able to be fully market based, as suppliers will only contract capacity to meet their market demand. There are circumstances, like where diversification supply is required, where investment in infrastructure could be required which isn't market based, but has a direct benefit to the end consumer as a result of better access to competitive gas sources.

4.2. Energy Islands

Projects that seek to diversify supply sources could in certain cases be incentivised to do so through national or European Regulation where a country relies solely on a single supply source. The implementation of projects that help diversify supply not only improve the national supply mix, but also help meet the European goal to remove Energy Islands by 2015.

The Energy Infrastructure Guidelines may improve the situation regarding both 4.1. and 4.2. issues. The first report by the Commission on the implementation of the respective Regulation[4] and its contribution to the implementation of infrastructure projects and the functioning of the Internal Energy Market will be important for such assessment.

FINANCING

5.1. Availability of Funds and Associated Conditions

Europe is going through a period of financial turmoil. Financing conditions vary more than ever across Europe, and are dependent on national economic conditions. The combination of national austerity measures and the unwillingness of financial institutions to lend money, means there is a risk that vital gas infrastructure projects will not come to fruition within their required timescales, if at all. It is a tough financial climate to secure large and attractive amounts of funding, and even when funding is secured the conditions obtained could still lead to a low project yield, triggering the decision of not undertaking the project.

The Connecting Europe Facility is to become available as of 2014 and should facilitate the implementation of PCI projects. It is important that the scheme is available for all selected projects on a non-discriminatory and transparent basis.

In addition, financing tools, as for example those offered by EIB to infrastructure projects, should be more widely available to project promoters.

5.2. The Amortisation Rate

Project amortisation rates and long-term capacity contracts associated with that project now differ significantly. Whilst a project promoter could reasonably expect their infrastructure asset to last over 50 years, capacity contracts, and possibly also the associated supply contracts, cover much shorter time frame, the usual range being 10-25 years. This raises the question of whether a project promoter should try to make profits within such limited scope and recoup as much money as possible in the limited contractual timeframe, due to the lack of certainty in the long term.

POLITICAL

Last but not least, there is the impact of political decisions on the willingness to invest in long-term assets. Whilst political decisions do not form a physical barrier they have a considerable impact on market confidence, especially on the consideration of how to reach long-term environmental targets.

It is therefore paramount that political messages are clear and consistent. Investment in gas infrastructure is a long term financial commitment. Inconsistent or partially contradictory political messages can have a direct effect on whether the market feels confident to invest or not. On the one hand the market is stimulated by initiatives like the Energy Infrastructure Package which promotes the construction of Projects of Common Interest. On the other hand the European Commission Roadmap 2050 envisages a European energy mix in which the role of gas is severely diminished by 2050.

Gas has been touted as a transitional fuel for renewables, but this ignores the fact that gas power plants, might only be needed in a period of demand when there isn't much renewable generation on-line. It is not clear whether it is going to be economically viable for power plants to be utilised in such a way. Gas power plants may be vital for generating electricity in extreme operational conditions, yet some may be drastically underutilised. Until this conundrum is solved, there will be a risk that sufficient gas-fired power generation will not be available to act as the back-up fuel.

To conclude, a stable and predictable regulatory framework is paramount to tackling the barriers to investment in efficient gas infrastructure. TSOs are dedicated to facing the challenges ahead, based on engagement and co-operation with policy makers. By working together, the Internal Energy Market can be completed to the benefit of all European end consumers.

[4] To be published not later than 2017

Conclusions

The development of new tailored gas infrastructure supports all three pillars of the European energy policy. It enables and facilitates a liquid and competitive common gas market, through increased physical Market Integration. The resulting flexibility of the European gas system will enable and enhance supply diversification, notwithstanding a declining indigenous production, thus enhancing the Security of Supply. Improved gas infrastructure will also play a significant role in improving sustainability in Europe and therefore helping achieve the EU environmental targets. The results of this TYNDP show these correlations extensively.

