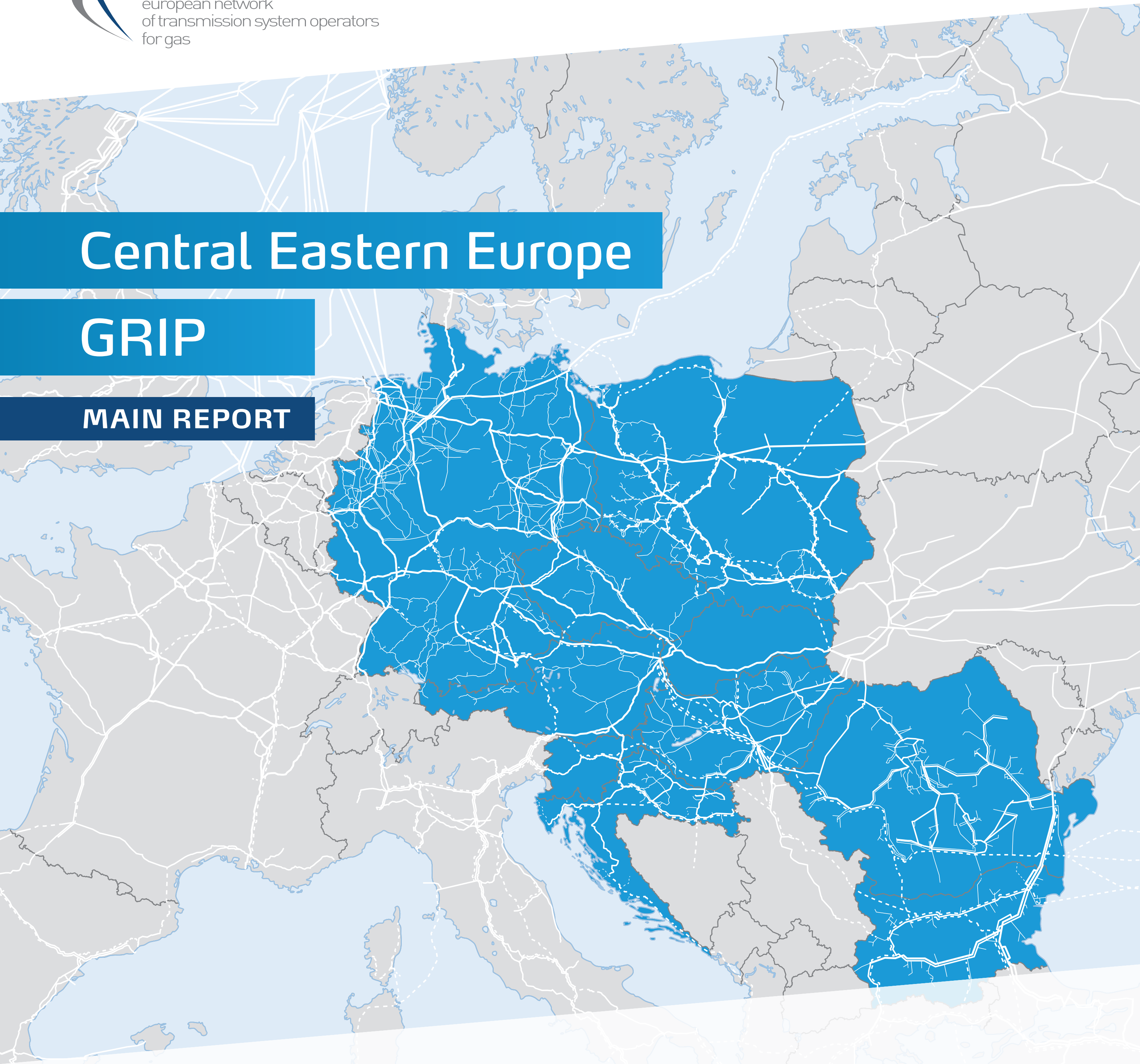
european network
of transmission system operators
for gas

GAS REGIONAL INVESTMENT PLAN 2017



Central Eastern Europe

GRIP

MAIN REPORT

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Foreword

The present report is the third edition of the Gas Regional Investment Plan for Central and Eastern Europe. On behalf of the cooperating TSOs of this region for updating and also partially upgrading the previous plan, I'm pleased to introduce its result, the CEE GRIP 2017.

All involved TSOs from the ten EU member states aim to provide the stakeholders with this report which is a comprehensive outlook about infrastructure projects in the region. These projects are either planned or already under implementation. They will contribute to meeting future gas demand, as well as to the functioning of the transmission networks not only within the region but also in regard to their transit function beyond the region.

The CEE GRIP especially takes into account the analyses made by the TSOs about the efficient enhancement of the security of supply (SoS), the diversification of supply sources and routes, and further market integration. This report also incorporates the corresponding comments received from market participants since the first edition.

The analyses and descriptions made for/in the CEE GRIP are based on the same data as used for the EU-wide Ten-Year Network Development Plan 2017, published recently by ENTSOG. Together with the respective National Network Development Plans, these documents thus constitute a consistent set of plans which enable the identification of additional measures for the efficient development of gas transmission networks in the future.

The TSOs of the CEE region would like to thank stakeholders who have given advice and support to the elaboration of all three editions. They would also like to encourage all stakeholders to provide further comments and proposals in the upcoming consultation process and workshop, which are both scheduled to take place by mid-2017.

Michael Kehr

Director, Strategy
NET4GAS, s.r.o.

Executive Summary

Planning and development of gas infrastructure are vital for meeting the obligations under EU Directive 2009/73/EC, and these are further detailed in Regulation (EC) 715/2009. The third edition of the Gas Regional Investment Plan for Central and Eastern Europe (CEE GRIP) is now strongly linked with the EU-wide Ten-Year Network Development Plan 2017 (TYNDP 2017).

A harmonised data set is used for developing both reports in parallel. The CEE GRIP supports and complements the TYNDP 2017, published for public consultation on 20 December 2016[1)]. The GRIP of the CEE region is presented for the period 2017–2026 based on analyses in light of the possible evolution of gas infrastructure with a focus on specific regional matters of supply, demand, and infrastructure capacity.

The CEE region consists of 10 countries (Austria, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Poland, Romania, Slovakia, and Slovenia).

The following summary sets out key outputs of this CEE GRIP. The findings are provided in four main sections, depending on the subject of analysis:

1) The EU-wide Ten-Year Network Development Plan 2017 is available under the following link: http://www.entsog.eu/publications/tyndp#ENTSOG-TEN-YEAR-NETWORK-DEVELOPMENT-PLAN-2017


Image courtesy of GAZ-SYSTEM

INFRASTRUCTURE PROJECTS IN THE CEE REGION

- In total, there are 111 gas infrastructure projects planned for implementation in the CEE region in the upcoming decade – 18 projects have already reached a final investment decision (FID) and 93 projects are at an earlier stage of development (non-FID).
- There are 21 projects that have been commissioned in the CEE countries since the release of the CEE GRIP 2014–2023 in May 2014. These projects contributed to the improved diversification of gas supply sources and infrastructure integration.
- The projects' statuses in the TYNDP 2017 reflect the situation as of May 2016. Since that date, 21 projects have updated their commissioning year. Most of those projects have a delay of one year.[2)]

ASSESSMENT – INFRASTRUCTURE RESILIENCE IN THE CEE REGION

- Two additional stress scenarios were analysed and presented in the report beyond the TYNDP 2017 scope. These stress scenarios are (i) a simultaneous disruption of the gas supply routes via Ukraine and Belarus and (ii) a disruption of the whole Russian gas supply source.
- The simultaneous disruption of gas routes via Belarus and Ukraine shows a supply disruption in the countries in southeastern Europe (Croatia, Hungary, Romania, and Bulgaria) and Poland. Gas supplies to Germany, the Czech Republic, Austria, Slovakia, and Slovenia would not be affected, as deliveries to these countries would be redirected via Nord Stream pipeline.
- The disruption case of the whole Russian gas source is the most extreme possible for the region and shows the countries concerned to be highly dependent on Russian gas supplies. However, with the implementation of planned infrastructure projects (which improve the security of supply and the diversification of gas sources and routes) this dependency is mitigated, as these projects will foster the diversification of gas supply sources and improve infrastructure integration between the CEE countries.

2) The updated commissioning years reflect the situation as of January 2017. For the sake of clarity with the TYNDP 2017, any commissioning update has no impact on the analysis performed in the CEE GRIP.

CEE GRIP REGIONAL N-1 ANALYSIS

- The CEE GRIP Regional N-1 analysis covers gas supply disruption cases through Ukraine and Belarus for the winter and summer periods. The assessment is based on the N-1 methodology according to Regulation (EU) 994/2010, which was adjusted to enable the application to be used for CEE GRIP purposes.
- In the winter period 2017/2018 under the Ukrainian gas route disruption case, Bulgaria and Romania do not meet the basic N-1 criterion (the result has to be equal to or greater than one). The implementation of planned infrastructure projects in upcoming years can solve this situation.
- Due to geographical reasons, the disruption of supplies via Belarus only affects Poland, but the assessment indicates a decreasing dependency over the entire time span for both winter and summer periods.
- Almost all countries in the CEE region obtain satisfactory N-1 calculation results in the summer period, as each country is able to cover its own gas demand and meet the injection requirements of underground storage facilities when the two analysed disruption cases are considered. With regard to the main findings, we can enumerate the following situations:
  - For Bulgaria during the Ukraine disruption scenario in summer 2017, such a disruption would cause a lack of sourcing for Bulgaria, impeding the filling of underground storage facilities. This situation could lead to a deepening of the problem identified during winter 2017/2018, because the underground storage facilities would be empty.
  - Some potential problems were also identified in Hungary and Romania in summer 2017, if a gas supply disruption via Ukraine lasted more than 45 and 138 days, respectively.
  - For Hungary during summer 2020, a Ukrainian disruption should not last longer than 37 days.

All these identified problems would be fully solved by the commissioning of the planned projects in the following years.

Image courtesy of GRTgaz Deutschland

NATURAL GAS AS A PERSPECTIVE FUEL IN TRANSPORTATION

- Economic growth is associated with increased transportation demands. However, due to urbanisation tendencies, metropolitan cities often suffer from vehicular overcrowding and from the resulting harmful pollutants produced by commercial diesel vehicles, especially when used in a stop-and-go mode. Consequently, environmental legislation in Europe is also increasingly demanding and stringent, which brings natural gas into focus as an alternative transportation fuel. This could replace petrol and diesel while maintaining the successful principle of combustion engines.
- Natural gas (NG) is more environmentally friendly than its counterparts (petroleum-based fuels) and produces fewer greenhouse gas emissions and other air pollutants (PM, NO_x, etc.). Promoting the use of natural gas vehicles (NGVs[3)]) is therefore considered to be one of the most important strategies towards sustainable transportation.
- Over the last ten years, natural gas as a transportation fuel has experienced significant success in terms of adoption in various countries around the world and in the CEE region. That is because NG also offers apparent economic advantages. Especially when diesel vehicles must meet stringent EURO 6/VI emissions standards, their engines have become technically overcomplicated, which has also resulted in a noticeable increase in investment and powertrain repair costs. Thus, natural gas vehicles offer the lowest fuel costs, regular maintenance costs, and lower powertrain repair costs compared to diesel vehicles, with only slightly higher investment costs. Thus, the total costs of ownership of NGVs are the lowest of any other alternative, if such vehicles are intensively used. The economic advantage of NGVs may become even more pronounced with expected future increases in crude oil prices.
- The European Commission is well aware of the environmental, economic, and strategic advantages of using NG in transportation. Thus, the European Commission has adopted legislation providing for the use of NG in transportation the necessary groundwork for its future development. For example, it issued Directive 94/2014/EU on the deployment of alternative fuels infrastructure.
- The future expected increase in the usage of natural gas in the transportation sector, as a low-emission greenhouse gas (GHG) fuel alternative, alerts TSOs to facilitate the transmission of NG volumes used in transportation, to foster a further extended gas supply in the CEE region, and to make another step towards reaching EU climate targets in an efficient way.

3) A natural gas vehicle (NGV) is an alternative fuel vehicle that is fueled either by compressed natural gas (CNG) or liquefied natural gas (LNG). The only difference between CNG and LNG is that the former is not liquefied; in other words, they are stored in a different state of matter. However, the combustion engines of CNG and LNG vehicles do not differ, as they both combust NG in the gaseous phase.

1 Introduction

Image courtesy of NET4GAS

The Gas Regional Investment Plans (GRIPs) are being preparing as requirements to promote regional cooperation, which is enshrined in EU Directive 2009/73/EC, Article 7 and further detailed by REG 715/2009, Article 12. This report represents the third edition of the Gas Regional Investment Plan for Central and Eastern Europe (CEE GRIP) and provides a specific regional view of supply, demand, and capacity developments in the CEE region for the upcoming decade (2017–2026).

The aim of this report is to support and add to the previously published EU-wide Ten-Year Network Development Plan 2017[1)] (TYNDP 2017) prepared by the European Network of Transmission System Operators for Gas (ENTSOG). The goal is to provide additional information focusing on the CEE region and to emphasise the regional gas infrastructure outlook by assessing the basis for identification of potential future gas infrastructure needs in the region. This CEE GRIP edition is the first one which is fully based on a harmonised data set, as was used for developing the TYNDP 2017, which ensures consistency between these two reports. Due to the fact that the CEE GRIP is published after the TYNDP 2017, where the project status reflects the situation as of May 2016, the contributing transmission system operators (TSOs) in the CEE GRIP took the opportunity to present the updated commissioning years of the infrastructure projects planned in this region. If any modifications to the source data from the TYNDP 2017 were used in this report, they are clearly explained in the text of specific chapters and annexes. The difference between the TYNDP 2017 and the CEE GRIP is also in the time period analysed. While the TYNDP 2017 looks 20 years ahead due to REG 347/2013 and the ESW-CBA methodology currently in force (approved by the European Commission in February 2015), the CEE GRIP focuses on a 10-year timeline to provide more precise information about the near future.

Beyond the TYNDP 2017, the CEE GRIP provides an additional overview of broader gas market dynamics by looking at aspects linked to supply scenarios, market integration, and the security of supply (SoS) on the regional level. The key analysed areas which formed the main focus of this report are:

- The future development of gas transmission infrastructure in the CEE region
- Specific simulations of network modelling to assess market integration and SoS
- The development of a regional approach to SoS demand and supply scenarios
- CEE GRIP Regional N-1 analysis up to a 10-year time frame
- A detailed focus on the potential of natural gas in the transportation sector

The general methodological approach used in the CEE GRIP is based on the one used in the TYNDP 2017. For analyses and results carried out beyond the focus of the TYNDP 2017, the description of the specific methodology used is detailed in the respective chapters concerned. The status and all data used in the report reflect the best information available at the moment of collection. Through the present document, the CEE TSOs support the exchange of valuable information and analysis for all implied actors and assist the market in assessing gas infrastructure needs in the CEE region.

1) The EU-wide Ten-Year Network Development Plan 2017 is available under the following link: http://www.entsog.eu/publications/tyndp#ENTSOG-TEN-YEAR-NETWORK-DEVELOPMENT-PLAN-2017

TSOs CONTRIBUTING TO THE CEE GRIP

The CEE GRIP region covers 10 countries, with the involvement of 18 TSOs. The complete list of countries and TSOs contributing to the CEE GRIP is presented in table 1.1.

Work on the third edition of the CEE GRIP was coordinated by NET4GAS, s.r.o.

The CEE GRIP document was approved by following TSOs contributing to the CEE GRIP:

- GAS CONNECT AUSTRIA GmbH
- Trans Austria Gasleitung GmbH
- Bulgartransgaz EAD
- Plinacro d.o.o.
- NET4GAS s.r.o.
- Fluxys TENP GmbH
- GASCADE Gastransport GmbH
- Gasunie Deutschland Transport Services GmbH
- GRTgaz Deutschland GmbH
- ONTRAS Gastransport GmbH
- Open Grid Europe GmbH
- terranets bw GmbH
- FGSZ Ltd.
- Magyar Gáz Tranzit ZRt.
- Gas Transmission Operator GAZ-SYSTEM S.A.
- Transgaz S.A.
- PLINOVODI d.o.o.

INVOLVED TSOs

AUSTRIA	GAS CONNECT AUSTRIA GmbH	
	Trans Austria Gasleitung GmbH	
BULGARIA	Bulgartransgaz EAD	
CROATIA	Plinacro d.o.o.	
CZECH REPUBLIC	NET4GAS, s.r.o.	
GERMANY	Fluxys TENP GmbH	
	GASCADE Gastransport GmbH	
	Gasunie Deutschland Transport Services GmbH	
	GRTgaz Deutschland GmbH	
	ONTRAS Gastransport GmbH	
	Open Grid Europe GmbH	
	terranets bw GmbH	
HUNGARY	FGSZ Ltd.	
	Magyar Gáz Tranzit ZRt.	
POLAND	Gas Transmission Operator GAZ-SYSTEM S.A.	
ROMANIA	Transgaz S.A.	
SLOVAKIA	eustream, a.s.	
SLOVENIA	Plinovodi d.o.o.	

Table 1.1: The list of TSOs contributing to the CEE GRIP 2017

2 Infrastructure Projects in the CEE Region

Image courtesy of GASCADE

The EU energy policy aims to support the development of an internal energy market that guarantees secure, competitive, and sustainable sources of energy for customers. Actions to support this policy are being undertaken in the gas sector. They focus on putting in place an appropriate regulatory framework and the adequate level of necessary infrastructure for both the present and the future. In relation to infrastructure activity, a number of developments have taken place in the Central Eastern Europe (CEE) region in recent years. This was primarily done by improving cross-border integration between individual countries, reinforcing internal network grids, and providing for the physical diversification of gas supplies in the region for the first time.

The path towards a well-functioning and competitive gas market in Central Eastern Europe is not yet complete however. The region continues to be strongly dependent on Russian gas as its major gas supply source, and the north-south gas corridor remains under development. This case shows that the activity linked to the need for new infrastructure developments to foster diversification of gas supply sources and to further improve market integration remains highly dynamic and remains part of the core business of the CEE TSOs. Such actions are expected to contribute towards the creation of a regional gas market in the CEE region with a high level of security, competition, and liquidity.

The present chapter focuses on the infrastructure level. It provides a short summary of investments that have been commissioned since the publication of the last edition of the CEE GRIP. As it was the case in the previous editions, it also gives an overview of gas projects planned for implementation in the upcoming decade. In order to reach the widest group of project promoters, the data set has been based on the process run by ENTSOG for the purpose of the TYNDP 2017. This ensures the full involvement of all relevant stakeholders, including the TSOs, fellow system operators (SSOs, LSOs), and third-party project promoters in the region.

The table below summarises investment projects that were included in the CEE GRIP 2014–2023 and have been commissioned since the release of the last CEE GRIP report in May 2014.

INVESTMENT PROJECTS COMMISSIONED AFTER THE PUBLICATION OF THE CEE GRIP 2014–2023

PROJECT PROMOTER	PROJECT NAME	CODE
Bulgartransgaz EAD	Romania–Bulgaria Interconnection (EEPR-2009-INTg-RO-BG)	TRA-F-57 [1)]
eustream, a.s.	Slovakia–Hungary interconnection	TRA-F-016
	Exit Capacity Budince	TRA-F-1047 [2)]
GASCADE Gastransport GmbH	Installing a reverse flow in Mallnow	TRA-F-292
	Installation of Nord Stream onshore project	TRA-F-289
	Extension of GASCADE grid in the context of the Nord Stream (on-shore) project	TRA-N-249
Gasunie Deutschland Transport Services GmbH	Extension of existing gas transmission capacity in the direction to Denmark – 1. Step	TRA-F-231
	Extension of existing gas transmission capacity in the direction to Denmark – 2. Step	TRA-N-232
GAZ-SYSTEM S.A.	Physical reverse flow on the metering station in Mallnow	TRA-F-326
	Upgrade of gas infrastructure in northern and central Poland	TRA-F-248
	Upgrade of the entry points in Włocławek on the Yamal-Europe pipeline	TRA-N-276
	LNG terminal in Świnoujście	LNG-F-246
	Increase of reverse capacity at Mallnow interconnection point	TRA-F-893
	Physical reverse capacity at Lasów interconnection point	TRA-F-897
Magyar Gáz Tranzit ZRt.	Slovak-Hungarian interconnector (Vecsés–Szada–Balassagyarmat)	TRA-F-148
Plinovodi d.o.o.	CS Kidričevo (3rd unit 3.5 MW)	TRA-F-096
	M2/1 Trojane – Vodice	TRA-F-097
	M2/1 Rogaška Slatina – Trojane	TRA-F-104
	MRS Šempeter – Reconstruction	TRA-F-110
SNTGN Transgaz S.A.	RO–BG Interconnection	TRA-F-029
terranets bw GmbH	Nordschwarzwaldleitung	TRA-N-228

1) This project was not in the CEE GRIP 2014–2023, but it was commissioned in November 2016.
2) This project was not in the CEE GRIP 2014–2023, but it was commissioned by the end of 2016

Table 2.1: Investment projects commissioned after the publication of the CEE GRIP 2014–2023

TSOs and other project promoters submitted a total of 111 investment projects within the geographical coverage area of the CEE GRIP 2017 in the TYNDP 2017. These projects are planned to be commissioned in the upcoming decade and include projects that have not been used in any assessment due to absence of their mirror projects (= follow-up projects).

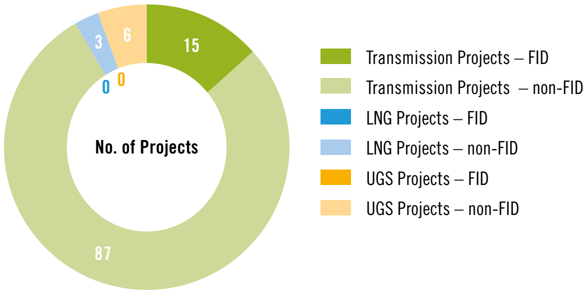


Figure 2.1: Investment projects included in the CEE GRIP 2017 by type and implementation status

The following tables present the main information on the projects within the geographical coverage area of the CEE GRIP 2017. The third editions of the Gas Regional Investment Plans shall be based on the data used in the TYNDP 2017. Therefore, the tables are based on the information submitted in the TYNDP 2017[1)], but they have been extended by updated project commissioning dates which reflect the situation as of January 2017. **For the sake of clarity, the presented updates have no impact on the assessments and analysis provided in the following chapters in this report.**

More detailed data concerning these projects is available in the CEE GRIP Annex A – Infrastructure projects. This annex represents an extract from the TYNDP 2017 Annex A.

1) The TYNDP 2017 reflects the project status as of May 2016

Austria

LIST OF PROJECTS IN AUSTRIA

TYNDP 2017	Name	Promoter	Expected commissioning year (according to TYNDP 2017)	Update of expected commissioning year	PCI (2nd list)
• TRA-N-954	TAG Reverse Flow	Trans Austria Gasleitung GmbH	2018	**2019**	No
TRA-N-361	GCA 2015/08: Entry/Exit Murfeld	GAS CONNECT AUSTRIA GmbH	2019	2019	Yes
TRA-N-021	Bidirectional Austrian-Czech Interconnector (BACI, formerly LBL project)	GAS CONNECT AUSTRIA GmbH	2020	2020	Yes
• TRA-N-423	GCA Mosonmagyaróvár	GAS CONNECT AUSTRIA GmbH	2020	2020	Yes
TRA-N-801	Břeclav-Baumgarten Interconnection (BBI) AT	GAS CONNECT AUSTRIA GmbH	2020	**Unknown**	No

• Project not marked on the map

Table 2.2: List of projects in Austria

Bulgaria

LIST OF PROJECTS IN BULGARIA

	TYNDP 2017	Name	Promoter	Expected commissioning year (according to TYNDP 2017)	Update of expected commissioning year	PCI (2nd list)
	TRA-F-137	Interconnection Bulgaria – Serbia	Ministry of Energy	2018	**2020**	Yes
	TRA-F-378	Interconnector Greece-Bulgaria (IGB Project)	ICGB a.d.	2018	**2020**	Yes
•	TRA-N-379	A project for the construction of a gas pipeline BG – RO	Bulgartransgaz EAD	2018	**Unknown**	Yes
	TRA-N-140	Interconnection Turkey-Bulgaria	Bulgartransgaz EAD	2020	2020	Yes
•	TRA-N-298	Rehabilitation, Modernisation and Expansion of the NTS	Bulgartransgaz EAD	2020	2020	Yes
	TRA-N-654	Eastring – Bulgaria	Bulgartransgaz EAD	2021	2021	Yes
	UGS-N-138	UGS Chiren Expansion	Bulgartransgaz EAD	2022	2022	Yes
	TRA-N-592	Looping CS Valchi Dol – Line valve Novi Iskar	Bulgartransgaz EAD	2022	2022	Yes
	TRA-N-593	Varna-Oryahovo gas pipeline	Bulgartransgaz EAD	2022	2022	Yes
	TRA-N-594	Construction of a Looping CS Provadia – Rupcha village	Bulgartransgaz EAD	2022	2022	Yes
•	UGS-N-141	Construction of new gas storage facility on the territory of Bulgaria	Bulgartransgaz EAD	Unknown	Unknown	No

• Project not marked on the map

Table 2.3: List of projects in Bulgaria

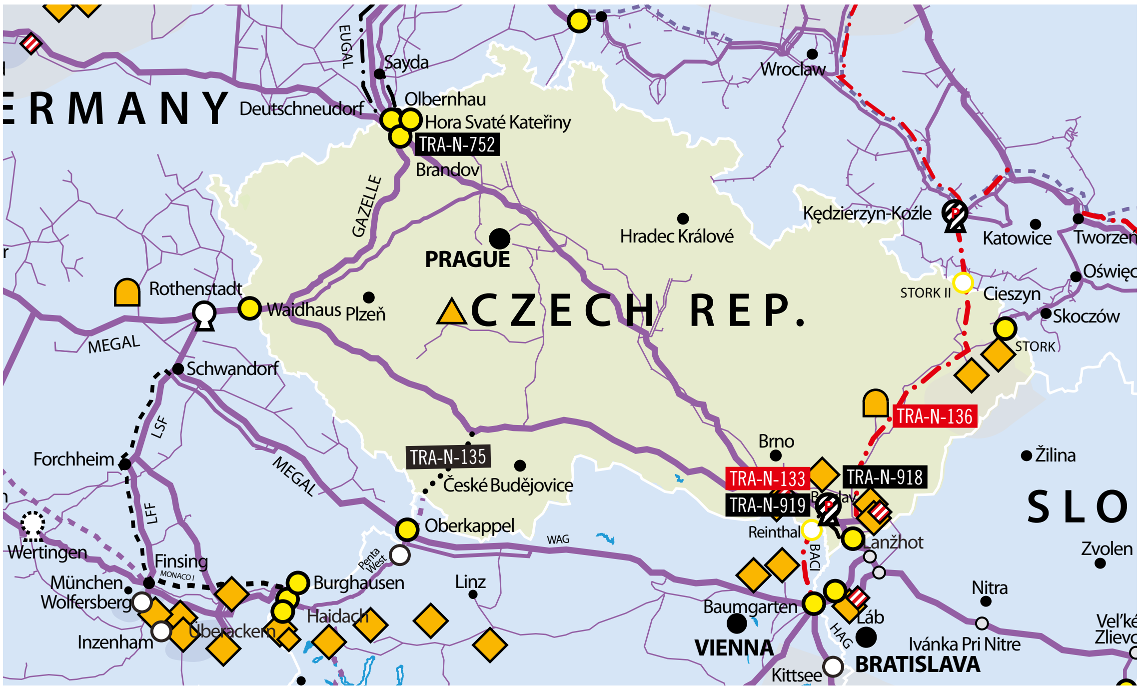
Croatia

TYNDP 2017	Name	Promoter	Expected commissioning year (according to TYNDP 2017)	Update of expected commissioning year	PCI (2nd list)
TRA-F-334	Compressor station 1 at the Croatian gas transmission system	Plinacro Ltd	2017	**2019**	Yes
LNG-N-082	LNG terminal Krk	LNG Hrvatska d.o.o.	2018	**2020** 1)	Yes
TRA-N-90	LNG evacuation pipeline Omišalj – Zlobin (Croatia)	Plinacro Ltd	2018	**2019** 1)	No
TRA-F-86	Interconnection Croatia/Slovenia (Lučko – Zabok – Rogatec)	Plinacro Ltd	2019	2019	Yes
TRA-N-066	Interconnection Croatia –Bosnia and Herzegovina (Slobodnica – Bosanski Brod)	Plinacro Ltd	2019	2019	No
TRA-N-075	LNG evacuation pipeline Zlobin-Bosiljevo-Sisak-Kozarac	Plinacro Ltd	2020	2020	Yes
TRA-N-1057	Compressor stations 2 and 3 at the Croatian gas transmission system	Plinacro Ltd	2020	2020	Yes
TRA-N-302	Interconnection Croatia-Bosnia and Herzegovina (South)	Plinacro Ltd	2021	2021	No
TRA-N-068	Ionian Adriatic Pipeline	Plinacro Ltd	2022	2022	No
TRA-N-070	Interconnection Croatia/Serbia (Slobdnica-Sotin-Bačko Novo Selo)	Plinacro Ltd	2023	2023	No
TRA-N-1058	LNG Evacuation Pipeline Kozarac-Slobodnica	Plinacro Ltd	2023	2023	Yes
TRA-N-303	Interconnection Croatia-Bosnia and Herzegovina (west)	Plinacro Ltd	2026	2026	No
TRA-N-336	Interconnection Croatia/Slovenia (Umag-Koper)	Plinacro Ltd	2026	2026	No

1) Update of expected commissioning year reflects a situation as of February 2017.

Table 2.4: List of projects in Croatia

Czech Republic



LIST OF PROJECTS IN CZECH REPUBLIC

TYNDP 2017	Name	Promoter	Expected commissioning year (according to TYNDP 2017)	Update of expected commissioning year	PCI (2nd list)
TRA-N-136	Poland-Czech Republic Interconnection (CZ)	NET4GAS, s.r.o.	2019	**2022**	Yes
TRA-N-752	Capacity4Gas (C4G) – DE/CZ	NET4GAS, s.r.o.	2019	2019	No
TRA-N-918	Capacity4Gas (C4G) – CZ/SK	NET4GAS, s.r.o.	2019	2019	No
TRA-N-133	Bidirectional Austrian Czech Interconnection (BACI)	NET4GAS, s.r.o.	2020	2020	Yes
TRA-N-919	Capacity4Gas (C4G) – CZ/AT	NET4GAS, s.r.o.	2020	**Cancelled**	No
TRA-N-135	Connection to Oberkappel	NET4GAS, s.r.o.	2022	**Unknown**	No

Table 2.5: List of projects in Czech Republic

Germany


NOGAT
NORPIPE
EUROPIPE
EUROPIPE II
Ellund
DEUDAN
Trelleborg
BALTIC PIPE
Greifswald
TRA-F-768
Świnoujście
Kamminke
Szczecin
TRA-N-763
EUGAL
OPAL
NEL
Quarnstedt
Hamburg
TRA-N-807
RHG
Groningen
Dornum
NGT
Emden
TRA-N-949
Oude Statenzijl
Bunde
Bunder-Tief
TRA-N-951
Wardenburg
Oldenburg
NOWAL
ERLANDS
AMSTERDAM
Vlieghuis
Nordlohne
Emsbüren
Rehden
Drohne
TRA-F-291
Steinitz
Enschede
Ahlten
Hannover
BERLIN
Mallnow
Kienbaum
Winterswijk
Legden
TRA-N-825
Münster
WEDAL
Zevenaar
Werne
TRA-F-345
TRA-N-329
Essen
Dortmund
Tegelen
Haanrade
Düsseldorf
ZEELINK
Guben
Gubin
Kassel
MIDAL
Leipzig
Broichweiden
Bocholtz
Stolberg
Eynatten
Raeren/Lichtenbusch
Lasów
Reckrod
GERMANY
TRA-F-344
Herbstein
Sayda
Olbernhau
Hora Svaté Kateřiny
Deutschneudorf
TRA-N-814
Brandov
GAZELLE
LUX.
TENP
Remich
Gernsheim
MEGAL
Rimpar
TRA-N-755
Lampertheim
Rothenstadt
Waidhaus
Plzeň
PRAGUE
CZECH
TRA-F-337
TRA-F-753
Schwandorf
Obergailbach
Medelsheim
Karlsruhe
Au am Rhein
Stuttgart
Leonberg
LSF
TRA-F-343
Forchheim
Amerdingen
TRA-N-340
Wertingen
České Budějovice
Oberkappel
WAG
Finsing
MONACO I
TRA-F-241
Burghausen
Penta West
Linz
München
Wolfersberg
Haiming
Überackern
Inzenham
Haidach
TRA-F-208
Fallentor
Wallbach
Oltingue
Basel
Thayngen
Lindau
Leiblach
Pfronten
Kiefersfelden
Kufstein
Salzburg
Rodersdorf
Zürich
LIECHT.
Innsbruck
BERN
AUSTRIA

LIST OF PROJECTS IN GERMANY

	TYNDP 2017	Name	Promoter	Expected commissioning year (according to TYNDP 2017)	Update of expected commissioning year	PCI (2nd list)
	TRA-N-814	Upgrade IP Deutschneudorf and Lasow	ONTRAS Gastransport GmbH	2016	**2019**	No
	TRA-F-241	MONACO section phase I (Burghausen-Finsing)	bayernets GmbH	2017	2017	No
	TRA-F-291	NOWAL – Nord West Anbindungsleitung	GASCADE Gastransport GmbH	2017	2017	No
	TRA-F-768	Extension Receiving Terminal Greifswald	NEL Gastransport GmbH, Gasunie Deutschland Transport Services GmbH, Fluxys Deutschland GmbH	2017	2017	No
	TRA-F-208	Reverse Flow TENP Germany	Fluxys TENP GmbH, Open Grid Europe GmbH	2018	2018	Yes
	TRA-F-337	CS Rothenstadt	GRTgaz Deutschland GmbH	2018	2018	No
	TRA-F-343	Pipeline project "Schwandorf-Finsing"	Open Grid Europe GmbH	2018	2018	No
	TRA-F-344	Compressor station "Herbstein"	Open Grid Europe GmbH	2018	2018	No
	TRA-F-345	Compressor station "Werne"	Open Grid Europe GmbH	2018	2018	No
	TRA-F-753	West to East operation of the IP Waidhaus	GRTgaz Deutschland GmbH	2018	2018	No
•	TRA-F-937	Nord Stream 2	Nord Stream 2 AG	2019	2019	No
	TRA-N-340	VDS Wertingen	bayernets GmbH	2019	2019	No
	TRA-N-763	EUGAL – Europäische Gasanbindungsleitung (European Gaslink)	GASCADE Gastransport GmbH	2019	2019	No
	TRA-N-807	Expansion NEL	NEL Gastransport GmbH, Gasunie Deutschland Transport Services GmbH, Fluxys Deutschland GmbH	2020	2020	No
	TRA-N-949	Oude(NL) – Bunde(DE) GTG H-Gas	Gastransport Nord GmbH	2020	2020	No
	TRA-N-951	Embedding CS Folmhusen in H-Gas	Gasunie Deutschland Transport Services GmbH	2020	2020	No
•	TRA-N-808	Transport of gas volumes to the Netherlands	Gasunie Deutschland Transport Services GmbH	2021	2021	No
	TRA-N-329	ZEELINK	Open Grid Europe GmbH	2021	2021	No
•	TRA-N-755	CS Rimpar	GRTgaz Deutschland GmbH	2023	2023	No
•	TRA-N-809	Additional East-West transport NL	Gasunie Deutschland Transport Services GmbH	2023	2023	No
	TRA-N-825	Compressor station "Legden"	Open Grid Europe GmbH	2023	2023	No
•	TRA-N-955	GUD: Complete conversion to H-gas	Gasunie Deutschland Transport Services GmbH	2030	2030	No

• Project not marked on the map

Table 2.6: List of projects in Germany

Hungary

LIST OF PROJECTS IN HUNGARY

TYNDP 2017	Name	Promoter	Expected commissioning year (according to TYNDP 2017)	Update of expected commissioning year	PCI (2nd list)
• TRA-N-524	Enhancement of Transmission Capacity of Slovak–Hungarian interconnector	Magyar Gáz Tranzit ZRt.	2017	**2019**	No
• TRA-N-636	Development of Transmission Capacity at Slovak–Hungarian interconnector	Magyar Gáz Tranzit ZRt.	2017	**2018**	No
TRA-N-286	Romanian–Hungarian reverse flow Hungarian section 1st stage	FGSZ Ltd.	2020	2020	Yes
TRA-N-325	Slovenian–Hungarian interconnector	FGSZ Ltd.	2020	2020	Yes
TRA-N-585	Hungarian section of Tesla project	FGSZ Ltd.	2020	2020	Yes
TRA-N-586	HU–UA reverse flow	FGSZ Ltd.	2020	2020	No
TRA-N-656	Eastring – Hungary	FGSZ Ltd.	2021	2021	Yes
TRA-N-831	Vecsés – Városföld gas transit pipeline	Magyar Gáz Tranzit ZRt.	2021	2021	No
TRA-N-018	Városföld – Ercsi – Győr	FGSZ Ltd.	2022	2022	Yes
TRA-N-061	Ercsi – Szazhalombatta	FGSZ Ltd.	2022	2022	Yes
TRA-N-123	Városföld CS	FGSZ Ltd.	2022	2022	Yes
TRA-N-377	Romanian–Hungarian reverse flow Hungarian section 2nd stage	FGSZ Ltd.	2022	2022	Yes
TRA-N-380	BG – RO – HU – AT transmission corridor	FGSZ Ltd.	2024	2024	No
TRA-N-065	Hajduszoboszlo CS	FGSZ Ltd.	Unknown	Unknown	No

• Project not marked on the map

Table 2.7: List of projects in Hungary

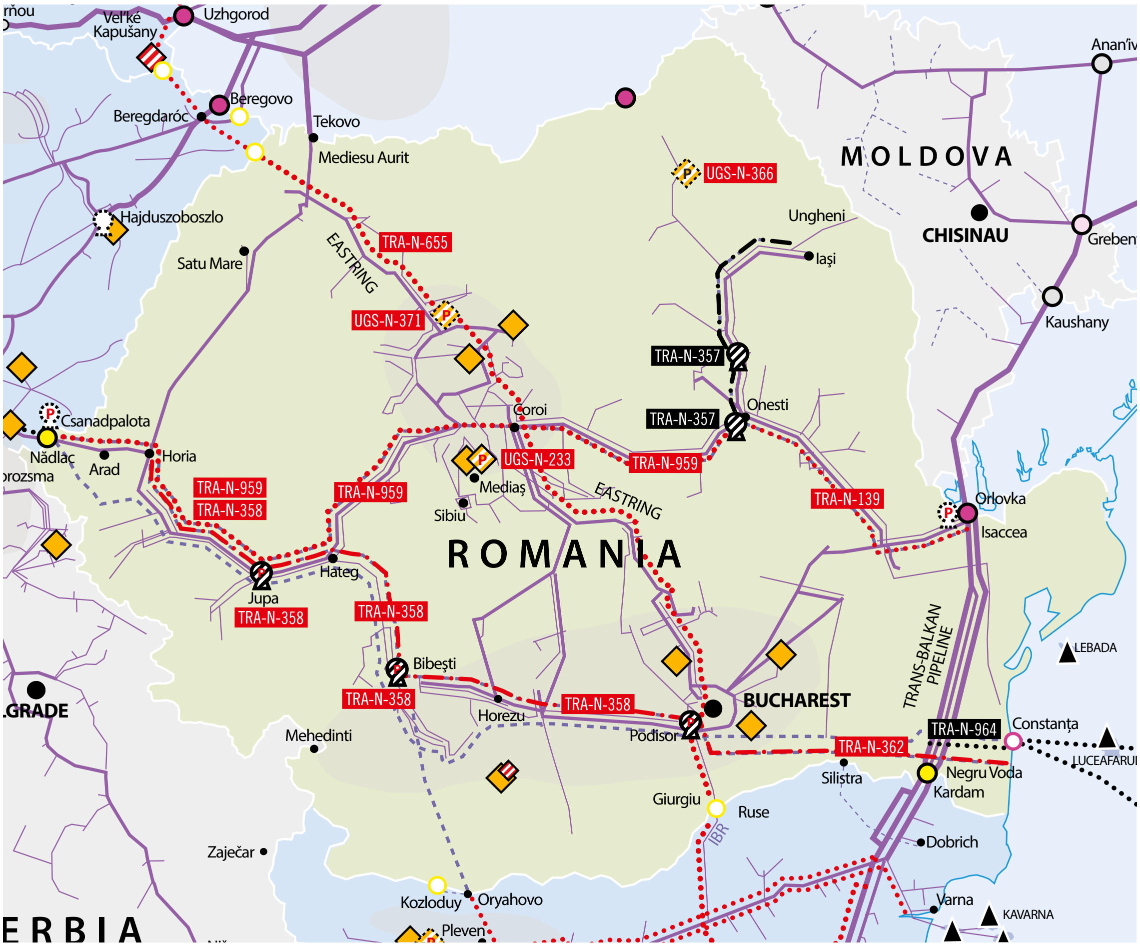
Poland

LIST OF PROJECTS IN POLAND

TYNDP 2017	Name	Promoter	Expected commissioning year (according to TYNDP 2017)	Update of expected commissioning year	PCI (2nd list)
TRA-N-212	Gas Interconnection Poland-Lithuania (GIPL) – PL section	GAZ-SYSTEM S.A.	2019	**2021**	Yes
TRA-N-247	North – South Gas Corridor in Western Poland	GAZ-SYSTEM S.A.	2019	2019	Yes
TRA-N-273	Poland – Czech Republic interconnection (PL section)	GAZ-SYSTEM S.A.	2019	**2022**	Yes
TRA-N-275	Poland – Slovakia interconnection (PL section)	GAZ-SYSTEM S.A.	2019	**2021**	Yes
LNG-N-272	Upgrade of LNG terminal in Świnoujście	GAZ-SYSTEM S.A.	2020	2020	Yes
TRA-N-621	Poland – Ukraine Gas interconnection (PL section)	GAZ-SYSTEM S.A.	2020	2020	No
LNG-N-947	FSRU Polish Baltic Sea Coast	GAZ-SYSTEM S.A.	2020	2020	No
TRA-N-271	Poland – Denmark interconnection (Baltic Pipe) – PL section	GAZ-SYSTEM S.A.	2022	2022	Yes
TRA-N-245	North – South Gas Corridor in Eastern Poland	GAZ-SYSTEM S.A.	2023	2023	Yes
UGS-N-914	UGS Damasławek	GAZ-SYSTEM S.A.	2026	2026	No