The extensive stakeholder engagement process organised by ENTSOG in relation to this TYNDP contributed to the holistic and transparent view of European wide gas infrastructure developments as presented in this Report. Compared to the TYNDP 2011-20202 ENTSOG modelled a significant amount of additional cases. This is the result of ENTSOG's initiative to develop a wider range of both supply and demand situations as also requested by stakeholders. Combined with the improvements of the Network Modelling tool, ENTSOG has been able to carry out and present in-depth analysis of the European infrastructure and its potential development over the next ten years.

SUPPLY ADEQUACY

The Supply Adequacy Outlook presented in this TYNDP does not signal any lack of supply on an aggregated European yearly level considering the ENTSOG demand curve. This conclusion is based on the use of three potential supply scenarios for each identified supply source. The ENTSOG demand curve is well within the range of the aggregate Intermediate Supply Scenario and it can be reasonably assumed that the actual future combination of the different Supply Potentials will allow for flexibility and arbitrage opportunities on the market of the countries covered in the TYNDP. The evolution of the Supply Potential will be also strongly influenced by the trend followed by the demand.

The yearly European gas demand is expected to grow on average by 1% over the 10-year horizon. This growth is expected to come mainly from gas consumption by power generators, with the electricity sector's demand forecast to increase by 33% over the 10-year period. Actual volumes of residential, commercial and industrial consumptions are expected to remain at current levels in the EU as a whole, although important differences are foreseen in individual countries.

Compared to the previous TYNDPs' outlooks, the demand curve follows the evolution already described in 2011 with minor changes at the European level. The aggregation of individual countries neutralizes however significant demand reductions in mature markets with accelerated growths in other countries.

Compared to other scenarios developed by IEA, Eurogas and academic institutions for the Commission, the ENTSOG scenario is located towards the middle part of the range. Comparison of those scenarios driven by environmental targets (Eurogas Roadmap, IEA 450 scenario, and Commission Roadmap) reveals significant differences before the end of the period. The Eurogas Roadmap presents a demand scenario that achieves the environmental targets and converges with ENTSOG's scenario for the last years of the horizon.

From a network development and operation perspective, it is crucial to study the potential development of the high daily demand, either on a single day or over a period of sustained high daily demand. It is that level of demand that determines the necessary physical capability of the network.

Three different levels of high daily demand conditions have been considered. On a single day, the Design-Case Demand Situation, defined as the addition of the national peak demands per day as calculated by TSOs and included in their National Development Plans where existing, is on average 3% higher than the 'Uniform Risk High Daily Demand Situation'. The latter covers a climatic conditions situation with statistical occurrence of 1-in-20 years. In a parallel statistical approach, an equivalent level of risk defines the '14-day Demand Situation'. This situation describes the Average Daily Demand on a sustained 2-week cold event which is on average a 10% lower than the single day Design-Case Situation. When comparing assessment results between these situations, it appears that the definition of a common occurrence situation for a 14-day period has brought much more added value than for the single day. Subsequently in the assessment, ENTSOG has only used the Design-Case for the 1-day High Daily Demand Situation favouring the consistence with National Plans.

The high daily demand defined under the Design-Case Situation is expected to increase on average by 0.6% over the 10-year period. This trend is defined by the combination of the soft decrease of -0.2% expected in the peak demands from the Residential, Commercial and Industrial sectors and the average growth of 3% in the high daily demands for power generation.

The supply coverage of the high-daily-demand-based cases has been built on the assumption that the maximum flexibility of the pipeline imports has been reached during the last three years. Consequently, UGS and LNG supplies have been considered as last resort sources in addition to the maximum pipeline import values registered between 2009 and 2011 by source to keep the supply-demand balance under High Daily Demand Situations.

In line with the assumptions taken on supply, demand and infrastructure development, the following conclusions may be drawn from the assessment of results of the simulations carried out by ENTSOG in the framework of this Report.

KEY CONCLUSIONS OF INFRASTRUCTURE RESILIENCE ASSESSMENT

The Resilience assessment modelling shows how much flexibility is available in the European gas system even in situations of very high daily demand. Under the Reference Case, only 4 Zones have been identified where the Remaining Flexibility would fall below 1%. The implementation of Non-FID projects in these Zones (Bosnia-Herzegovina, Denmark, Sweden, Finland and Luxembourg) would resolve all the issues over the 10-year range apart from Sweden where national specificities are in play.

The network modelling of disruptions cases concerning Norwegian, Algerian, Libyan and Azeri supplies showed that European Zones should not be limited in meeting their demand, even in such stressful situations and considering high daily demand. The disruption through Belarus did however show 2 significantly impacted Zones (Lithuania and Poland). The uncovered demand from these 2 Zones over the 10-year period ranged from 32% down to 13% of the combined total Zone demands under the 14-day Uniform Risk Situation thanks to the commissioning of the FID projects. With the implementation of all Non-FID projects in the respective region both Zones would be able to meet their full demand even with a Belarus disruption.

Moreover, the network modelling showed that the most stressful supply situation is the disruption of transit through Ukraine. Under such disruption, 7 Zones would not be able to meet their demand and the level of this uncovered demand under the 14-day Uniform Risk Situation for the region would range from 42% up to 54% over the 10-year period if only the FID projects came on-line. The modelling showed that the Ukrainian disruption is still the greatest threat to European Security of Supply. Only if the Non-FID projects were implemented by the end of 2022, the region could adequately cope with a significant supply loss from Ukraine in conjunction with a single high demand day.

The resilience testing of the 14-day Uniform Risk Situation has enabled the identification of an additional investment gap related to the situation of Poland under Belarus disruption.

It is highlighted that storage (both UGS and storage component of LNG terminals) has a vital role to play within the European Energy mix. The network modelling of the resilience cases over the 10-year period showed that in situations of high daily demand up to 78% of storage capacity would be required to allow each European Zone to meet its demand. This level of storage capacity utilisation drops to around 50% if all the Non-FID projects are implemented but still reaches a high level.

KEY CONCLUSIONS OF SUPPLY SOURCE DEPENDENCE ASSESSMENT

Supply source dependence naturally reduces a Zone's Security of Supply, and supply should be diversified to provide such Zone with more flexibility. For the first time, ENTSOG analysed a Zone's dependence on each supply source applying Full Minimisation modelling approach which is based on an Average Demand Situation.

The results showed that no Zone had a supply dependency on Norwegian, Algerian, Libyan or Azeri supplies over 20%. The 2013 modelling results did show however that there were 14 countries that had a dependency on the Russian gas of over 20%, and for 10 of them the dependency was reaching over 60%. The current FID projects as supplied for this TYNDP are not sufficient to mitigate the increased dependency on Russian gas due to the decline in National Production and the rise in demand; 11 Zones show a 60% dependency and another 4 a dependency of between 40% and 60%. If the Non-FID projects in the region came to fruition, this would have a profound impact on the level of dependency on Russian gas; the Non-FID 2022 outlook shows only 3 Zones with a dependency of over 20% and no Zones with a dependency of over 60%.

It is necessary to note however that Russian supplies play a vital role within the European gas mix, and will certainly continue to do so over the studied 10-year period.

The dependency on LNG is much more localised with only 5 Zones having an LNG dependence of between 40% and 60% in 2013; this situation has been identified for the Iberian Peninsula, south of France and Greece. As LNG is already a diversified source of gas (European supplies have been arriving from 9 different suppliers over the last 3 years), Zones are less vulnerable to a single supplier. The implementation of the covered FID and Non-FID projects in the region would reduce its reliance on LNG and further improve flexibility.

KEY CONCLUSIONS OF THE ASSESSMENT ON NETWORK ADAPTABILITY TO SUPPLY EVOLUTION

The ability of the European gas system to face very different supply mix is rather high despite the increasing spread between the Minimum and Maximum Potential Supply scenarios of each source on the 10-year range.