Table 2.8: List of projects in Poland

Romania


Uzhgorod
Veľké Kapušany
Beregovo
Beregdaróc
Tekovo
Mediesu Aurit
Hajduszoboszlo
Satu Mare
EASTRING
TRA-N-655
UGS-N-371
UGS-N-366
MOLDOVA
CHISINAU
Ungheni
Iaşi
Ananiv
Grebeni
Kaushany
TRA-N-357
TRA-N-357
Onesti
Csanadpalota
Nădlac
Arad
Horia
TRA-N-959
TRA-N-358
TRA-N-959
Coroi
UGS-N-233
TRA-N-959
Mediaş
Sibiu
EASTRING
TRA-N-139
Orlovka
Isaccea
ROMANIA
Haţeg
Jupa
TRA-N-358
TRA-N-358
Bibeşti
TRA-N-358
TRA-N-358
Horezu
Podişor
BUCHAREST
TRANS-BALKAN PIPELINE
LEBADA
TRA-N-964
Constanța
LUCEAFARUL
TRA-N-362
Silistra
Negru Voda
Kardam
Mehedinti
Giurgiu
Ruse
IBR
Dobrich
Zaječar
Kozloduy
Oryahovo
Pleven
Varna
KAVARNA
GRADE
ERBIA

LIST OF PROJECTS IN ROMANIA

TYNDP 2017	Name	Promoter	**Expected commissioning year** (according to TYNDP 2017)	Update of expected commissioning year	**PCI** (2nd list)
TRA-N-357	NTS developments in North-East Romania	SNTGN Transgaz S.A.	2018	2018	No
UGS-N-233	Depomures	Engie Romania S.A.	2019	2019	Yes
TRA-N-139	Interconnection of the NTS with the DTS and reverse flow at Isaccea	SNTGN Transgaz S.A.	2019	2019	Yes
TRA-N-964	New NTS developments for taking over gas from the Black Sea shore	SNTGN Transgaz S.A.	2019	2019	No
TRA-N-358	Development on the Romanian territory of the NTS (BG – RO – HU – AT Corridor)	SNTGN Transgaz S.A.	2020	2020	Yes
TRA-N-362	Development on the Romanian territory of the Southern Transmission Corridor	SNTGN Transgaz S.A.	2020	**2021**	Yes
TRA-N-655	Eastring – Romania	SNTGN Transgaz S.A.	2021	2021	Yes
• TRA-N-053	White Stream	White Stream Ltd.	2022	2022	No
UGS-N-371	Sarmasel undeground gas storage in Romania	Societatea Națională de Gaze Naturale ROMGAZ S.A.	2022	2022	Yes
UGS-N-366	New undergound gas storage in Romania	Societatea Națională de Gaze Naturale ROMGAZ S.A.	2023	2023	Yes
TRA-N-959	Further enlargement of the BG – RO – HU – AT transmission corridor (BRUA) phase 3	SNTGN Transgaz S.A.	2023	2023	Yes
• TRA-N-376	Azerbaijan, Georgia, Romania Interconnector – AGRI	AGRI LNG Project Company SRL (RO)	2026	2026	No

• Project not marked on the map

Table 2.9: List of projects in Romania

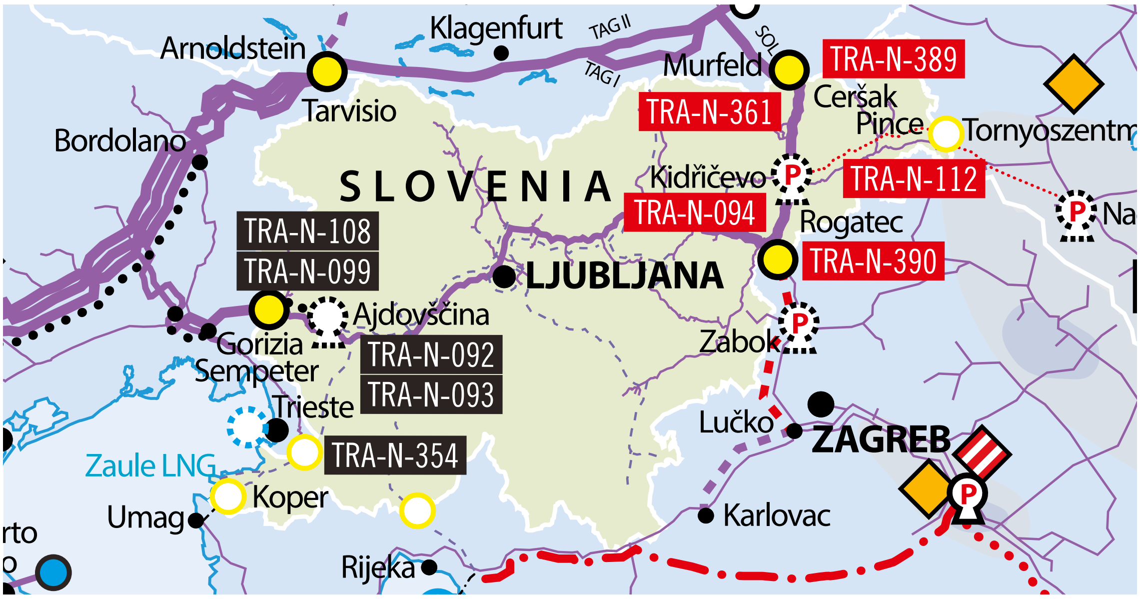
Slovakia

LIST OF PROJECTS IN SLOVAKIA

TYNDP 2017	Name	Promoter	Expected commissioning year (according to TYNDP 2017)	Update of expected commissioning year	PCI (2nd list)
TRA-N-190	Poland – Slovakia interconnection	eustream, a.s.	2019	**2021**	Yes
TRA-N-902	Capacity increase at IP Lanžhot entry	eustream, a.s.	2019	**2020**	No
TRA-N-628	Eastring – Slovakia	Eastring B.V.	2021	2021	Yes
TRA-F-017	System Enhancements – Eustream	eustream, a.s.	2026	2026	No

Table 2.10: List of projects in Slovakia

Slovenia



LIST OF PROJECTS IN SLOVENIA

TYNDP 2017	Name	Promoter	Expected commissioning year (according to TYNDP 2017)	Update of expected commissioning year	PCI (2nd list)
• TRA-N-365	M6 Ajdovščina – Lucija	Plinovodi d.o.o.	2019	**2020**	No
TRA-N-390	Upgrade of Rogatec interconnection (M1A/1 Interconnection Rogatec)	Plinovodi d.o.o.	2020	2020	Yes
TRA-N-094	CS Kidričevo, 2nd phase of upgrade	Plinovodi d.o.o.	2020	2020	Yes
TRA-N-108	M3 pipeline reconstruction from CS Ajdovščina to Šempeter/Gorizia	Plinovodi d.o.o.	2020	2020	No
TRA-N-112	R15/1 Pince – Lendava – Kidričevo	Plinovodi d.o.o.	2020	2020	Yes
TRA-N-389	Upgrade of Murfeld/Ceršak interconnection (M1/3 Interconnection Ceršak)	Plinovodi d.o.o.	2020	2020	Yes
TRA-N-092	CS Ajdovščina, 1st phase of upgrade	Plinovodi d.o.o.	2021	2021	No
TRA-N-093	CS Ajdovščina, 2nd phase of upgrade	Plinovodi d.o.o.	2022	2022	No
TRA-N-099	M3/1a Šempeter – Ajdovščina	Plinovodi d.o.o.	2022	2022	No
• TRA-N-101	M8 Kalce – Jelšane	Plinovodi d.o.o.	2022	2022	No
• TRA-N-107	M6 Interconnection Osp	Plinovodi d.o.o.	2022	2022	No
• TRA-N-261	M3/1c Kalce – Vodice	Plinovodi d.o.o.	2022	2022	No
• TRA-N-262	M3/1b Ajdovščina – Kalce	Plinovodi d.o.o.	2022	2022	No
• TRA-N-114	R61 Dragonja – Izola	Plinovodi d.o.o.	2024	2024	No

• Project not marked on the map

Table 2.11: List of projects in Slovenia

3 Assessment – Infrastructure Resilience in the CEE Region

Image courtesy of ONTRAS

3.1 General Note

This assessment chapter focuses on the ability of the European gas system to meet the supply-demand balance under stress scenarios. The CEE GRIP provides a look at two different stress scenarios which were not presented in the TYNDP 2017. These stress scenarios are a simultaneous disruption of the gas supply routes via Ukraine and Belarus and a disruption of the Russian gas supply source. The situation under normal conditions is also presented in the chapter in order to provide a baseline comparison as to how the CEE region is affected by these two specific stress scenarios.

Assessment results for CEE GRIP-specific simulations are based on the TYNDP 2017 methodology and data set. Specifically, all data serving as the basis for infrastructure modelling in the CEE region originate from the TYNDP 2017, and all relevant data were collected by ENTSOG in a dedicated collection process. The ENTSOG simulation tool was used to model the scenarios described, which ensures consistency with the TYNDP 2017.

The ENTSOG model works on a top-down approach when countries are used as the basic blocks interlinked by cross-border capacity. Applicable capacity is the sum of technical capacity at interconnection points between two neighbouring countries and the application of the "lesser-of-rule" to the values of the capacity at both sides of the border for each interconnection point (IP). Storage facilities, national gas production, and LNG terminals enter the model within the corresponding country and not according to their territorial location. Further, the model assumes that each modelled country represents a single entry/exit zone. Therefore, the consideration of internal interconnections is limited. The European approach does not consider potential internal bottlenecks, gas quality issues, and the adaptation of national infrastructure to disruption scenarios. As stated in the TYNDP 2017, the assessment is carried out from a European perspective, under the assumption of perfect market functioning. This ensures a focus on conclusions where solving the identified gap cannot be managed by market or regulatory rules and would presumably require infrastructure development with cross-border significance.

Regarding the planned infrastructure projects, only the full years of a project's operation are considered in the assessment. This means that the first full year of operation used in the assessment is the first full calendar year following the expected commissioning date (the expected capacity increment). All projects related to the CEE region are listed in Chapter 2 – Infrastructure Projects in the CEE Region. For more details concerning a particular infrastructure project, please see the CEE GRIP Annex A – Infrastructure Projects.

3.2 Disrupted Demand, Remaining Flexibility and Preconditions for Assessment

This analysis presents the evolution of a Disrupted Rate (DR) and a Remaining Flexibility (RF) indicator in the CEE region under the following stress scenarios modelled for the years 2017, 2020 and 2025:

- Simultaneous disruption of the gas supply routes via Ukraine and Belarus
- Disruption of the Russian gas supply source

The baseline reference scenario is the normal situation when there is no disruption. The target of this analysis is not to identify which projects might directly mitigate the risks of demand disruption or low Remaining Flexibility but to determine their impact under the stress scenarios described.

The preconditions for this assessment are based on the TYNDP 2017 methodology. The assessment is prepared under three demand scenarios1):

- Blue Transition
- Green Evolution
- EU Green Revolution

For two climatic situations:

- 1-day Design Case (DC, Peak Day)
- 2-week high demand case (2W, 14-day uniform risk)

And four infrastructure levels which are considered in the assessment:

- LOW infrastructure level
- ADVANCED infrastructure level
- PCI 2nd list infrastructure level
- HIGH infrastructure level

1) For detailed information about the methodology used, please see the TYNDP 2017 and its annexes which are available under the following link:
http://www.entsog.eu/publications/tyndp#ENTSOG-TEN-YEAR-NETWORK-DEVELOPMENT-PLAN-2017

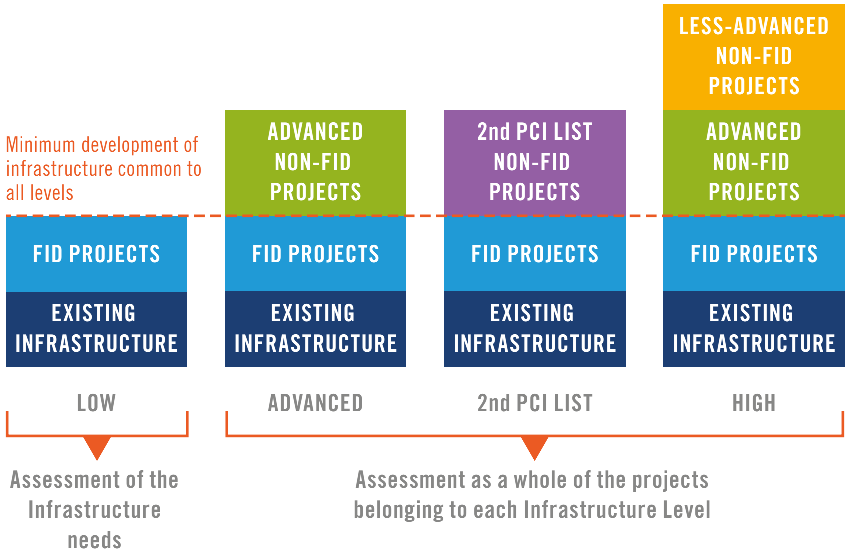


Figure 3.1: Infrastructure Levels (Source: TYNDP 2017)

All assessment results prepared for the CEE GRIP can be found in the CEE GRIP Annex B - Modelling Results. The following figure describes the differences between the infrastructure levels.

According to the TYNDP 2017 methodology, the Remaining Flexibility (RF) indicator measures the resilience of a zone (at the country level). The indicator is calculated for high demand situations as the additional share of demand each country is able to cover before an infrastructure or supply limitation is reached. This calculation is made independently for each country, meaning that they do not share European supply flexibility. The higher the indicator value is, the better the resilience. In cases where countries experience disrupted demand, the Remaining Flexibility is equal to zero.

The Disrupted Rate (DR) represents the share of the gas demand that cannot be satisfied. It is calculated as a daily volume. The level of disruption is assessed assuming cooperative behaviour between European countries in order to mitigate its relative impact. This means that countries try to reduce the Disrupted Rate of other countries by sharing the load. Non-alignment of the Disrupted Rate between countries indicates an infrastructure bottleneck. The distribution of Disrupted Rate among countries is therefore a strong indication of infrastructure needs.

In this chapter, you will find a presentation of assessment results for the CEE region for the Peak Day of the Blue Transition and the Green Evolution demand scenarios for the LOW, 2nd PCI, and HIGH infrastructure levels with and without a simultaneous disruption of the gas supply routes via Ukraine and Belarus and a disruption of the Russian gas supply source. Comprehensive results for all modelled specific disruption cases for CEE GRIP can be found in CEE GRIP Annex B – Modelling Results. The results are presented for the years 2017, 2020 and 2025.

3.2.1 PEAK DAY UNDER THE NORMAL SITUATION (WITHOUT DISRUPTION)

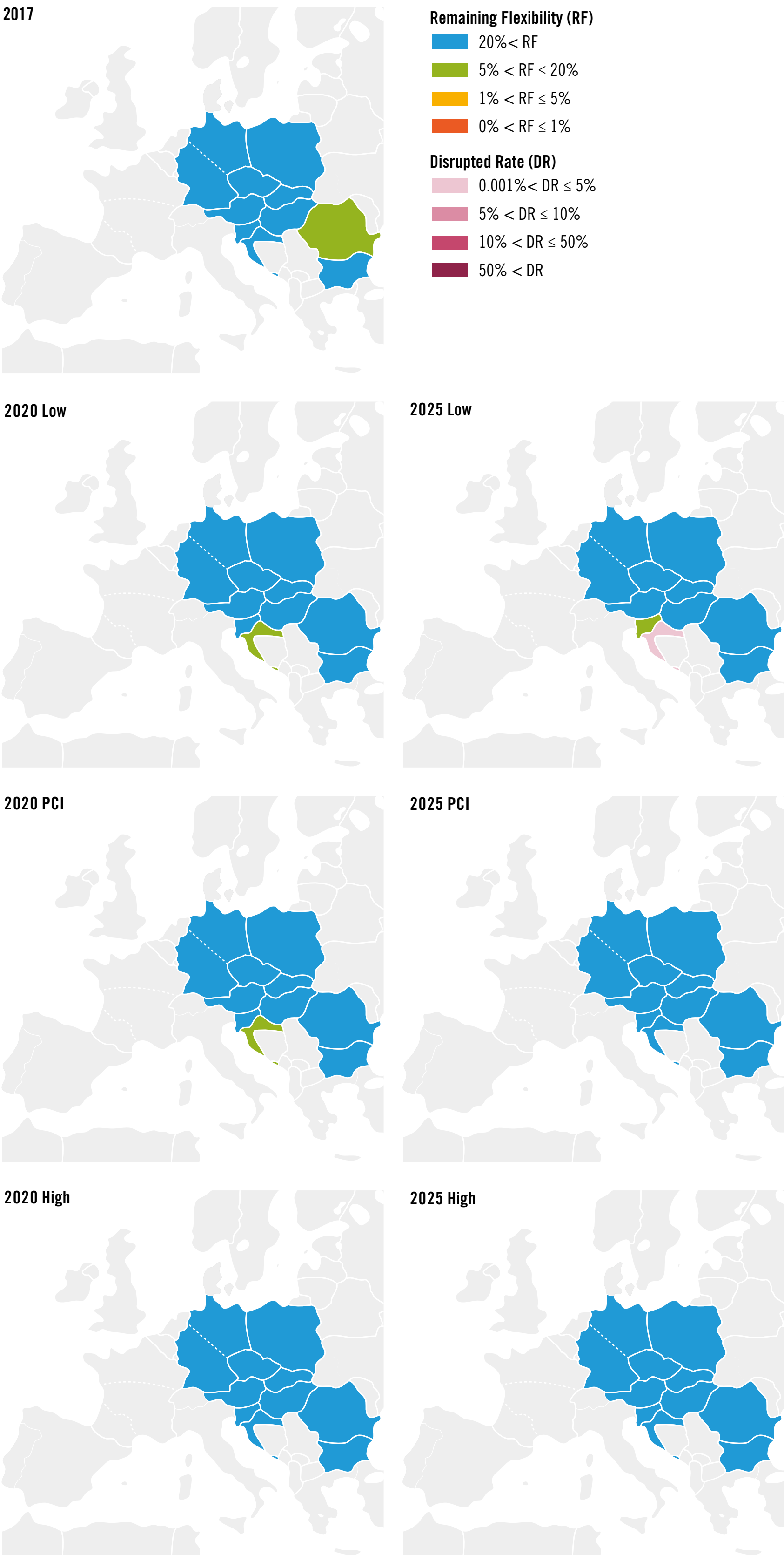


Figure 3.2: Evolution of Disrupted Rate (DR) and Remaining Flexibility (RF), Normal situation, Peak Day (DC), Blue Transition

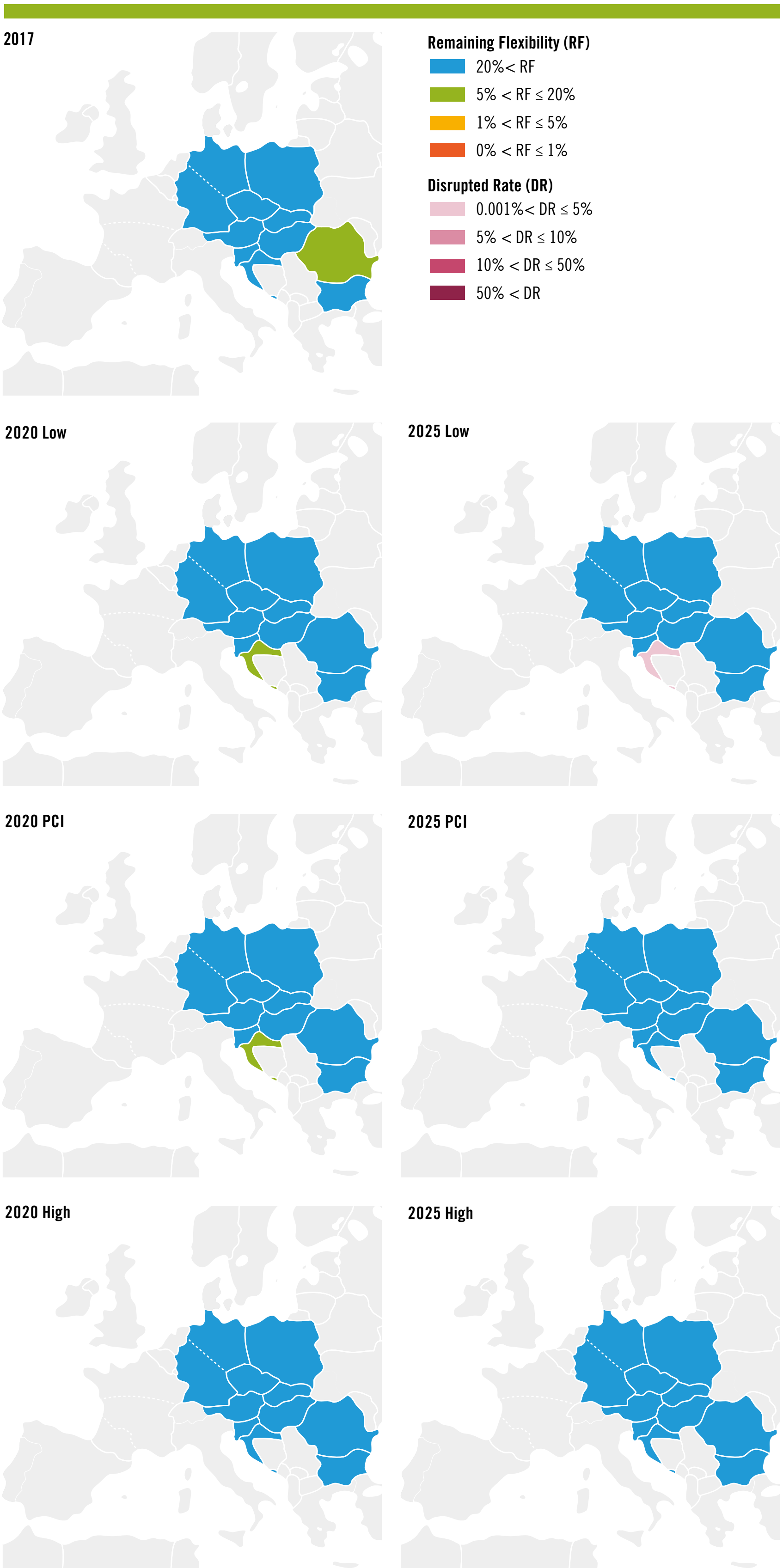


Figure 3.3: Evolution of Disrupted Rate (DR) and Remaining Flexibility (RF), Normal situation, Peak Day (DC), Green Evolution

Assessment of the peak day under the normal situation is based on the results modelled and presented in the TYNDP 2017 (TYNDP 2017 Annex E – Modelling Results) and serves as a baseline reference scenario for CEE GRIP specific disruption simulations.