Some of the targeted supply scenarios have not been reached because of:

- The limited ability to decrease Russian supplies through Ukraine to Hungary and Romania due to the lack of interconnection of these countries with the rest of Europe. Such difficulties disappear with the commissioning of Non-FID projects in that region

(being new sources or new routes)

- The limited ability to decrease LNG to Iberian Peninsula and South of France due to the lack of interconnection with Northern Europe (merger of GRTgaz North and South Zone and MidCat by 2022 will partially mitigate the issue for Portugal, Spain and TIGF Zones).
- The limited ability to decrease Algerian pipe supplies to Iberian Peninsula due to the lack of interconnection with Northern Europe.
- The reliance on LNG is also high for Poland in 2022.

KEY CONCLUSIONS OF THE SUPPLY DIVERSIFICATION ASSESSMENT

The Targeted Maximisation analysis aimed at the identification of supply source diversification showed the varying capability of the different Zones to accept supplies from a range of suppliers. It can be concluded that the gas infrastructure within the European gas system has the ability to ensure that each Zone has, on average, 3 different suppliers providing at least 5% of yearly supply. In addition, the Report identifies for each Zone which supply sources can be accessed and whether the resulting (modelled) level of supply is over 5% or 20%, which were the two benchmarks set for the analysis.

The resulting range of different supplies relates directly to their individual nature. Specific suppliers like Russia and Norway show a high minimum supply rate over the 10-year range which is linked to their regional nature. LNG, as a global commodity, has a much wider supply range which is directly related to market trends on a global scale. Throughout the 10-year range, the development of LNG, Algerian, Libyan and Azeri supplies offers the greatest flexibility but also the greatest levels of supply uncertainty.

KEY CONCLUSIONS ON THE DEVELOPMENT OF PILOT ENTSOG CAPACITY-BASED INDEXES

In addition to the assessment of modelling results as such, new capacity-based indexes have been introduced aiming at measuring the Import Route Diversification and Import Dependence per each Zone. ENTSOG defined 2 pilot indicators in a first attempt to quantify each Zone's supply diversification. This initiative is related to the draft Energy Infrastructure Guidelines that are to enter into force in spring 2013 and oblige ENTSOG to develop a CBA methodology for the assessment of infrastructure at both the energy system-wide level and at the level of individual projects.

The 'Import Route Diversification Index' shows the level of diversification in terms of alternative paths gas can use when reaching a Zone, and its development over the 10-year period for each Zone. No benchmark has been defined; nevertheless the calculation results allow comparisons across Europe and show the evolution until 2022. From a first analysis, the data show that the overall Import Route Diversification will slightly improve with the commissioning of FID projects by 2017. The commissioning of Non-FID projects will be required to further improve the diversification

The 'Import Dependence Indicator' analyses supply diversification in terms of dependence on gas coming from adjacent Zones. This indicator shows the impact that National Production and the existence of local storage has on a Zone, whilst also showing the reliance some Zones have on imports. Again, no benchmark has been defined; nevertheless the calculation results allow comparisons across Europe and show the evolution until 2022. The overall Import Dependency remains stable as UGS projects just compensate for both the increase in gas demand and the decrease of National Production. The situation could clearly improve only by 2022 with the commissioning of Non-FID projects.

This TYNDP confirms that in most parts of Europe a well-developed gas infrastructure, connected to various supply sources and capable of dealing with high daily demand and various supply situations is in place. The achieved infrastructure-related Market Integration indicates the potential for the commercial integration of markets in Europe. The number of projects included in this TYNDP illustrates that the market is willing to invest heavily in gas infrastructure. The results lead to the conclusion that these market initiatives (both FID and Non-FID projects) are likely to overcome most of the potential investment gaps and will support supply source diversification. Further analysis should be carried out at the regional and national levels where ENTSOG identified that the covered gas infrastructures would not able to face the conditions as set out in the cases studied.