Analysis of the normal situation is also part of the TYNDP 2017, and the results indicate that the European gas infrastructure, respectively in the CEE region, is able to cope with high demand situations. The differences between the Blue Transition and Green Evolution scenarios appear only in the LOW infrastructure scenario, in 2025, when the Remaining Flexibility of Slovenia will decrease.

The only country which faces a Disruption Demand under specific modelled conditions is Croatia (LOW, 2025). This is caused by increasing country demand over the long term and can be mitigated by the implementation of planned projects which belong to the PCI category.

3.2.2 PEAK DAY UNDER SIMULTANEOUS UKRAINIAN AND BELARUSIAN GAS ROUTE DISRUPTIONS

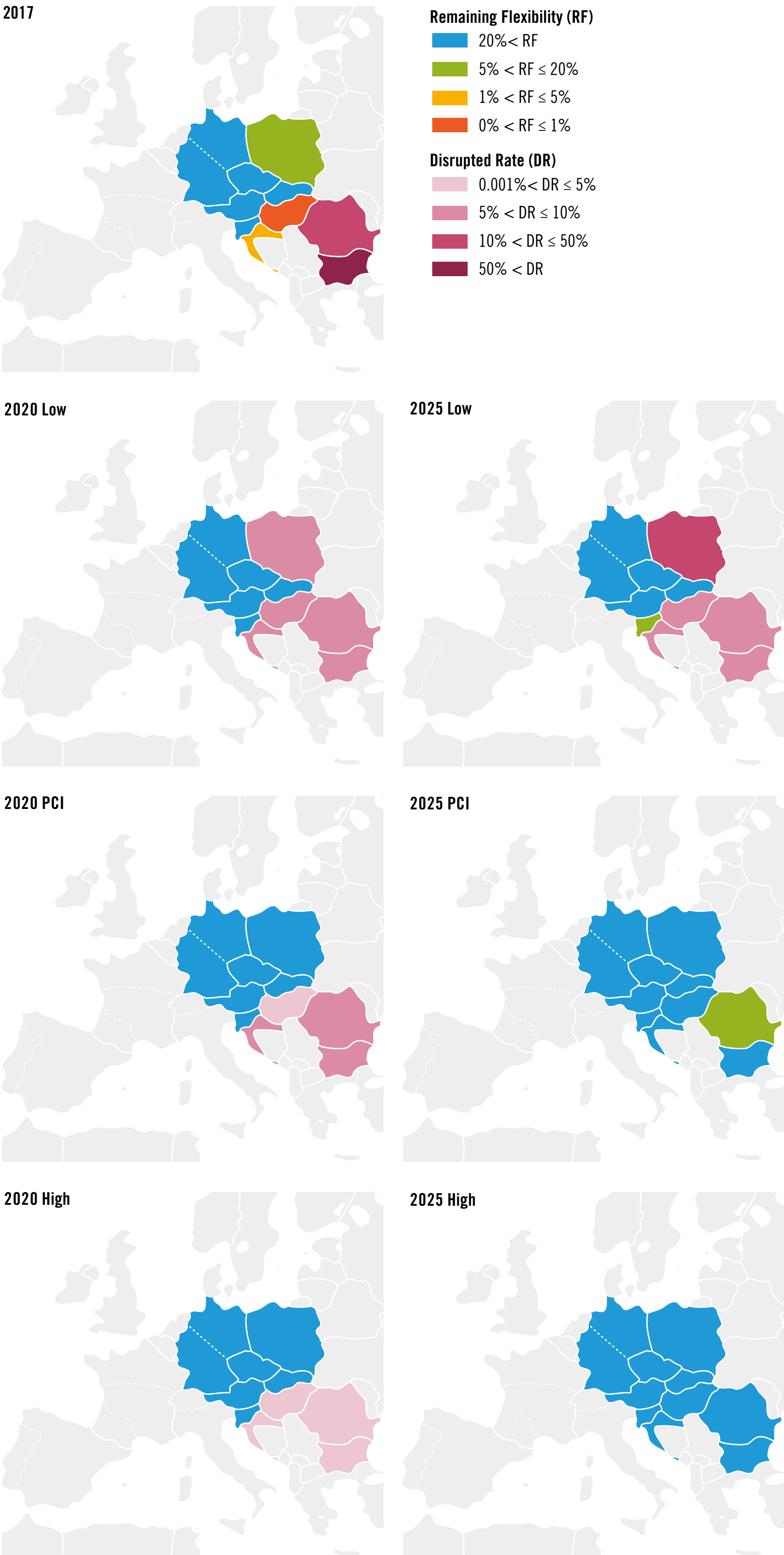


Figure 3.4: Evolution of Disrupted Rate (DR) and Remaining Flexibility (RF), Route gas disruption via Ukraine + Belarus, Peak Day (DC), Blue Transition

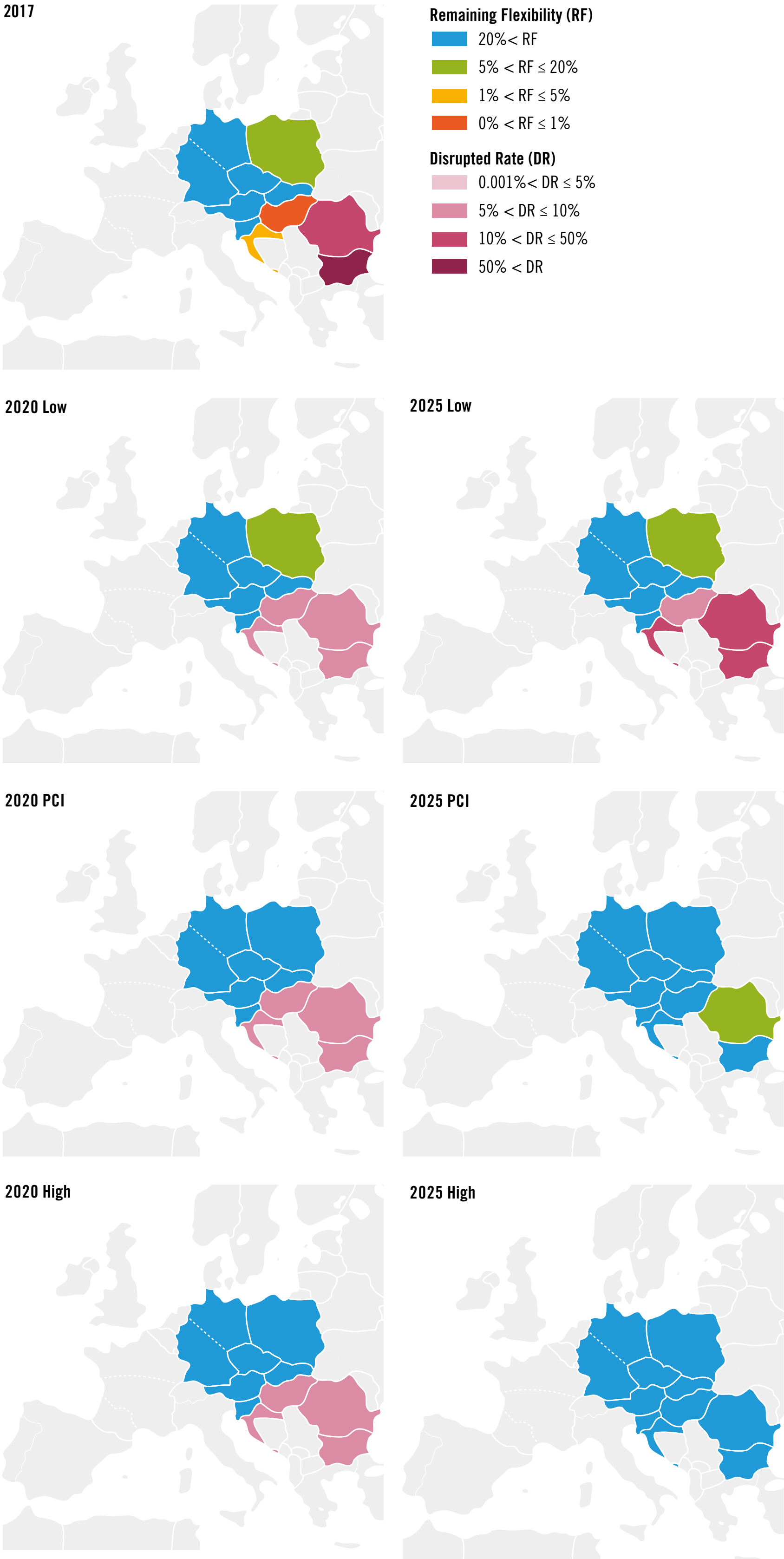


Figure 3.5: Evolution of Disrupted Rate (DR) and Remaining Flexibility (RF), Route gas disruption via Ukraine + Belarus, Peak Day (DC), Green Evolution

The simultaneous transit disruption of Russian gas imports via Ukraine and Belarus is one of two additional disruption cases which were specially performed for CEE GRIP purposes. Countries in the CEE region are the countries most dependent on the transit of Russian gas, and the gas supply routes through Ukraine and Belarus are historically the most important for supplying the region.

The simultaneous disruption of supply via Belarus and Ukraine would lead to the redirection of gas flows from Russia. Nord Stream would then be used as the only pipeline to transport Russian gas to the CEE region. The results indicate that Poland would be negatively affected by the disruption of gas supply routes via Belarus and Ukraine. Also, countries in southeastern Europe (Croatia, Hungary, Romania, and Bulgaria) would be affected by a disruption of the gas supply route via Ukraine. At the same time, the gas supply via Nord Stream pipeline would leave Germany, the Czech Republic, Slovakia, Austria, and Slovenia unaffected.

The results under the LOW infrastructure scenario show the need for infrastructure to provide diversified supplies of gas and market integration that would benefit Poland, the southeastern EU countries, and the CEE region as a whole. This is illustrated by the improving situation if the planned infrastructure projects are implemented. In particular, projects which improve the security of supply and the diversification of gas sources and routes mitigate the effects of this disruption case.

3.2.3 PEAK DAY UNDER A RUSSIAN GAS SOURCE DISRUPTION

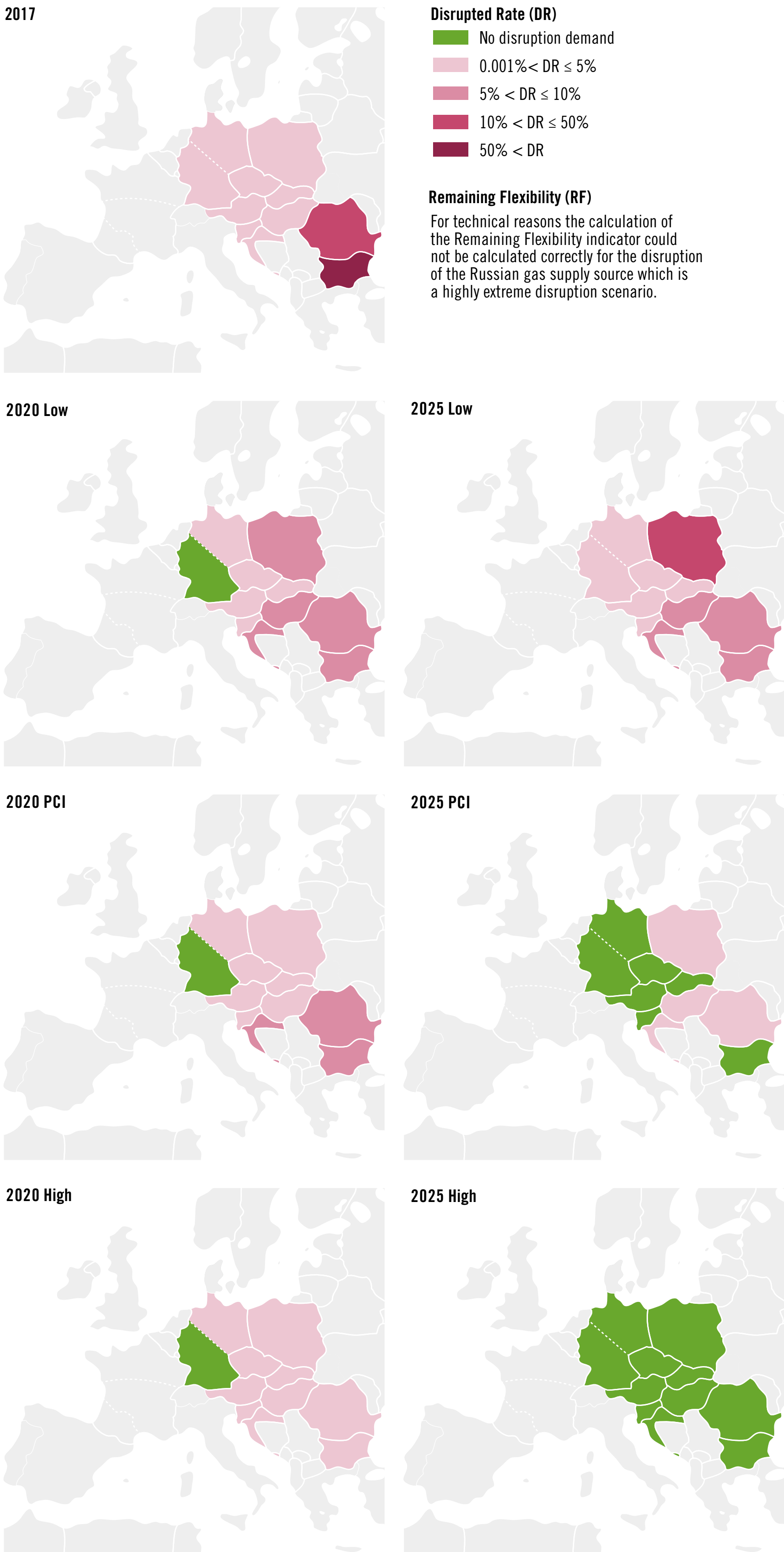


Figure 3.6: Evolution of Disrupted Rate (DR) and Remaining Flexibility (RF), Russian gas source disruption, Peak Day (DC), Blue Transition

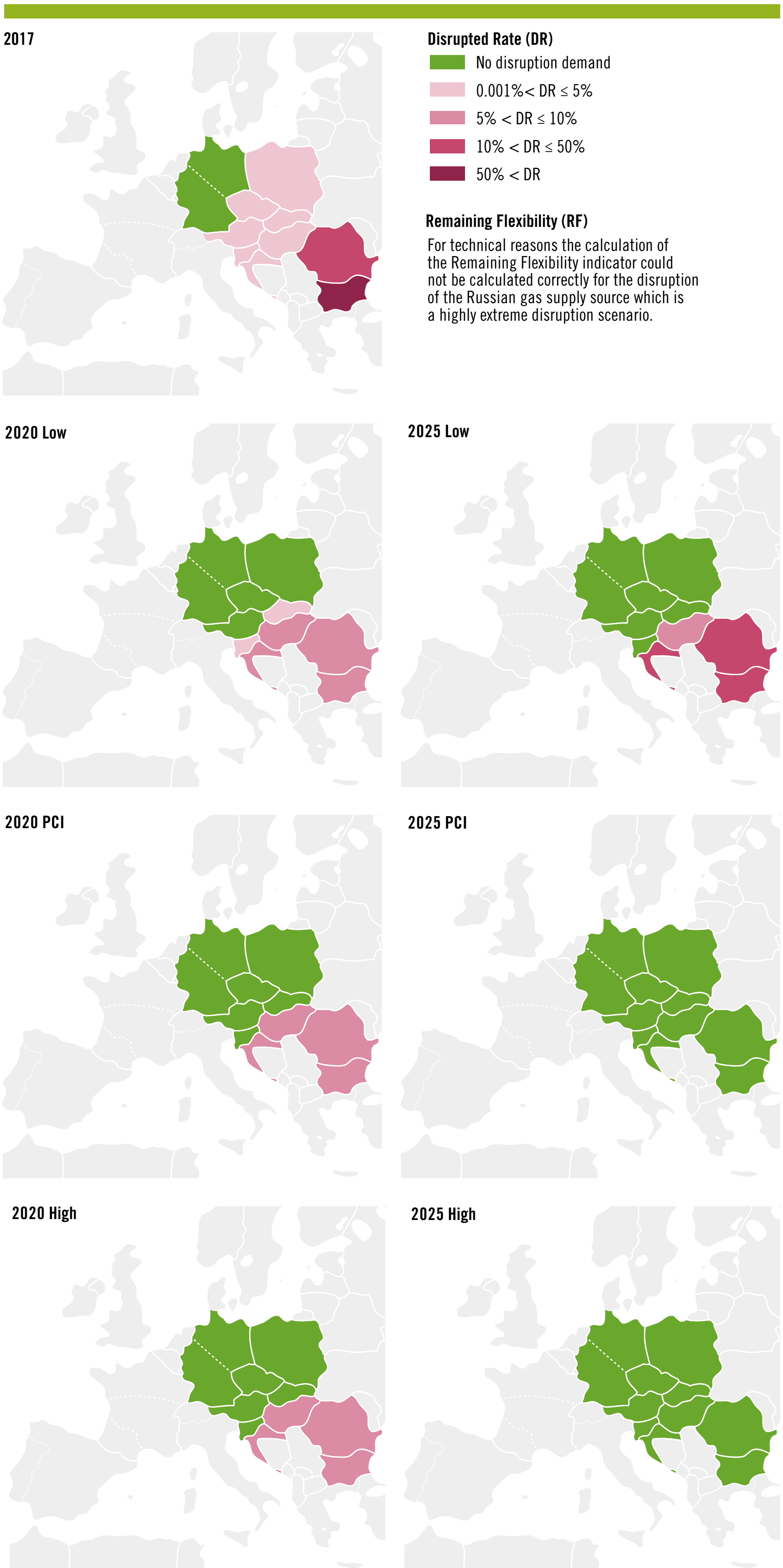


Figure 3.7: Evolution of Disrupted Rate (DR) and Remaining Flexibility (RF), Russian gas source disruption, Peak Day (DC), Green Evolution

The case analysed of a Russian gas supply source disruption (no Russian gas flow to Europe) is the most extreme one and was also performed especially for CEE GRIP purposes. This simulation illustrates to what extent the CEE region is dependent on the gas source from Russia. It also shows that some planned infrastructure projects can mitigate this situation.

After consultation with ENTSOG, it was found that for technical reasons the calculation of the Remaining Flexibility indicator could not be calculated correctly for disruption of the Russian gas supply source which is a highly extreme disruption scenario. Therefore, in this chapter, only the results of the Disruption Rate are presented. In CEE GRIP Annex B, the results for Remaining Flexibility are marked as "n/a".

The results under this scenario show that all countries in the CEE region (including also Germany, the Czech Republic, Slovakia, Austria and Slovenia) are negatively affected by this disruption case.

The commissioning of planned infrastructure projects helps to remove the gas infrastructure bottlenecks in the CEE region by increasing the diversification of gas supply sources for the region (enhanced access to LNG, gas from the southern gas corridor and Norway) and improving cross-border interconnections between the CEE countries.

Implementation of projects with the PCI status between the years 2020 and 2025 has a positive effect on the countries in central and southeastern Europe. These projects are able to slightly mitigate the negative impact of the analysed disruption case on these countries. However, the implementation of planned infrastructure projects (HIGH infrastructure scenario), which improve the security of supply and the diversification of gas sources and routes, would solve any disruption of supply under this scenario.

4 CEE GRIP Regional N-1 Analysis

Image courtesy of GAZ-SYSTEM

4.1 General Note

The countries in the CEE region are exposed to gas supply disruptions, in the current supply situation primarily from the eastern direction. Therefore, the participating TSOs decided to prepare the CEE GRIP Regional N-1 Analysis in the CEE GRIP. The assessment covers the gas supply disruption cases through Ukraine and Belarus.

The assessment is based on the capacities at interconnection points (IP) and the resulting residual capacities for neighbouring countries through supply corridors within the CEE region. The supply corridors and the results for each country in the analysed CEE region are described below. The analysis is calculated for a ten-year period until 2026. Special focus is put on the winter periods in the years 2017/2018, 2020/2021, 2025/2026 and the summer periods in the years 2017, 2020, 2025. If not stated otherwise, all input data for the analysis are in line with the TYNDP 2017. The capacity data reflects currently existing infrastructure and FID and non-FID projects planned to be commissioned before 2025.

4.2 Supply Corridors

The CEE region analysed consists of nine countries: Austria, Bulgaria, Croatia, the Czech Republic, Hungary, Poland, Romania, Slovakia and Slovenia. Germany is not part of this analysis because not all German TSOs are involved in the CEE GRIP. The following paragraphs comprise a brief description of supply corridors for each country from the analysed region; only interconnection points which are relevant to the analysis are described.

4.2.1 AUSTRIA (AT)

The gas supply corridors in the following picture show the main supply corridor for Austria, which under normal conditions runs through Ukraine and Slovakia and through IP Baumgarten (at the figure marked AT1). Other gas supply corridors in case of a supply disruption through Ukraine, but also under normal conditions, are through Germany (marked AT2) and through Italy (AT3). From 2018 and 2022, two new supply corridors for Austria can be used by commissioning two projects which are planning to create a reverse flow capability between Slovenia and Austria, and Hungary and Austria, respectively. The remaining gas in Austria could be used for export to Slovakia, Hungary, Slovenia and the Czech Republic (from 2020) under a Ukraine disruption scenario.

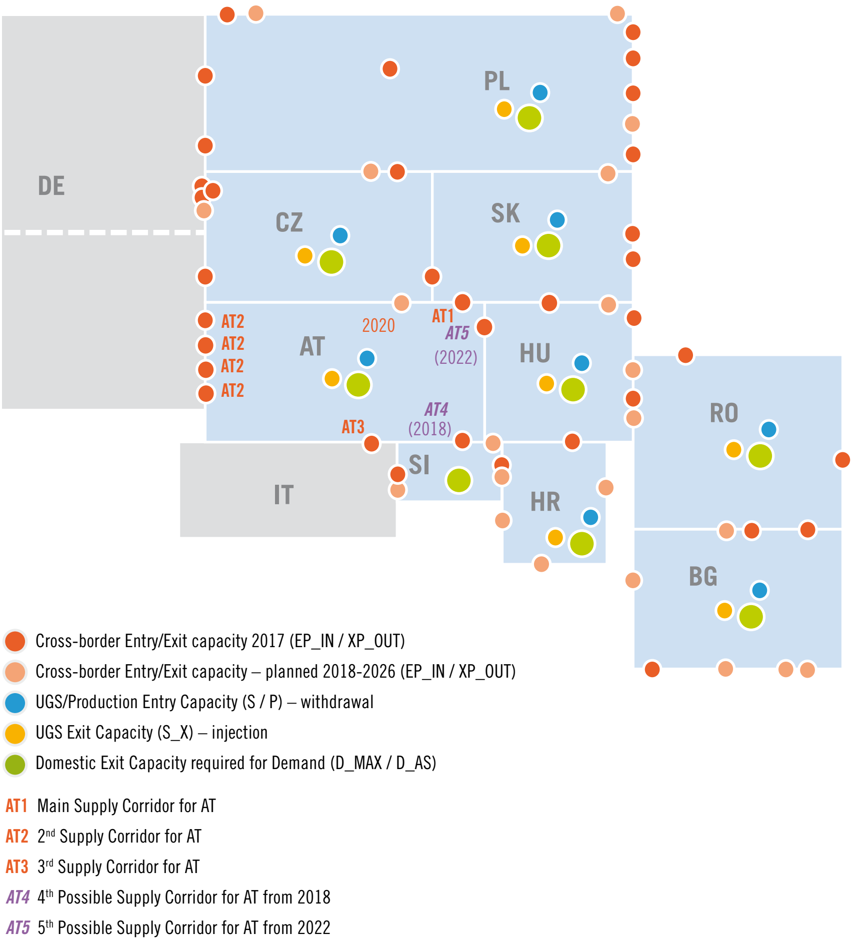


Figure 4.1: CEE Region N-1: AT

4.2.2 BULGARIA (BG)

The following picture shows the main supply corridor for Bulgaria which under normal conditions runs through Ukraine, Moldova, and Romania (at the figure marked BG1). Other gas supply corridors in case of supply disruption through Ukraine are through Greece (marked BG2; this connection can be used in reverse-flow mode during emergency situations which is in line with the requirement of REG 994/2010) and through Romania (marked BG3). The four new cross-border interconnections are planned from 2019.

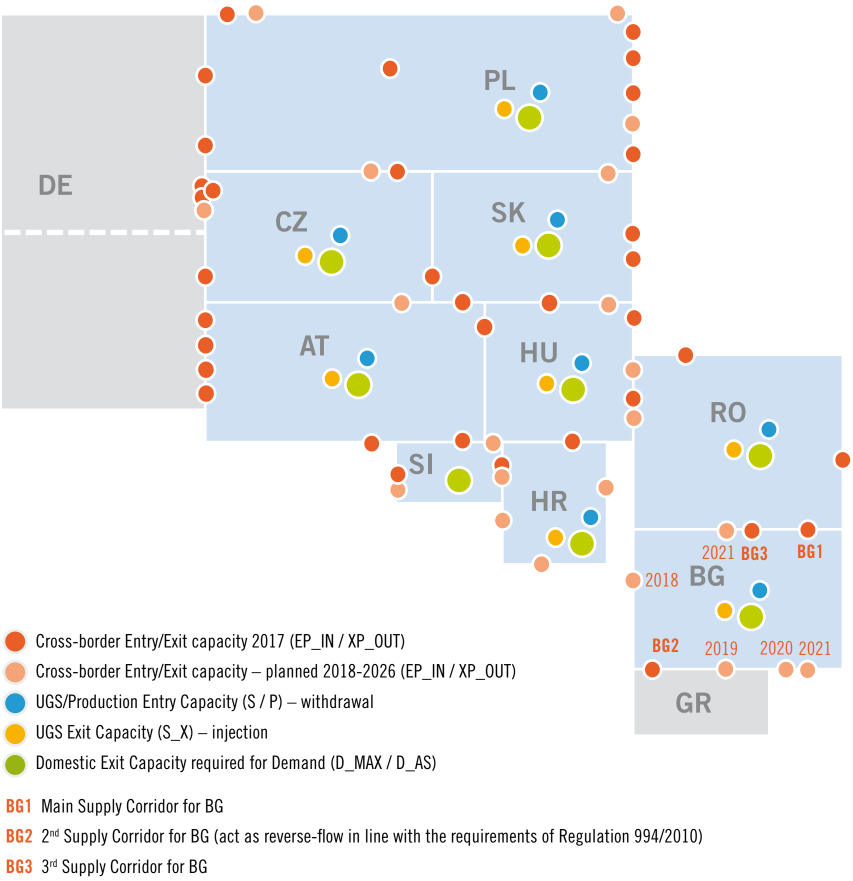


Figure 4.2: CEE Region N-1: BG

4.2.3 CROATIA (HR)

Croatia has two gas supply corridors. The main supply corridor is through Slovenia (at the figure marked HR1). The second one is through Hungary (marked HR2). Both supply corridors are for domestic demand at the moment. After the Croatian LNG terminal (2018) and the Ionian-Adriatic Pipeline (2023) are built, Croatia can then become a transit country.

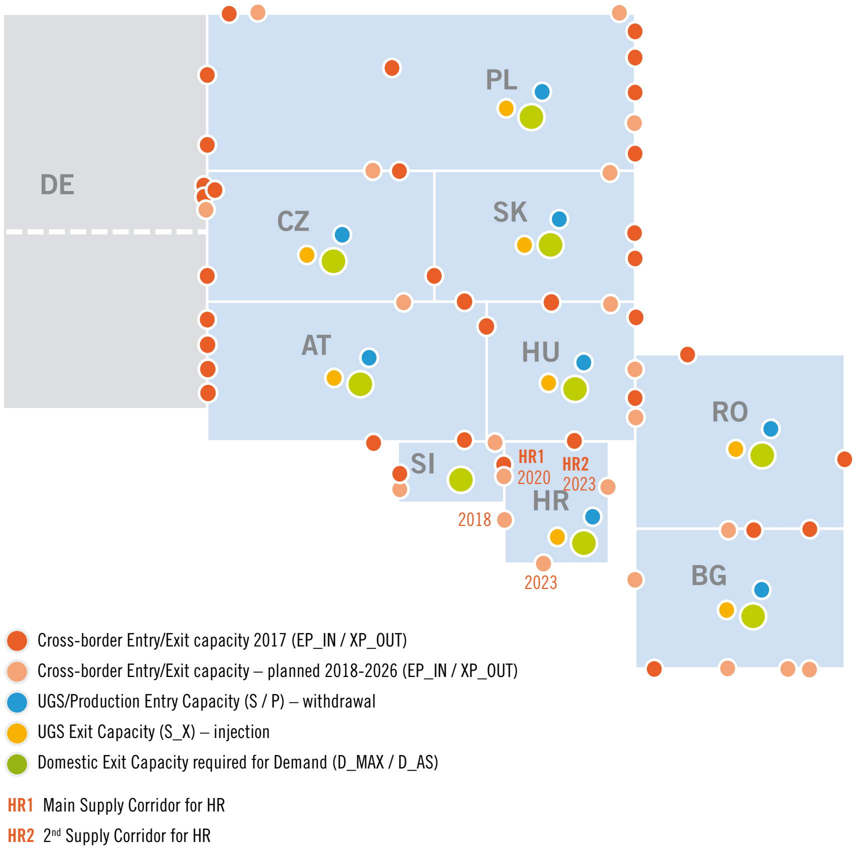


Figure 4.3: CEE Region N-1: HR

4.2.4 THE CZECH REPUBLIC (CZ)

Under ordinary conditions, the main supply corridor for the Czech Republic has recently become through Germany via the Nord Stream and OPAL pipelines (at the figure marked CZ1), followed by the traditional route via Slovakia (marked CZ2). Another gas supply corridor for the Czech Republic can be made through Germany from the NetConnect market area (marked CZ3). In case of a gas supply disruption through Ukraine, the remaining gas in the Czech Republic imported through CZ1 and CZ3 could be used for export to Slovakia, Poland, and Austria (via Slovakia). Two infrastructure projects are currently planned as a part of the north-south gas corridor and their realisation would establish a bidirectional connection with Poland with an enlarged capacity and the first direct bidirectional connection with Austria. Newly is also planned an extension of the supply corridor from Germany (CZ1).

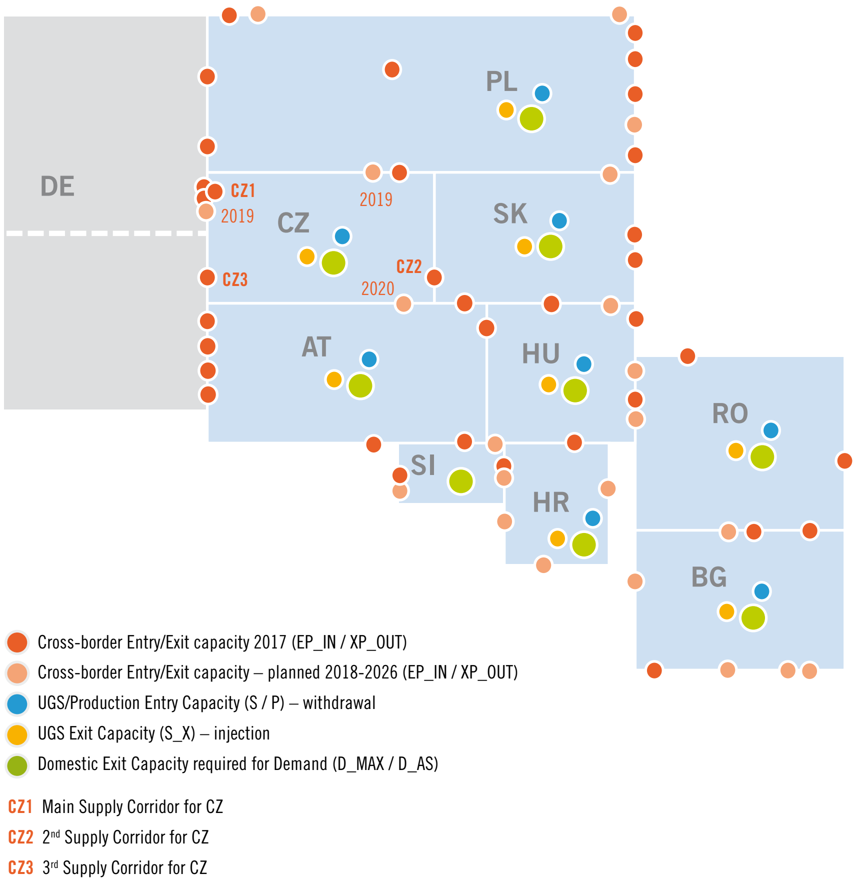


Figure 4.4: CEE Region N-1: CZ

4.2.5 HUNGARY (HU)

The picture below illustrates the supply corridors for Hungary. The main supply corridor runs from Ukraine, which delivers most of the imported gas under normal conditions (at the figure marked HU1). The second supply corridor through Austria (marked HU2) and the third supply corridor through Slovakia (marked HU3) are also of great importance. The other gas supply corridors for Hungary can possibly be made through Romania (marked HU4) and Croatia (marked HU5). The interconnector between Hungary and Croatia has been designed as bidirectional. However, due to incomplete investment on the HR side (lacking a compressor station), it is currently only capable of offering firm capacity from Hungary towards Croatia. Through the increased use of the compressor station on the Hungarian side (which necessitates a pressure management agreement between the TSOs), the capability of firm capacity from Croatia to Hungary of about half of the entire capacity of the interconnector could be created. The Hungarian TSO is ready to implement this temporary solution until the necessary investments are made on the Croatian side to ensure full HR>HU capability. The pressure management agreement is under public procurement, and the contract was signed in December 2016.

In case of a gas supply disruption on the Ukrainian/Hungarian interconnector, the main import supply corridors for Hungary from the north run through Austria (HU2) and Slovakia (HU3). The remaining capacity that could be used in case of supply disruption (from Ukraine) is the supply from Hungarian storage and domestic production points. During a Ukrainian disruption, Hungary would be the main gas supply direction for Romania and Serbia. Four new interconnectors and transit routes are under preparation. They are a connection between Slovenia and Hungary (2020), an enhancement of transmission capacity of the Slovakian-Hungarian interconnector (2021), and two planned connections at the Hungarian/Romanian border (2021 and 2024).

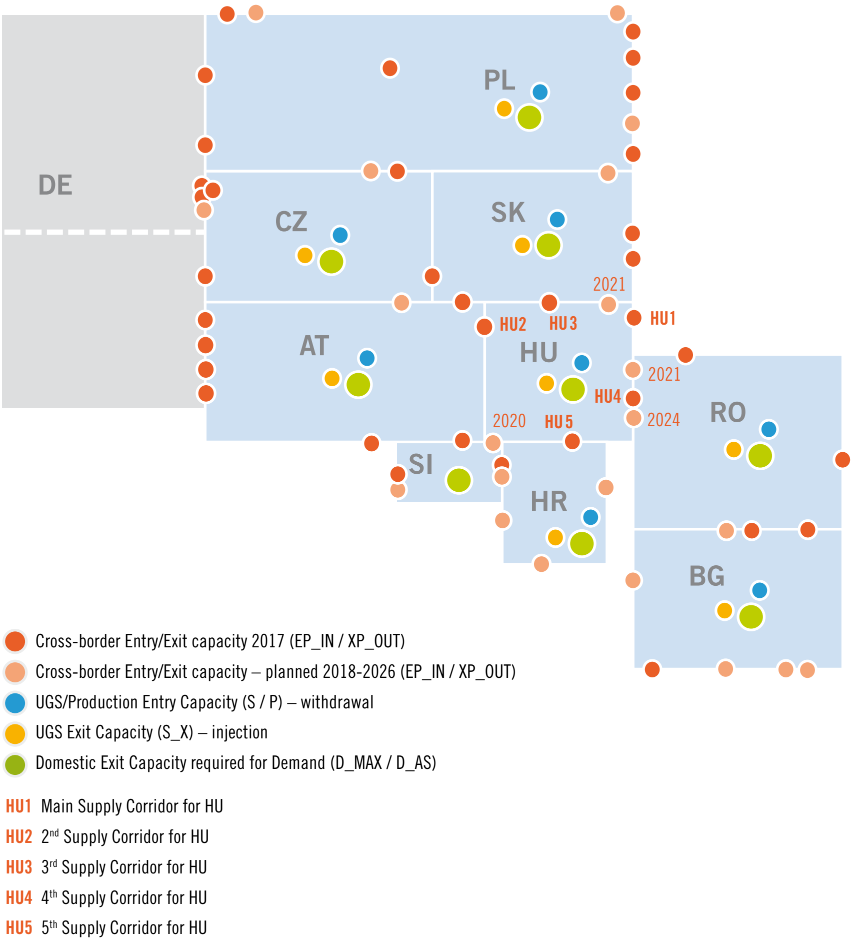


Figure 4.5: CEE Region N-1: HU

4.2.6 POLAND (PL)

The picture below illustrates the supply corridors for Poland. Under normal conditions, the main supply corridors run through the LNG terminal in Świnoujście (marked PL1), Belarus (marked PL2), and Ukraine (marked PL3). Other gas supply corridors for Poland run through Germany (marked PL4) and the Czech Republic (marked PL5). The commissioning of new interconnection projects with the Czech Republic, Slovakia and Lithuania are planned in the upcoming years. A capacity extension of the LNG terminal at Świnoujście is planned for 2020, and a new supply corridor from Norway via Denmark is scheduled for 2022.

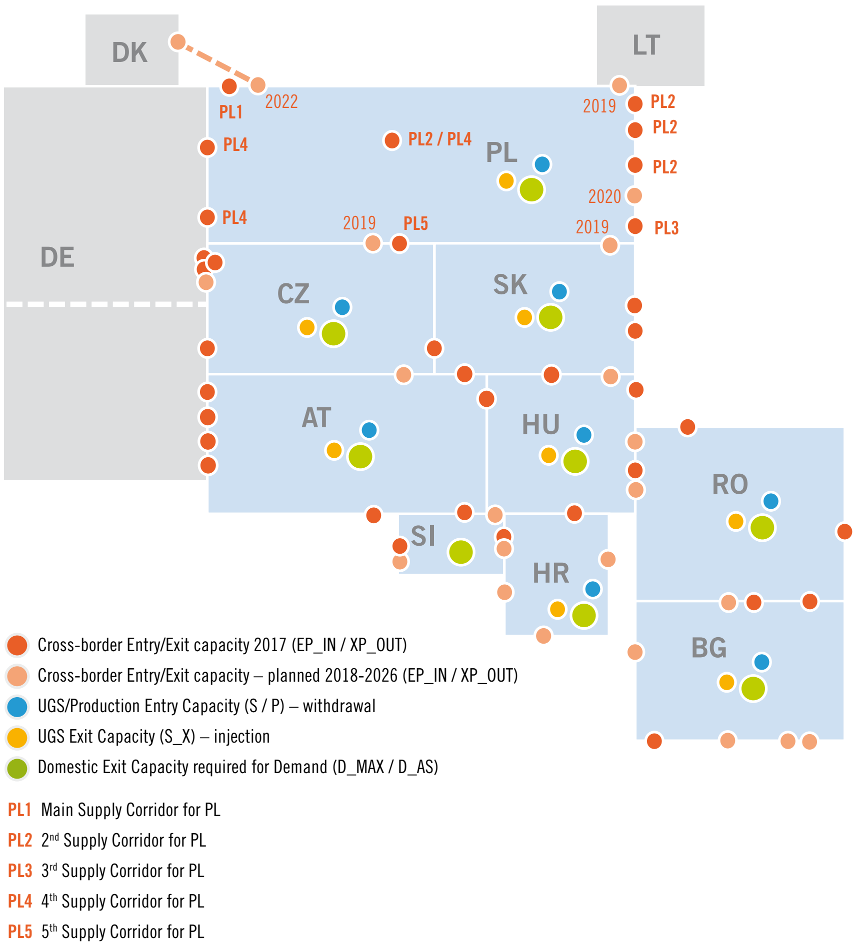


Figure 4.6: CEE Region N-1: PL

4.2.7 ROMANIA (RO)

The following picture shows the main supply corridor for Romania, which under normal conditions runs through Ukraine (at the figure marked RO1). In case of a total Ukrainian supply disruption, the other supply corridors for Romania run through Hungary (marked RO2) and Bulgaria (marked RO3). Romania has a significant indigenous production of natural gas which can help to cover domestic consumption during a gas supply disruption through Ukraine. Three interconnections are planned. However, just one is planned with a connection into the Romanian gas market (2024).

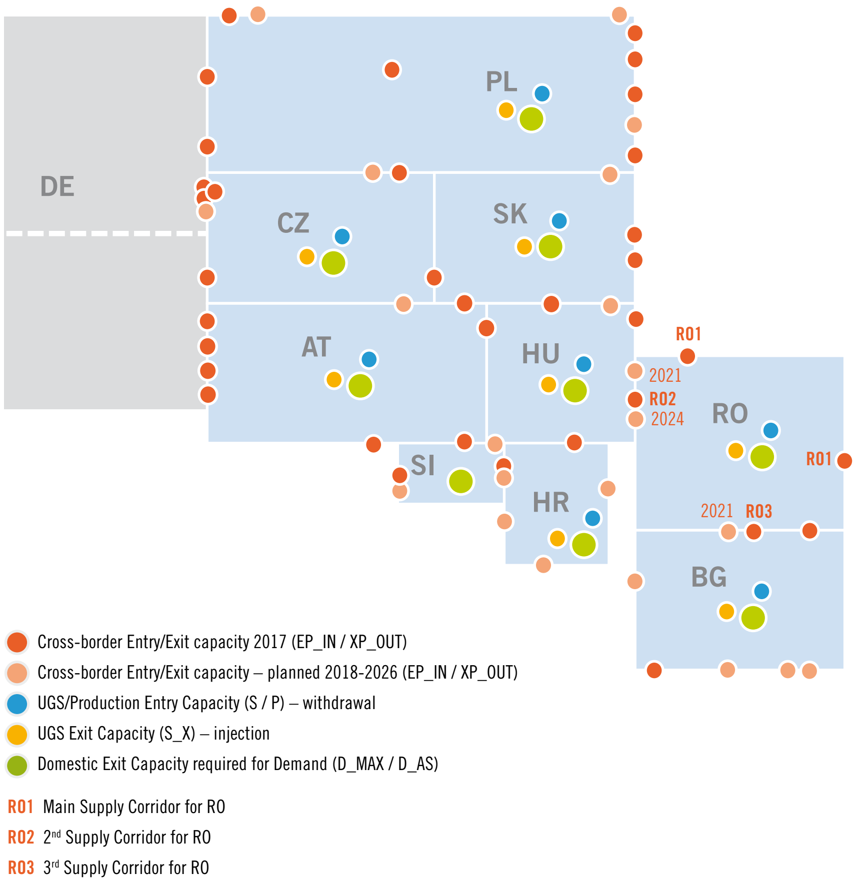


Figure 4.7: CEE Region N-1: RO

4.2.8 SLOVAKIA (SK)

Taking into account the position of Slovakia on the gas route from Russia, it is obvious that the main supply corridor enters the country at the UA/SK border (at the figure marked SK1). In the event of a Ukrainian supply disruption, a reverse flow capability starts to play an important role for supplying Slovakia. Other supply corridors, in case of a supply disruption through Ukraine, are through the Czech Republic (marked SK2), Austria (marked SK3), and Hungary (marked SK4). In 2019 and 2021, the commissioning of cross-border projects with Poland and Hungary is planned.