WAY FORWARD

The Ten-Year Network Development Plan 2013-2022 is the first full 2-year cycle Report produced by ENTSOG. The experience shows that this cycle is appropriate for a document of this scope and size.

As highlighted in the past, the TYNDP is an evolving report that depends on the development of the market, stakeholders' expectations and the legal and regulatory framework. Stakeholders' engagement is indeed seen as a crucial element in achieving improvements in the future. Such involvement does not only cover feedback on the methodology applied or the focus of the Report but also the submission of data going beyond the project-specific information.

The TYNDP identifies different challenges for the development of the Report as well as for the development of the infrastructures themselves. These relate in particular to the development of good understanding of the gas-electricity interface and gas demand in general, and to the barriers to investments.

ENTSOG has included research and development activities relating to gas demand and the role of gas for achieving sustainable energy future in its Annual Work Programme 2013. ENTSOG will build on TSOs' experience in this area while also engaging closely with ENTSO-E and encouraging involvement of other organisations as well. Results of these activities will hopefully be available at least partially for the next Report.

As for the barriers to investment, ENTSOG has taken a stock of barriers as perceived by Transmission System Operators and calls for further discussion on them with policy makers and stakeholders. ENTSOG reiterates that a stable and predictable regulatory framework is paramount to overcome the barriers to investment in efficient gas infrastructure. It is highlighted that TSOs are dedicated to facing the challenges ahead, and that only by working together the Internal Energy Market can be completed to the benefit of all European end consumers.

Last but not least, ENTSOG will soon also face the challenge of developing a CBA methodology to be applied at the system-wide level in the TYNDP and by individual project promoters for the assessment of their infrastructure within the process of identification of Projects of Common Interest. The pilot PCI process started by the European Commission in 2011 and involving the Member States, National Regulatory Authorities, TSOs, ACER, ENTSOG and non-TSO project promoters has been useful to identify the most difficult elements of such cost benefit assessment and this experience has been feeding into ENTSOG's initial preparation of the formal CBA development process. ENTSOG anticipates that, as with the TYNDP itself, several rounds of iteration may be needed to arrive at a sufficiently robust methodology accepted by majority of stakeholders.

ENTSOG hopes that you have found this TYNDP 2013-2022 useful and informative, and encourages you to get involved in the development of the next edition.


Image courtesy of NET4GAS

Definitions

TERM	DEFINITIONS
Number formatting , .	 Coma (,) is used as a 1000 separator Point (.) is used as a decimal separator
1-day Uniform Risk Demand Situation	means a daily demand Situation forecasted under the same risk of a climatic occurrence close to 1-in-20 years
14-day Uniform Risk Demand Situation	means a 14-day average daily demand Situation forecasted under the same risk of a climatic occurrence close to 1-in-20 years
Average Day Demand Situation	means a daily average demand Situation calculated as 1/365th of an annual demand
Case	means a combination of a demand and supply situation, infrastructure cluster and the respective time reference.
Design-Case Demand Situation	means a high daily demand situation used by TSOs in their National Development Plans to determine the resilience of their system and needs for investment
Even Minimisation	means a modelling approach aimed at minimising supply from each source separately down to its Minimum Potential scenario and replacing it with corresponding volume from the remaining sources through the increase of each supply source and import route in proportion to their shares in the Reference Case; their Maximum Potential scenario is used as a limit.
FID project	means a project where the respective project promoter(s) has(have) taken the Final Investment Decision.
Full Minimisation	means a modelling approach aimed at minimising supply from each source separately, in order to identify Zone Supply Source Dependence, and replacing it with the corresponding volume from the remaining sources in such a way that the maximum minimisation of the analysed supply is achieved;