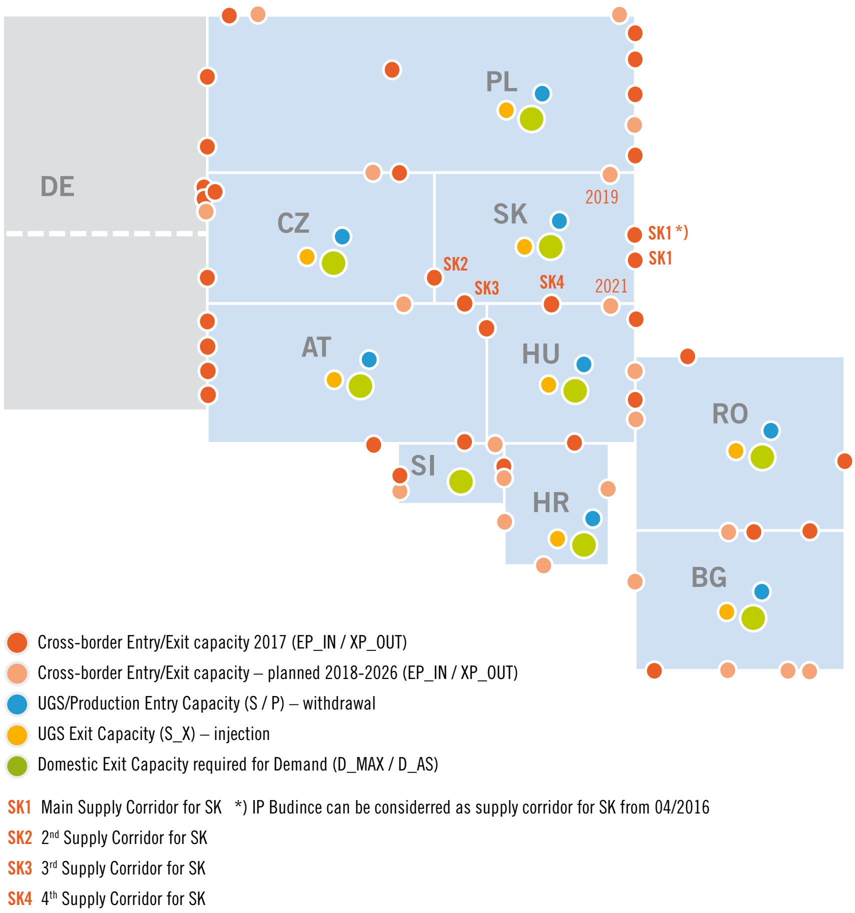


Figure 4.8: CEE Region N-1: SK

4.2.9 SLOVENIA (SL)

The picture below shows the main supply corridor for Slovenia, which under normal conditions runs through Austria (at the figure marked SI1). Other gas supply corridors, in case of a supply disruption through Ukraine, run through Italy (marked SI2) and through Croatia (marked SI3). The supply corridor through Croatia can possibly be used from 2020 when reverse flow capacity is planned to be built. The first interconnection between Slovenia and Hungary is planned for 2020. An interesting fact about Slovenia is that it has no indigenous production of natural gas or any underground storage in its territory.

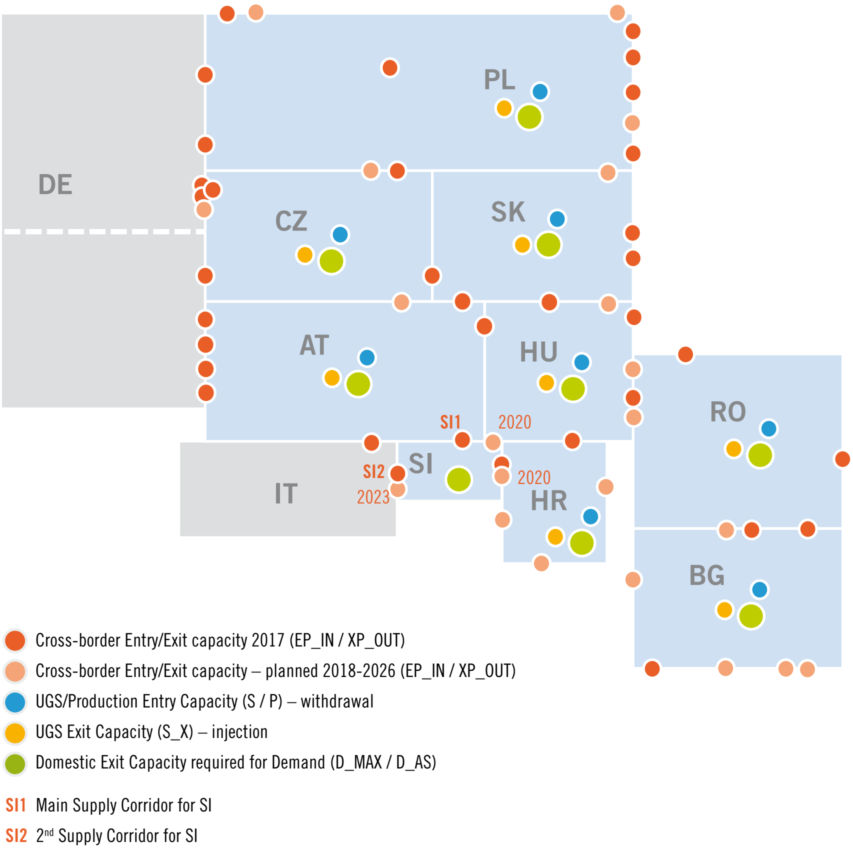


Figure 4.9: CEE Region N-1: SI

4.3 Methodology

4.3.1 CEE GRIP REGIONAL N-1 FORMULA

The CEE GRIP Regional N-1 analysis was prepared for the two scenarios of complete gas supply disruption through Ukraine and Belarus. Only nine out of the ten countries involved in the CEE GRIP are considered to be part of the analysed CEE region (AT, BG, HR, CZ, HU, PL, RO, SK, and SI). Germany is not part of the analysis, because not all TSOs from Germany are involved in the CEE GRIP. All entry points with neighbouring countries out of the analysed CEE region are taken into account, without any capacity reduction (with the exception of interconnection points with Ukraine and Belarus, respectively). On the other hand, exit points with neighbouring countries beyond the analysed CEE region are not taken into account[1]. The supply corridors are defined by the route from the source to each country and flows to neighbouring countries are determined as the rest of the gas volume after the demand in the given country is covered. Another assumption for the analysis is that only one direction of gas flow through one interconnection point is possible. If two directions of gas flow through one interconnection point were possible, then one of the following rules was applied:

a) If there exists a country which does not meet the security of supply criterion according to REG 994/2010 (i.e. the result of the N-1 formula shall be equal to or above 1), then the supply corridor which can help to meet the security of supply criterion was chosen.

b) The direction of gas flow which can increase the N-1 result of a neighbouring country with a smaller N-1 result than the export one, is chosen.

c) Where the direction of gas flow which should be used in the analysis was not clear, then the flow to a country which had the potential to export gas to countries outside the analysed CEE region is chosen.

The analysis has been prepared for the following winter periods:

- 01.10.2017–31.03.2018,
- 01.10.2020–31.03.2021,
- 01.10.2025–31.03.2026

and the summer periods:

- 01.04.–30.09.2017,
- 01.04.–30.09.2020,
- 01.04.–30.09.2025.

The N-1 formula used is presented below together with an explanation of all parameters. The analysis only takes into consideration the infrastructure capacities, as it assesses the infrastructure standards, not the supply standard. For planned infrastructure projects, the High Infrastructure Scenario and the rule of full season (winter October-March, summer April-September) in which the repercussion of the infrastructure project fully applies was considered in the analysis.

If not stated otherwise, all input data for the analysis are taken from the TYNDP 2017. Input data used for the analysis are part of the CEE GRIP Annex C – Capacities for Regional N-1 analysis.

1) In the general rules of the calculation, there is one exception at the request of GAZ-SYSTEM. The exception concerns the Poland - Lithuania Interconnection which is planned to bring SoS and market-related benefits mostly for the Baltic States. Therefore, the exit flows from Poland to Lithuania are assumed in the calculations.

4.3.1.1 Winter period

From each country, entry capacities at each interconnection point, as well as the withdrawal capacity of storage facilities, national production, domestic demand, and exit capacities to neighbouring countries are used for the calculation of regional N-1. After a matching/correction of entry and exit capacities of each interconnection point (lesser-of rule), the surplus gas is allocated to neighbouring countries to meet the domestic demand of countries which are "in need". The N-1 value for winter is calculated for each country by setting the interconnection points of the main supply corridor to zero or to a minimum volume that an upstream country (next or nearer to Ukraine/Belarus transport to a relevant interconnection point) is able to export. If the investigated country has surplus gas after satisfying its demand for sharing, the gas is then allocated to downstream countries, where necessary. These values are used for the N-1 calculation as entries for a particular country. In case the N-1 value is equal to or above 1, this means that the respective country is able to cover its own demand in case of a gas supply disruption via Ukraine or Belarus. Under the assumption that underground storage facilities are filled up during the summer period (as the N-1 calculation assesses the infrastructure, not the supply standard), the maximum deliverability has been applied. The stock levels of underground storage facilities, as well as the duration of the disruption, have not been taken into consideration in the winter formula.

The N-1 Formula for the winter period is based on REG 994/2010, when the technical capacity of the single largest gas infrastructure in the original formula is replaced by all interconnections with Ukraine (or Belarus respectively) in the modified formula for the CEE GRIP.

Winter N-1 Formula:

$$N-1_{WINTER} = \frac{\sum_i^n EP\_IN_m + P_m + S_m - UA/BY\_connections_m}{D\_MAX_m} \geq 1$$

Where:

EP_IN	All border entry points (transmission and LNG) capable of supplying gas to the calculated area (GWh/d)
P	National production, entry capacity (GWh/d)
S	Storage, entry capacity (withdrawal) (GWh/d)
D_MAX	Domestic winter peak demand (1 in 20) (GWh/d)

4.3.1.2 Summer period

In addition to the data for entry capacities used for the CEE GRIP Regional N-1 analysis during the winter period, the working gas volumes and maximum injection capacity to the underground storage facilities of each country are also used for the analysis during the summer period. The summer formula is set to determine how long a gas supply disruption through Ukraine and Belarus can last without endangering the ability to cover demand and/or to fill the storage facilities in the respective country. After a matching/correction of entry and exit capacities of each interconnection point (lesser-of rule), the surplus gas is allocated to neighbouring countries to meet their domestic demand. The N-1 value for the summer is calculated for each country by setting the interconnection points of the main supply corridor to zero or to the minimum volume that an upstream country (next or nearer to Ukraine/Belarus transport to a relevant interconnection point) is able to export. If the investigated country has surplus gas for sharing after satisfying its demand, the gas is then allocated to downstream countries, where necessary. These values are used for the N-1 calculation as entries for each particular country.

Summer N-1 Formula:

$$\sum XP\_OUT_{m,\,SUMMER} = \sum_i^n EP\_IN_m + P_m - D\_AS_m - UA/BY\_connections \geq 0$$

For calculation purposes, the time period for injection into underground storage facilities during the summer is considered to be 180 days in duration.

EP_IN All border entry points (transmission and LNG) capable of supplying gas to the calculated area (GWh/d)

P National production, entry capacity (GWh/d)

D_AS Domestic average summer demand (1 in 20) (GWh/d)

XP_OUT Remaining gas to fulfil demand in neighbouring countries and for injection into underground storage facilities in country concerned (GWh/d)

S_WGV Working gas volume of underground storage facilities in country concerned (GWh)

S_X Storage, exit capacity (injection) (GWh/d)

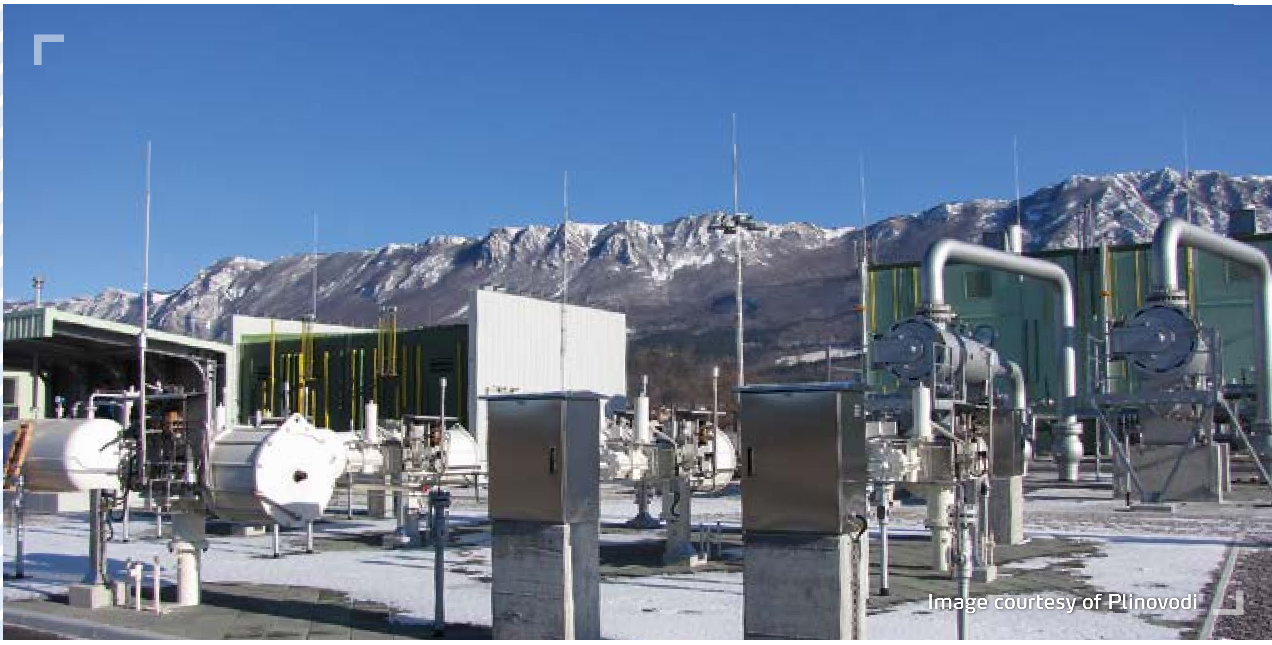


Image courtesy of Plinovodi

4.4 Disruption via Ukraine

When a gas supply disruption through Ukraine was considered, the CEE GRIP Regional N-1 analysis identified a problem in Bulgaria and Romania during the winter period 2017/2018. During this time period, the capacity of the bidirectional IP Ruse (BG)/Giurgiu (RO) cannot be used due to the lack of gas in both countries.

If planned infrastructure projects (from the High Infrastructure Scenario) are implemented in time, then the Regional N-1 criterion will be met for Bulgaria and Romania from the perspective of 2020/2021. In the analysed winter periods 2020/2021 and 2025/2026, the countries from the CEE region have no trouble in covering their domestic demand in the event of a gas supply disruption through Ukraine. The results are presented in the following table.

RESULTS OF CEE GRIP REGIONAL N-1 WINTER IN CASE OF A DISRUPTION VIA UKRAINE

COUNTRY	CEE GRIP Regional N-1 Winter		
	01.10.2017 – 31.03.2018	01.10.2020 – 31.03.2021	01.10.2025 – 31.03.2026
Austria	4.1427	4.9457	4.9457
Bulgaria	0.3449	1.1360	2.8557
Croatia	1.2289	1.4823	3.5177
Czech Republic	2.7627	3.5492	5.0676
Hungary	1.3485	1.2138	2.0745
Poland	1.3333	1.6655	1.8424
Romania	0.9775	1.1963	1.5255
Slovakia	4.1031	6.1296	6.0259
Slovenia	2.8330	3.2676	8.8429

Table 4.1: Results of CEE GRIP Regional N-1 Winter in case of a disruption via Ukraine

The analysis for the 2017 summer period resulted in the identification of a problem in Bulgaria. Due to the lack of gas in Bulgaria that would be caused by a gas supply disruption via Ukraine, there would be no gas for the underground storage facilities in Bulgaria during the summer. This situation could lead to a deepening of the problem identified during the winter period, because the underground storage facilities would be empty. This problem will be solved by the implementation of planned infrastructure projects in upcoming years. During the 2017 summer period, potential problems in injecting gas into underground storage facilities in Hungary and Romania were also identified, but only if the disruption lasted more than 45 and 138 days, respectively. A potential problem was also identified in Austria (only if the disruption lasted more than 116 days), but this would be caused by the fact that IP Baumgarten is used in the AT>SK direction in the analysis. If it had been used in the other direction, Austria would have no problem.

In the 2020 summer period, the potential problem of injecting gas into underground storage facilities was detected in Hungary, but only if the gas supply disruption through Ukraine lasted longer than 37 days.

The commissioning of projects in subsequent years will respond to all identified problems.

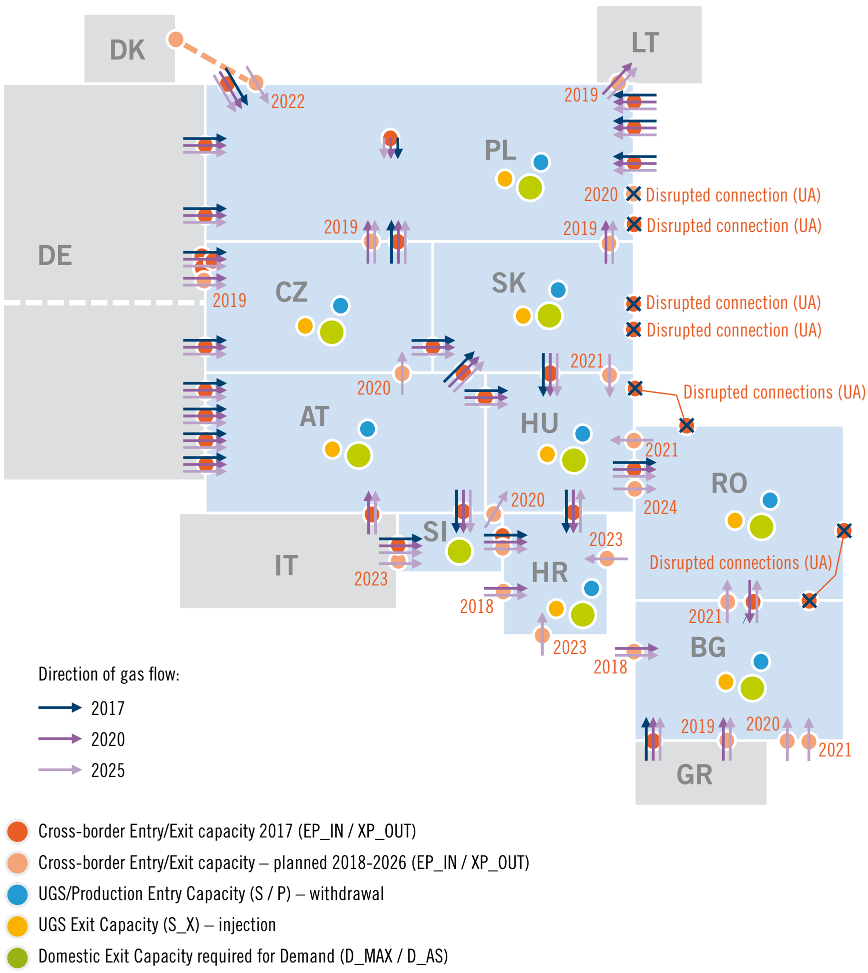


Figure 4.10: Direction of gas flow considered at each interconnection point under disruption via Ukraine

4.5 Disruption via Belarus

The CEE GRIP Regional N-1 analysis of a gas supply disruption through Belarus (including the interconnection points Wysokoje, Tietierówka, Kondratki and the Yamal-Europe Pipeline in the direction BY > PL) indicated that only Poland would be affected by this kind of gas supply disruption. The results of the analysis shows that Poland meets the N-1 criterion during all the analysed winter periods (2017/2018, 2020/2021 and 2025/2026) and that the results improve in the upcoming 10 years with the implementation of the new planned infrastructure projects.

Other countries in the CEE region would not be affected by a gas supply disruption via Belarus. Most of their gas transmission systems would operate in a business-as-usual regime, and their N-1 results would be above 1. This means that under normal circumstances all countries of the analysed CEE region (including Poland) would have sufficient capacity to both satisfy their domestic demand and transit needs to neighbouring countries over the whole 10-year period.

The results for countries in the analysed CEE region which would be affected by a gas supply disruption via Belarus, are presented in the following table.

RESULTS OF CEE GRIP REGIONAL N-1 WINTER IN CASE OF A DISRUPTION VIA BELARUS

COUNTRY	CEE GRIP Regional N-1 Winter		
	01.10.2017 – 31.03.2018	01.10.2020 – 31.03.2021	01.10.2025 – 31.03.2026
Austria	No effect	No effect	No effect
Bulgaria	No effect	No effect	No effect
Croatia	No effect	No effect	No effect
Czech Republic	No effect	No effect	No effect
Hungary	No effect	No effect	No effect
Poland	1.1902	1.5369	1.9207
Romania	No effect	No effect	No effect
Slovakia	No effect	No effect	No effect
Slovenia	No effect	No effect	No effect

Table 4.2: Results of CEE GRIP Regional N-1 Winter in case of a disruption via Belarus

The analysis for the 2017, 2020, and 2025 summer periods did not identify any problem with covering the average summer domestic demand and to meet the injection requirements of underground storage facilities in the whole CEE region.

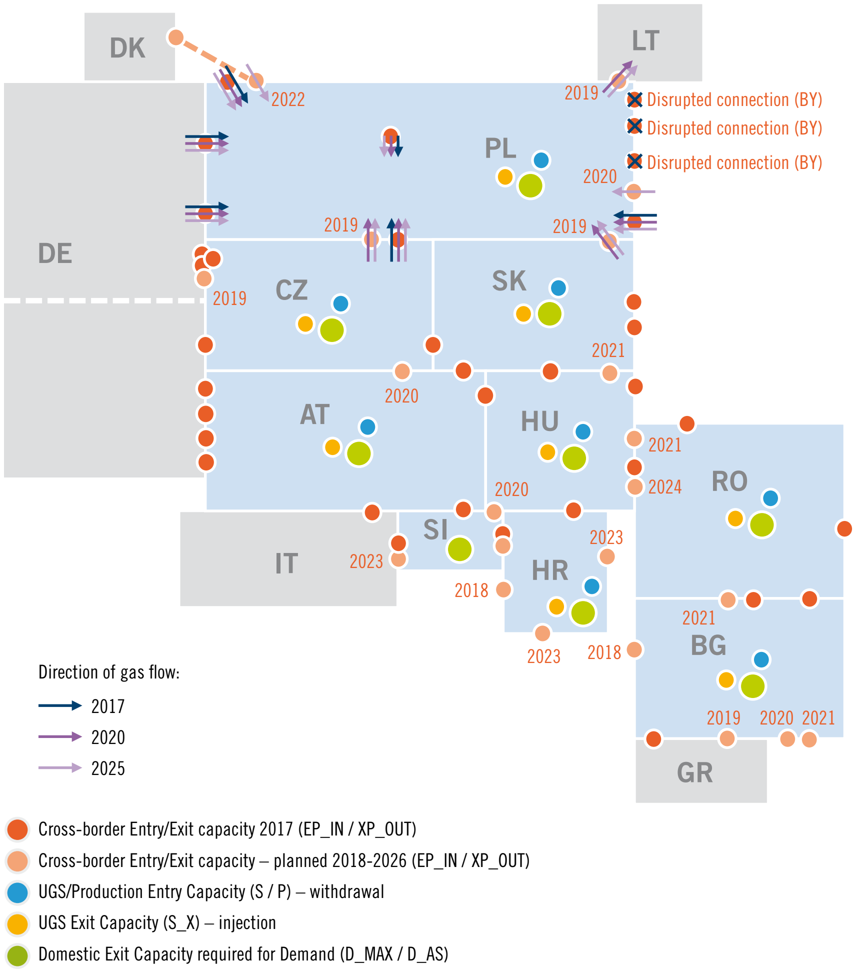


Figure 4.11: Direction of gas flow considered at interconnection points at Polish borders under a disruption via Belarus

5 Natural Gas as a Perspective Fuel in Transportation

Image courtesy of National Grid

5.1 General Note

Economic growth is largely associated with increased transportation demands. Due to urbanisation tendencies, metropolitan cities often suffer from vehicular overcrowding and the resulting harmful pollutants produced by commercial diesel vehicles, especially when used in a stop-and-go mode. Consequently, environmental legislation has become increasingly demanding and stringent.

Thus, this focuses Europe on using natural gas (NG) as an alternative transportation fuel replacing petrol and diesel, while still maintaining the successful principle of combustion engines.

In many areas of the world, natural gas is already well established, especially as an "urban" fuel for good reasons:

I. Low fuel costs, typically independent of oil import prices

II. Natural gas resources are larger and more evenly distributed in the world than those of crude oil

III. Conventional spark ignition engine compatibility

IV. Low emission of pollutants from combustion

V. Low noise emissions

VI. Natural gas can be replaced up to 100 % by biomethane or synthetic methane without changes to the engine, thus eliminating CO_2 emissions

VII. Lower maintenance and repair costs compared to diesel cars

In the following text, the advantages and challenges of NG as a fuel for transportation for the CEE region will be explained. NGVs[1)] will mainly be compared to diesel vehicles because of their typical use in fleets with high yearly mileage.

5.1.1 LNG & CNG FUEL PROPERTIES

At normal temperature and pressure, natural gas cannot be efficiently stored in a vehicle's tank. Increasing the pressure (CNG) or lowering the temperature (LNG) are two ways of reaching an acceptable energy density per volume unit. The first, and currently more widespread, form of compressed natural gas (CNG) is commonly used in the CEE region to power passenger cars, vans, and city buses. The natural gas is compressed to more than 20 MPa at normal temperature, shrinking its volume by 200 times. The liquefaction of natural gas (LNG) is, by contrast, more technologically challenging and expensive. It involves cooling the gas to around –162 °C, which converts the gas to a liquid and cuts its volume to 1/600th of the original. Typically, the gas is liquefied in producer countries for shipping it all over the world with vessels. Consequently, LNG for transportation is mainly available at filling stations within the radius of several hundreds of kilometers from the sea terminals where it is received. Despite the numerous advantages of LNG over CNG, particu-

1) A natural gas vehicle (NGV) is an alternative fuel vehicle that is fueled either by compressed natural gas (CNG) or liquefied natural gas (LNG). The only difference between CNG and LNG is that the former is not liquefied, in other words they are stored in a different state of matter but the combustion engines of CNG and LNG vehicles do not differ, as they both combust NG in its gaseous phase.

larly in heavy-duty trucks and inland water and seaborne maritime transport, in the CEE region LNG is still undergoing its pioneering stage with obvious potential. It still does not play the role it has along the French-Belgian-Dutch North Sea shore.

For comparison, some of the most important physiochemical properties of NG, diesel, and petrol are listed below.

PHYSIOCHEMICAL PROPERTIES OF SELECTED FUELS (NATURAL GAS, DIESEL, PETROL)

Physiochemical properties	Natural Gas	Diesel	Petrol
Carbon content [%]	75	87	85.5
Specific CO_2 emission [$kgCO_2$/kWh]	0.20	0.27	0.25
Auto-ignition temperature [°C]	540	210	258
Adiabatic flame temperature [°C]	1,890	2,150	2,054
Octane number [%]	130	–	85–95
Net calorific value [MJ/kg]	49.7	42.5	43.5
Net calorific value [kWh/kg]	13.8*)	11.8	12.1

A value of 13.8 kWh/kg was derived from the gross calorific value (GCV) of 10.43 kWh/m^3 at 20 °C, NCV/GCV ration of 0.901 and density 0.68 kg/m^3 at 20 °C, which is used for Russian gas that is the dominant gas source in the CEE GRIP region.

Table 5.1: Physiochemical properties of selected fuels (Natural Gas, Diesel, Petrol)

Image courtesy of Gasum

5.1.2 ENVIRONMENTAL ASPECTS OF NGVs IN GENERAL

The chemical composition of NG varies depending on its origin. In the CEE region (not taking into account western Germany), the lion's share of NG originates from Russia containing 97–98 vol. % of methane (CH_4). Apart from higher gaseous alkanes (ethane, propane), NG also contains small amounts of inert gases, such as CO_2 and N_2.

Hydrocarbons in combustion engines generally burn to produce carbon dioxide (CO_2) and water vapour (H_2O). The less carbon the fuel contains in relation to hydrogen the less CO_2 greenhouse gas is produced and the more harmless water vapour is emitted. Due to this simple fact, methane has its own unique greenhouse gas advantage over all other hydrocarbons, which have higher carbon/hydrogen ratios. The simplicity of the methane molecule in NG also allows it to be easily replaced by bio-methane made from biomass that has captured CO_2 from the atmosphere. Thus, using biomethane NGVs can profit from an almost closed CO_2 cycle, emitting nearly zero greenhouse gases. A similar result can be reached, of course, with electrical cars powered by renewable energy (neglecting the as yet unresolved additional pollution caused by the production and recycling of batteries), but with the disadvantage of giving up the principle of the combustion engine, including all the associated infrastructure in car production, garages, feedstock supply (iron vs. copper), filling stations, etc. The following Chapters 5.4.1 & 5.4.2 will give a rough estimation on the CO_2 savings of NGVs in the CEE region.

However, the combustion of NG or diesel fuel in vehicle engines produces not only greenhouse gases, i. e. CO_2 emissions, but also local pollutants, such as nitrogen oxides (NO_x), particulate matters (PM), hydrocarbons (HC), and carbon monoxide (CO). While HC and CO have not played a significant role since the introduction of three-way catalytic converters, most attention has recently been paid to NO_x and PM emissions, as they have the most harmful impacts to human health and environment. Consequently, many cities in Europe have banned vehicles emitting local pollutants by charging a toll or a fine for entering the city centre. Chapter 5.4.3 will compare these local pollutants from NGVs to diesel vehicles.

Due to the health effects of PM & NO_x, all EU countries adopted regulations for the emissions allowed from other pollution sources (heating, industrial emissions, etc.). In a similar way, regulations for the ambient concentration of pollutants, including PM and NO_x, have also been adopted.

5.1.3 SAFETY ASPECT OF NGVs

In its raw state, natural gas is odourless. Therefore, some necessary safety measures need to be undertaken. To spot any potential leaks, the gas is odorised with sulfuric compounds, making it easy to detect at low concentrations around 0.3 % by volume in air. When compared to diesel, CNG offers some safety advantages. One of them is a higher auto-ignition temperature of 540 °C in contrast to 210 °C for diesel. A higher auto-ignition temperature reduces the risks of possible ignition in an open environment. Similarly, it possesses a very narrow flammability range of 4.3–15.2 vol. %. Moreover, natural gas also poses fewer environmental hazards in the event of an accident. Given its physiochemical properties, should a natural gas leak occur the gas would dissipate into the atmosphere rather than spilling on to the ground and polluting groundwater sources. Regardless of all those advantages, NGVs as well as any other automobile vehicles require regular maintenance to minimise preventable accidents. High pressure fuel tanks are included in regular maintenance inspections.

5.2 Utilisation and Infrastructure in the CEE Region

Although natural gas vehicles and the necessary infrastructure are not available on such a large scale compared to diesel or petrol, the worldwide quantity of NGVs is increasing so rapidly, that there are very few consistent data available.

For that reason, a specific survey for CEE GRIP purposes was conducted, in which the CEE GRIP TSOs[2)] responded according to their best available knowledge and/or using publicly available data. The end of the statistical period under this survey is 31 December 2015, so unless specified differently, the statistical data in the following text refer to the situation as it was at the end of 2015.

2) The following are the ten countries, respectively TSOs of the countries, which responded to the CNG & LNG survey: Austria, Bulgaria, Croatia, Germany, Hungary, Poland, Romania, Slovakia, Czech Republic and Slovenia.

5.2.1 UTILISATION OF NGVs

The survey results indicate that around 195,000 NGVs were registered in the CEE region. The growth of NGVs in the CEE region is illustrated by the graph below[3].

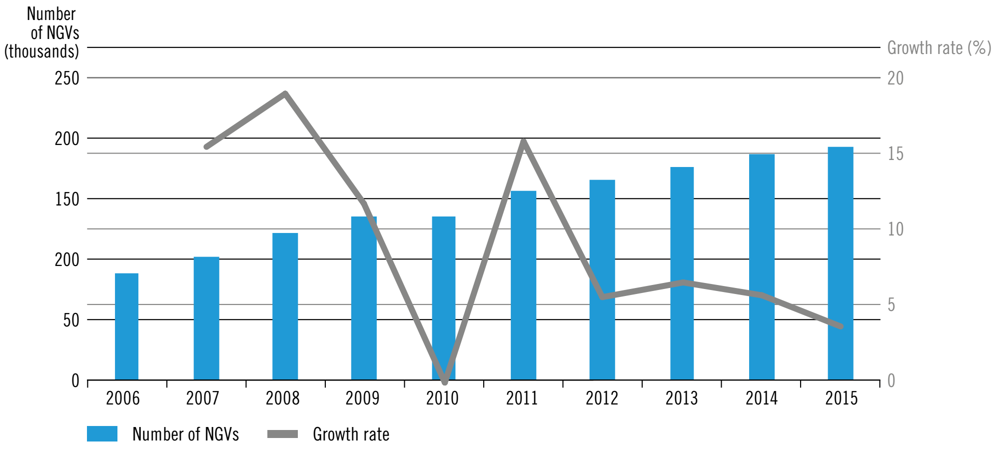


Figure 5.1: Number of registered NGVs in the CEE region in 2006 – 2015

The rising trend of NGVs is projected to continue with an average annual growth rate of 9.5 %. As per the survey, the NGV leader was Germany with over 97,000 registered vehicles. Following not so far behind Germany was Bulgaria with around 65,000 registered vehicles (see Figure 5.2). Although other countries do not contribute to such a great extent, it is important to approach each country individually. For example, in the Czech Republic there was an annual stepwise growth of 40 % in NGVs over the last ten years. Such rapid growth could indicate more intense prospective utilisation in the future. An important impulse for the Czech market in recent years was the introduction of the Škoda Octavia CNG model in 2014.

This development is influenced by the legislative framework applied in the respective markets. To the TSOs' knowledge, no concerted action has so far been started to boost NGV registrations in the CEE region by an exchange of experience between the gas industry and the car manufacturers. The TSOs regard this as a challenge for the future. However, as they are under a regulated regime, the TSOs have not yet been able to foster this development.

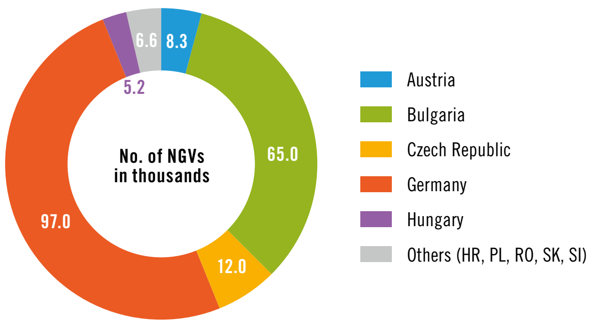


Figure 5.2: Number of registered NGVs in countries of the CEE region in 2015

LNG fuel vehicles, when compared to CNG, are still undergoing their pioneering stage in Europe, especially in the CEE region. Up to 2015, there were only around 1,500 LNG heavy-duty trucks in Europe. Therefore, there are only a few, if any, operating in Central and Eastern Europe.

3) For the purpose of this illustration, any missing values were extrapolated from existing data using linear regression analysis.

5.2.2 CNG & LNG FILLING STATIONS AND LNG BUNKER FACILITIES

Over the last ten years, the refuelling network has experienced mild growth, resulting in 1,362 CNG filling stations, 4 LNG filling stations, 2 LNG bunker facilities for maritime transport, and 1 LNG bunker facility for inland shipping by the year 2015. In contrast to the number of NGVs, the growth rate of the CNG filling stations has slowed down since 2007. This is a normal development, because a certain regional coverage of filling stations is a sine qua non in order to solve the so-called "hen and egg problem" during the introductory phase of a new fuel and the respective new vehicles. In Germany, for example, the gas industry decided in 2003 to build up a network of approximately 1,000 CNG stations for a potential number of 1 million NGVs that are expected in the future. Thus, vehicle numbers and filling stations do not grow proportionally.

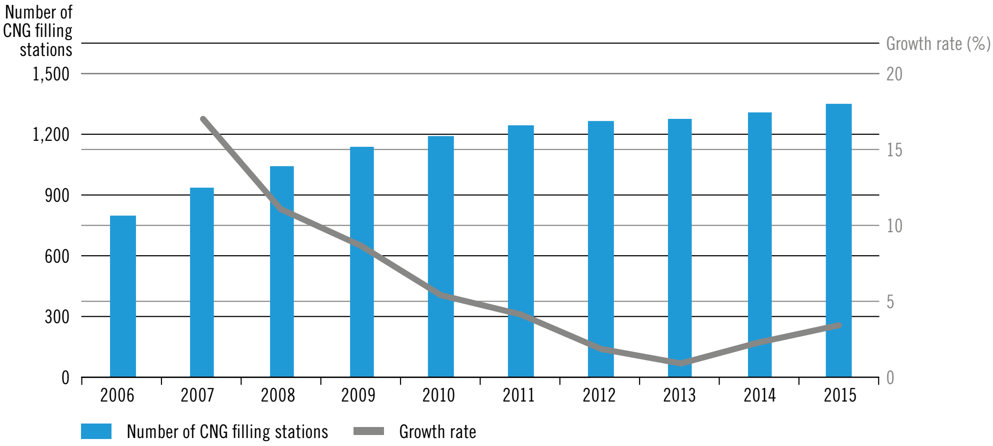


Figure 5.3: Number of CNG filling stations in the CEE region in 2006 – 2015

When considering filling stations, Germany again plays the leading role in the CEE region with 921 CNG filling stations, 1 existing LNG bunker facility for vessels (in Hamburg, 1 more planned in Dagebüll) and 2 planned mobile LNG refuelling stations in the port of Rostock for ships and heavy duty trucks. A similar coverage of CNG filling stations is found in Austria with 173 refuelling stations, closely followed by Bulgaria and the Czech Republic (see Figure 5.4). Generally, in the four mentioned countries, a sufficient network of CNG filling stations exists that will foster further growth in the CNG fleet and NG consumption in the transport sector.

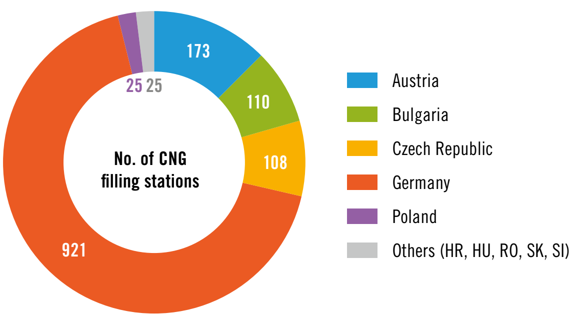


Figure 5.4: Number of CNG filling stations in countries of the CEE region in 2015

5.3 Legislation

Directive 94/2014/EU on the deployment of alternative fuels infrastructure, which is the cornerstone of the Clean Power for Transportation package, will probably cause a major expansion of the CNG & LNG infrastructure by 2030. Member States will have to develop National Policy Frameworks to establish networks of refuelling stations for NGVs in cities, densely populated areas, seaports, and along the Trans-European-Network for Transport (TEN-T).

The Member States are to provide refuelling points for:

- **CNG in cities/densely populated areas by 2020** in order to ensure that CNG motor vehicles can circulate in those urban/suburban agglomerations and other densely populated areas as well as throughout the European Union, at least along the existing TEN-T Core Network.
- **CNG & LNG along the TEN-T core network by 2025** in order to ensure that LNG heavy-duty motor vehicles and CNG motor vehicles can circulate throughout the European Union, where there is demand, unless the costs are disproportionate to the benefits, including the environmental benefits.
- **LNG in sufficient TEN-T seaports by 2025** to enable LNG seagoing ships to circulate throughout the TEN-T Core Network. If necessary, member States shall cooperate with neighbouring states in order to ensure there is a sufficient network in TEN-T Core.
- **LNG in sufficient TEN-T inland ports by 2030** to enable LNG inland waterway vessels to circulate throughout the TEN-T Core Network.

Utilisation of LNG in maritime transport could be promoted by regulations of the International Maritime Organisation (IMO) stated in the "International Convention on the Prevention of Pollution from Ships", also known as MARPOL 73/78.

This regulation has set a 0.1 % cap on sulphur content in marine fuel oil, which is combusted by ships in sulphur emission control areas (the Baltic and North Seas in the CEE GRIP region). As NG in the CEE region contains almost no sulphur, it is an ideal substitute for marine fuel oil.

Moreover, the IMO has set the year 2020 as the year of implementation of a new amended protocol regulating SO_x emissions from maritime ships globally. It sets a 0.5 % cap on sulphur content in marine fuel oil combusted outside of sulphur emissions control areas. The current limit is set at a huge 3.5 % sulphur limit.

This policy is expected to accelerate the use of LNG as a marine fuel, in the Baltic Sea as well as on the inland waterways of the CEE region like the Danube, Vistula, and Elbe Rivers.

Other important acts of legislation in favour of NGVs are Directive 2008/50/EC on ambient air quality and cleaner air for Europe and Regulation 715/2007/EC on type approval of motor vehicles with respect to emissions (Euro 5 and 6). While the first directive forces authorities to ban vehicles with harmful emissions from certain regions, the second imposes very challenging restrictions for the emissions of NO_x and PM of new passenger and commercial vehicles. However, NGVs have satisfied these restrictions for more than 10 years now.

5.4 Emissions Evaluation

5.4.1 GREENHOUSE GAS EMISSIONS

The two main approaches to greenhouse gas (GHG) evaluation of vehicles presented in this chapter are:

- JEC (Joint Research Centre) Methodology Versions 2.c (March 2007) and 4.a (January 2014) (Figure 5.6), which use the 5-seat C segment passenger car as a reference vehicle
- DLR (Deutsches Zentrum für Luft und Raumfahrt) & Partners (July 2013) (Figure 5.7), which use mid-size passenger car and city bus as reference vehicles

Both methods work with an overall balance of "well to wheels" (WTW), which accounts for production and transmission (well to tank – WTT) and consumption (tank to wheel – TTW) of the fuel, closely described in Figure 5.5. It should be mentioned that these studies comprise all emissions causing the greenhouse effect including, but not limited to, CO_2, N_2O, and CH_4. Methane (CH_4) is an especially potent greenhouse gas. Thus, any loss of unburned NG during exploitation, transmission, and distribution must be strenuously avoided.