TERM	DEFINITIONS
Even Maximisation	means a modelling approach aimed at maximising supply from each source separately up to its Maximum Potential scenario inducing the decrease of each other supply source and import route in proportion to their shares in the Reference Case; the Minimum Potential scenario is used as a supply source limit.
Import	means the supply of gas at the entry of the European network as defined by this TYNDP or gas delivered at the entry of a Zone.
Import Dependence	means a notion related to Supply Source Diversification in terms of dependence on gas coming from adjacent Zones; it is measured through a capacity-based Index showing the impact that National Production and the existence of local storage have on a Zone and its reliance on imports.
Import Route Diversification	means a notion related to Supply Source Diversification in terms of alternative paths gas can use when entering a Zone; it is measured through a capacity-based Index showing the size of path capacities in relation to the total Entry Capacity of a Zone. The result is proportional to the average Entry Capacity share, weighted by each Entry Capacity share.
Index	means an indicator measured at a Zone level and aimed at quantifying a notion developed for the purpose of this TYNDP; this Index is not linked to a benchmark, the calculation results nevertheless allow comparisons across Europe and show the evolution until 2022
Interconnection Point	means a point of interconnection between two different infrastructures; an Interconnection Point may or may not be operated by different infrastructure operators
National Production	means the indigenous production related to each country covered in the TYNDP; a Zone allocation has been carried out where relevant
Network Resilience	means a notion related to the capability of a network to ensure supply demand balance in High Daily Demand Situations, including also under Supply Stress.
Non-FID project	means a project where the Final Investment Decision has not yet been taken by the respective project promoter(s)
Plan	means the referenced TYNDP, including all Annexes; Plan and Report are used interchangeably

TERM	DEFINITIONS
Reference Case	means the Case that extends the historical (last three years) trend of supply over the 10-year period covered by the TYNDP; where new import pipe/LNG terminal projects are planned to come on stream the supply is adjusted in proportion to the last applicable supply situation
Remaining Flexibility	means a notion related to the assessment of Network Resilience; it refers to the ability of a Zone to offer additional room for supply arbitrage; the value of the Remaining Flexibility is benchmarked against defined limits to identify potential capacity gaps
Report	means the referenced TYNDP, including all Annexes; Report and Plan are used interchangeably
Scenario	means a set of assumptions related to a future development which is the basis for generating concrete value sets covering demand or supply.
Situation	Situation means a combination of conditions and circumstances relating to a particular occurrence of demand or supply, or both; such conditions and circumstances may relate to e.g. time duration, climatic conditions, or infrastructure availability.
Supply Dependence	means a notion related to Supply Diversification in terms of dependence of a Zone on a particular external supply source; it is measured through an indicator which is set at 20% and 60% share of an external supply source in covering the total annual demand forecast of a Zone.
Supply Potential	means the capability of a supply source to supply the European gas system in terms of volume availability; Supply Potential is defined through three scenarios: Maximum, Intermediate and Minimum
Supply Stress	means a supply situation which is marked by an exceptional supply pattern due to a supply disruption.
Targeted Maximisation	means a modelling approach aimed at maximising supply from each source separately as to reach each Zone; the decrease of each other supply is done in proportion to its share in the Reference Case and with the Minimum Potential scenario used as a limit. The use of an import route is a result of the modelling.

TERM	DEFINITIONS
Technical capacity	means the maximum firm capacity that the Transmission System Operator can offer to the network users, taking account of system integrity and the operational requirements of the transmission network (Art. 2(1)(18), REG-715)
Transmission	means the transport of natural gas through a network, which mainly contains high-pressure pipelines, other than an upstream pipeline network and other than the part of high-pressure pipelines primarily used in the context of local distribution of natural gas, with a view to its delivery to customers, but not including supply (Art. 2(1)(1), REG-715)
Transmission system	means any transmission network operated by one Transmission System Operator (based on Article 2(13), DIR-73)
Transmission System Operator	means a natural or legal person who carries out the function of transmission and is responsible for operating, ensuring the maintenance of, and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transport of gas (Article 2(4), DIR-73)
Zone	means an Entry/Exit Transmission system or sub-system, including all National Production, Underground Gas Storage and LNG terminal Interconnection Points connected to such system or sub-system, which has been defined on the basis of either the commercial (capacity) framework applicable in such system or sub-system or the physical limits of the respective Transmission system

Abbreviations

ABBREVIATION	FULL NAME
ACER	Agency for the Cooperation of Energy Regulators
bcm	Billion normal cubic meters (normal cubic meter (Nm3) refers to m3 at 0°C and 1.01325 bar)
CIS	Commonwealth of Independent States
CS	Compressor Station
COM	Commercial
DEg	Zone of Gaspool (DE)
DEn	Zone of NetConnect Germany (DE)
DOM	Domestic
ENTSO-E	European Network of Transmission System Operators for Electricity
ENTSOG	European Network of Transmissions System Operators for Gas
ETS	European Trading Scheme
EU	European Union
DIR-73	Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC
FID	Final Investment Decision
FRn	Zone of GRTgaz North Zone (FR)
FRs	Zone of GRTgaz South Zone (FR)
FRt	Zone of TIGF (FR)
GCV	Gross Calorific Value
GIE	Gas Infrastructure Europe
GLE	Gas LNG Europe
GSE	Gas Storage Europe
GWh	gigawatt hour
ID	Identification
IEA	International Energy Agency
IND	Industrial
IP	Interconnection Point
ktoe	a thousand of oil equivalent; where gas demand figures have been calculated in TWh (based on GCV) from gas data expressed in ktoe, this was done on the basis of NCV and it was assumed that the NCV is 10% less than GCV
L-gas	Low calorific gas
LNG	Liquefied Natural Gas
Mcm	Million normal cubic meters (normal cubic meter (Nm3) refers to m3 at 0°C and 1.01325 bar)
MEG	Maghreb Europe Gas pipeline (connecting Algerian upstream system with the Spanish transmission system)
MS	Member State
MS	Metering Station (when used in relation to infrastructure project)

ABBREVIATION	FULL NAME
mtoe	a million of oil equivalent; where gas demand figures have been calculated in TWh (based on GCV) from gas data expressed in mtoe, this was done on the basis of NCV and it was assumed that the NCV is 10% less than GCV
NCV	Net Calorific Value
OECD	Organisation for Economic Co-operation and Development
REG-715	Regulation (EC) No 715/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the natural gas transmission networks
REG-SoS	Regulation (EU) No 994/2010 of the European Parliament and of the Council of 20 October 2010 concerning measures to safeguard security of gas supply and repealing Council Directive 2004/67/EC
SoS	Security of Supply
TYNDP	Ten-year Network Development Plan
TSO	Transmission System Operator
UGS	Underground Gas Storage (facility)

Country Codes (ISO)

COUNTRY CODE	FULL NAME	COUNTRY CODE	FULL NAME
AL	Albania	**LU**	Luxembourg
AT	Austria	**LV**	Latvia
AZ	Azerbaijan	**LY**	Libya
BY	Belarus	**MA**	Morocco
BE	Belgium	**ME**	Montenegro
BH	Bosnia Herzegovina	**MK**	FYROM
BG	Bulgaria	**MT**	Malta
CH	Switzerland	**NL**	Netherlands, the
CZ	Czech Republic	**NO**	Norway
CY	Cyprus	**PL**	Poland
DE	Germany	**PT**	Portugal
DK	Denmark	**RO**	Romania
DZ	Algeria	**RU**	Russia
EE	Estonia	**RS**	Serbia
ES	Spain	**SE**	Sweden
FI	Finland	**SI**	Slovenia
FR	France	**SK**	Slovakia
GR	Greece	**TN**	Tunisia
HR	Croatia	**TR**	Turkey
HU	Hungary	**UA**	Ukraine
IE	Ireland	**UNMIK**	UNMIK
IT	Italy	**UK**	United Kingdom
LT	Lithuania		

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Image courtesy of Swedegas

Disclaimer

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