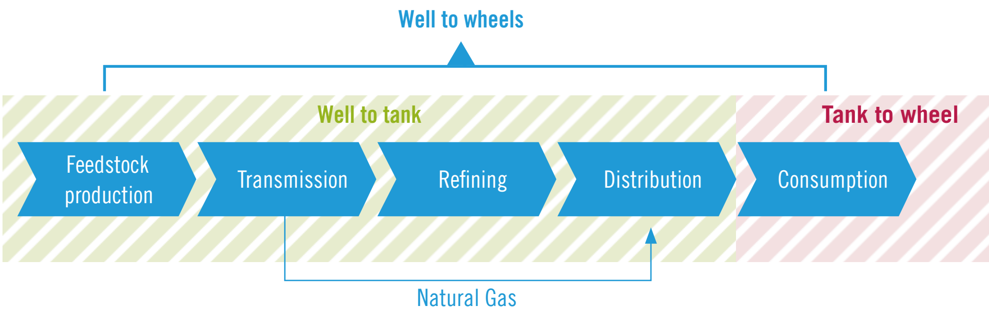


Figure 5.5: Well to wheels lifecycle diagram

As shown in Figures 5.6 and 5.7, GHG emissions per kilometre were in 2010 (JEC) and 2012 (DLR) about the same for CNG and diesel vehicles, as resulted from both evaluation methodologies. However, both evaluation methodologies predict a trend that the GHG emissions of CNG vehicles in the future will undercut the GHG emissions of diesel. While the JEC predicts a gap of 3.8 % in favour of CNG vehicles in the year 2020, the DLR predicts a gap of 9.8 % in favour of CNG passenger vehicles and even a gap of 14.3 % in favour of CNG buses by the year 2030.

The specific CO_2 emission per kWh given in Table 1 suggests a gap of 26 %. This theoretical value, however, is reduced, because the energy efficiency of a diesel-fuelled compression ignition engine is actually higher than the efficiency of a NG- or petrol-fuelled spark ignition engine, which is indicated in previous paragraph. For the same reason, compared to petrol-fuelled engines, NGVs by contrast actually demonstrate a positive advantage of 20 % regarding GHG emissions.

The DLR result for CNG buses is especially encouraging, and it confirms ongoing projects in Bulgaria and Germany for NG-fuelled buses and garbage collection trucks in urban areas.

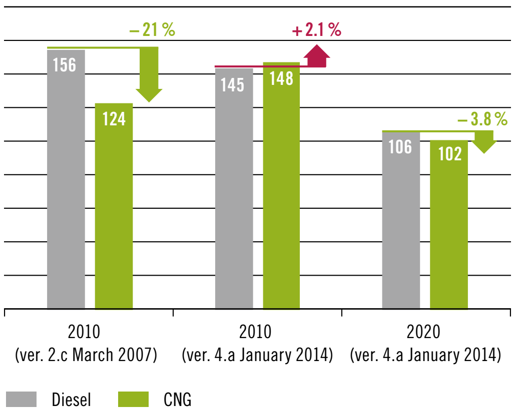


Figure 5.6: GHG emission evaluation of passenger vehicles using the JEC methodology (CO_{2eq}/km)

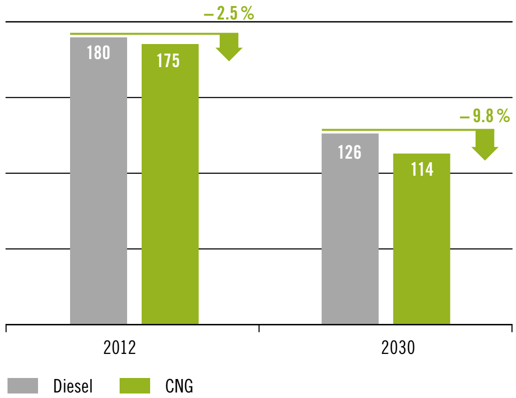


Figure 5.7: GHG emission evaluation of passenger vehicles using DLR & Partners' methodology (CO_{2eq}/km)

In addition to the intrinsic reduction of GHG as described above, NG can easily be blended with biomethane. Such an approach is similar to the obligatory blending of petroleum-based fuels with respective bio-components. These liquid bio-components, e.g. bio-ethanol and rapeseed oil, differ chemically and change the properties of the liquid fuel. As described in Chapter 5.1.2, biomethane, by contrast, does not change the properties of NG and allows NG to profit from the almost GHG-neutral well-to-wheel (WTW) balance of biomethane.

If 20 % of NG is substituted by biomethane, then, using the DLR & Partners' methodology, the WTW GHG emissions of a mid-sized passenger car are the following:

- 2012: 156 g CO_{2eq}/km
- 2030: 96 g CO_{2eq}/km

For year 2012, their methodology shows an additional 11 % decrease for CNG blended with 20 % of biomethane in WTW GHG emissions compared to pure CNG. Future outlooks are even more promising, due to sustainability efforts and the rising efficiency of production and transportation. Well-to-tank (WTT) emissions are expected to decrease by 2030, resulting in a 15 % total decrease of WTW GHG emissions when blending NG with biomethane.

5.4.2 POTENTIAL CO_2 SAVINGS

An extensive analysis was conducted in order to estimate the potential annual greenhouse gas savings by substituting 5 % of total diesel fuel consumption with CNG in the CEE region. The expected results for both methodologies can be seen in Figures 5.8 and 5.9.

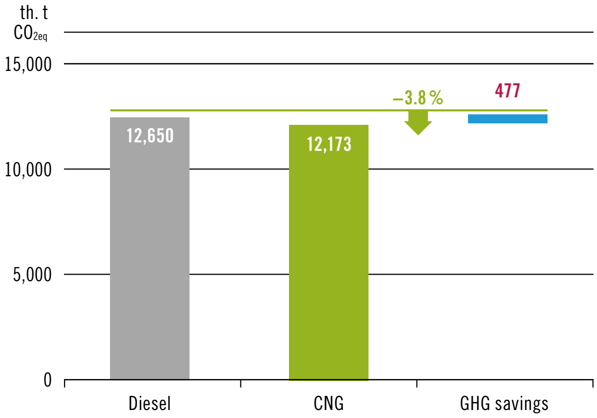


Figure 5.8: GHG – 5 % substitution of diesel fuel by CNG, JEC methodology

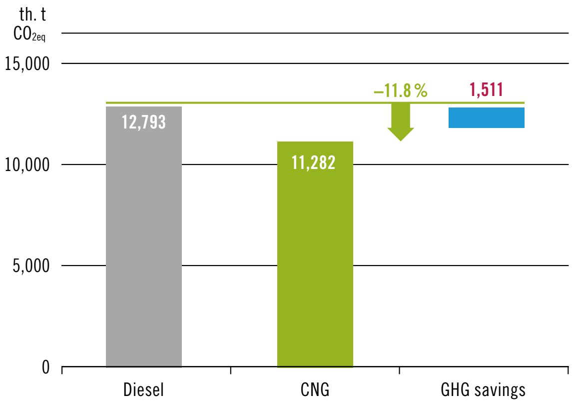


Figure 5.9: GHG – 5 % substitution of diesel fuel by CNG, DLR & Partners' methodology

The results show a greenhouse gas reduction of 3.8 % using the JEC methodology, which represents 477 thousand tons of CO_{2eq}. When the DLR & Partners' methodology is employed, an even more significant GHG reduction of 11.8 % is achieved, corresponding to 1,511 thousand tons of CO_{2eq}. This figure incorporates not only passenger cars but also buses, which represent heavy-duty vehicles. As described above, an even more significant reduction can be reached by blending CNG with biomethane.

5.4.3 EMISSIONS OF NO_x AND PARTICULATE MATTER

When compared to diesel engines, the average combustion temperature of NG is almost 260 °C lower at around 1,890 °C, which results in considerably smaller amounts of NO_x being emitted into the environment. The principle mechanism of NO_x formation is thermal dissociation and the subsequent reaction of nitrogen with oxygen molecules in the combustion air. Three major factors play a crucial role: oxygen concentration, combustion temperature, and time of exposure at the combustion temperature. As these factors increase, NO_x emission levels increase accordingly. Since natural gas has much lower combustion temperatures and does not require as much excess air, the NO_x emissions of CNG-powered vehicles are significantly lower than those from diesel.

The same is true for the emission of particulate matter (PM). NGVs are known to emit very little or no particulate matter. PM emission is closely associated with the residual combustion of fuel, which is a typical process for high molecular hydrocarbons, such as those in diesel fuel. Thus, the pollutant emissions of CNG vehicles have always easily met EURO 6 standards, even in former times when only EURO 1 and EURO 2 were in force.

Since the EURO 5 and EURO 6 emission standards came into force, the manufacturers of diesel vehicles must compensate for these handicaps by using costly aftertreatment of the exhaust gas in order to reach the high standards shown in Figure 5.10. Among these treatments are the Selective Catalytic Reduction of NO_x (SCR) and the Diesel Particulate Filter (DPF).

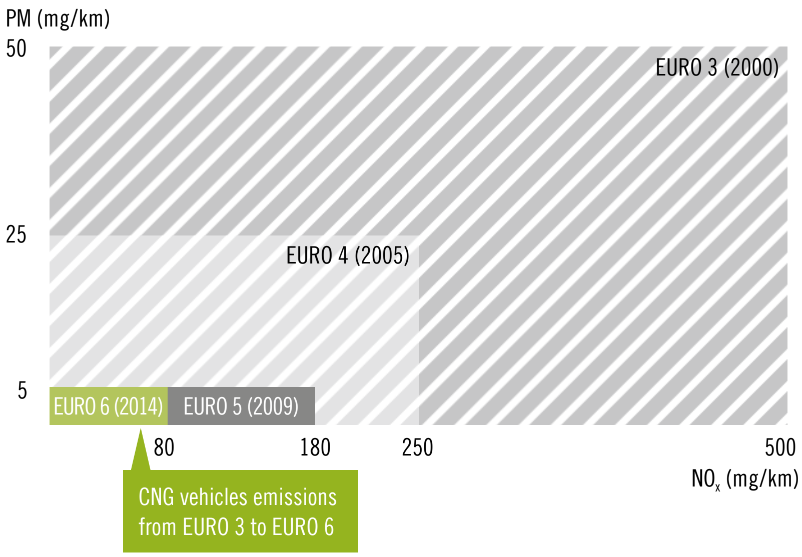


Figure 5.10: Development of EURO emissions limits of NO_x and PM pollutants for diesel passenger cars in the course of time from EURO 3 to EURO 6

Triggered by the behaviour of Volkswagen in the US in 2015, it has recently come under discussion whether new diesel cars reach the EURO 6 standards only under laboratory conditions, while emitting much higher quantities of harmful substances during normal operating conditions. This effect is even intensified when considering that commercial vehicles in urban areas typically operate in a stop-and-go mode, e.g. garbage collection trucks. In this low power range, the diesel engine is very inefficient and emits more NO_x and PM than in test driving cycles. According to a study by DLR in 2013 (shown in Figure 5.11), the real NO_x emissions exceeded the limit while the EURO 5 standards were in force. A similar study by the International Council on Clean Transportation in 2016 (given in Figures 5.12 and 5.13) also suggests that passenger cars do not meet the EURO 6 standards under normal operating conditions either. These facts put pressure on the manufacturers and may lead to a tightening of EURO 6 for diesel, causing a further increase in the cost of after-treatment. It should also be noted that diesel engines generally fulfil the foreseen environmental requirements only in a narrow band of operating conditions (especially with regard to ambient temperatures). By contrast, combustion engines using NG fulfil all emissions requirements regardless of the NGVs´ operational mode, speed, and load.

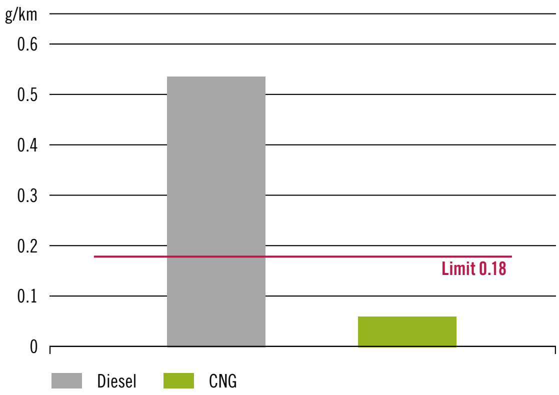


Figure 5.11: Real NO_x emission of a mid-sized passenger car while EURO 5 was in force (Source: DLR [Deutsches Zentrum für Luft und Raumfahrt] & Partners [July 2013])

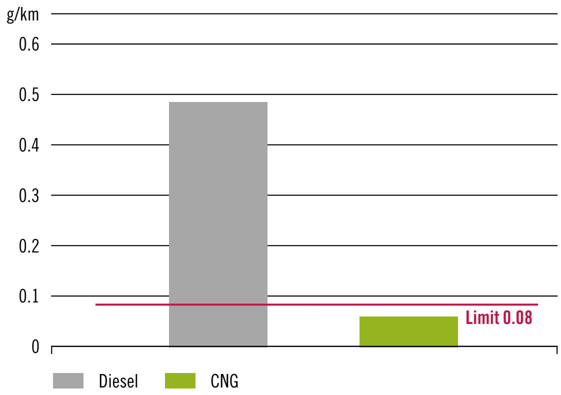


Figure 5.12: Real NO_x emission of a mid-sized passenger car while EURO 6 is in force (Source: DLR [Deutsches Zentrum für Luft und Raumfahrt] & Partners [July 2013]) and The International Council on Clean Transportation [December 2016])

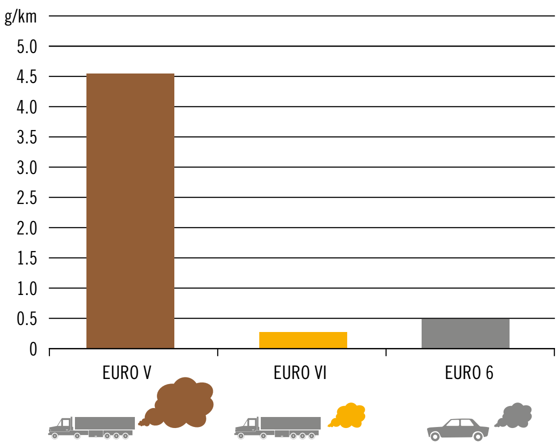


Figure 5.13: Real NO_x emissions of a heavy-duty diesel vehicle and a passenger diesel vehicle (Source: The International Council on Clean Transportation [December 2016])

5.4.4 EMISSION ASSESSMENT

The GHG emission evaluation using the JEC and DLR methodologies shows that NGVs offer about a 10 % reduction of GHG compared to diesel vehicles. An additional 15 % reduction can be reached by blending CNG with a 20 % mixture of biomethane.

Regarding pollutant emissions, NGVs have always been the cleaner option compared to diesel vehicles. With the introduction of EURO 6 standards, the costly after-treatment of diesel exhaust gases was established. However, it is questionable whether the existing driving test cycles of EURO 6 really guarantee the promised low emissions for urban transport. Future limits may make the after-treatment of diesel even more complex and costly.

Especially in the sector of heavy-duty vehicles like buses and garbage collection trucks, NGVs today already possess significant ecological and economic advantages over diesel engines. These advantages will only magnify when, as a result of political pressure, diesel emissions are properly tested under typical operating conditions in urban areas.

With the right cars available, passenger cars with high yearly mileage figures, like taxis and messenger services, offer a significant reduction potential of pollutants in city centres of the CEE region.

Image: iStockphoto

5.5 Economic Aspects

The operation of NGVs in a fleet is determined by the running costs for fuel and investment costs. Although the respective national conditions for CNG based on taxes, excise duties, subsidies, etc. vary in the CEE region, in general, the costs show a breakeven point when reaching a mileage of 20,000 to 40,000 km for passenger cars and 60,000 to 80,000 km for heavy-duty vehicles. After that point, the higher investment costs for NGVs are compensated by the cheaper fuel price.

While average diesel prices in the CEE region were above 1.2 EUR/litre over the last five years, the prices of CNG remained steadily low at around 1 EUR/0.95kg (which is equivalent to 1 litre of diesel) – see Figure 5.14[4)].

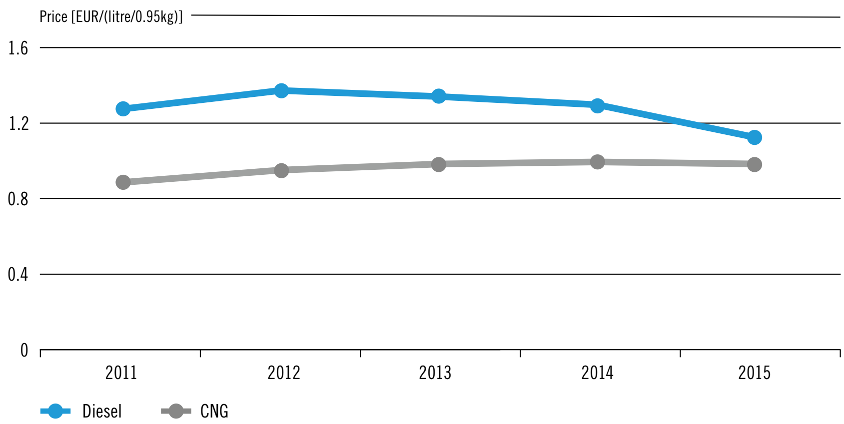


Figure 5.14: Average price of diesel fuel and CNG in the CEE region

4) For the purpose of price comparison, the following consumption equivalent ratio was implemented: The equivalent amount to 1 liter of diesel is 0.95 kg of CNG. This ratio was determined from a comparison of the fuel consumptions of several car models with a CNG powertrain and a diesel powertrain with the same power output. A comparison of fuels based on their energy content is not possible due to the different efficiencies of CNG and diesel powertrains.

As shown in Figure 5.15, the price differences go as high as 0.6 EUR per litre of diesel and its CNG equivalent. The difference is given mainly by an exemption from or a lower excise duty on CNG. For example, in Germany the excise duty for diesel fuel is 0.47 EUR/litre, which is almost twice as high as the excise duty for CNG. The higher price of diesel had also been driven by the high price of crude oil before 2015.

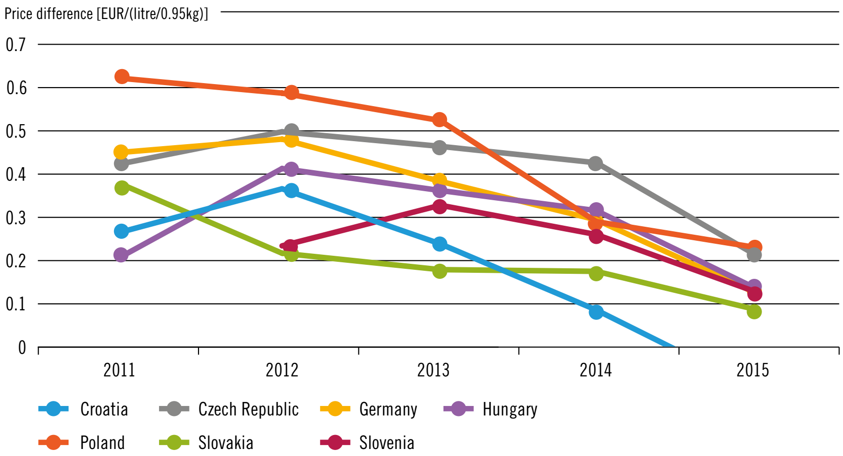


Figure 5.15: Price differences between diesel fuel and CNG

Also, the future expectations are that petrol and diesel prices will tend to fluctuate together because of their strong dependence on the international crude oil market and its strong ties to Middle East politics. Natural gas prices, however, are more locally driven and have proved to be less volatile than in the past, implying a much more stable final price of CNG.

Concerning the total cost of ownership, NGVs have standard maintenance and repair costs, but higher investment costs for the gas tank and gas valves. Keeping the emission assessment in mind, a trend can be stated that diesel vehicles have become and will become even more technically overcomplicated in order to meet the stringent emissions standards. This will result in an increase in diesel vehicle production costs, diesel vehicle purchase price increases, and diesel repair cost increases. This price differential may further rise when authorities decide to subsidise heavy-duty NGVs or impose stricter emission limits than EURO 6 in tenders for new vehicles. Thus, the TSOs expect the breakeven point for NGVs, compared to diesel vehicles, to move to a lower mileage figure in the future. This should further foster the growth of the NGV fleet in the CEE region and the usage of NG for transportation.

5.6 Other Future Pathways

Apart from CNG and LNG, there are other pathways in which natural gas can be utilised as a vehicle fuel. The following figure shows four of those alternative utilisations. They each differ in terms of technology maturity as well as vehicle performance and energy-environmental impacts.

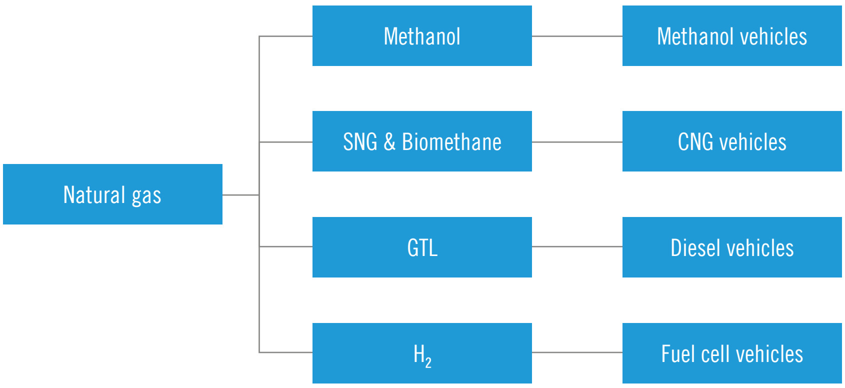


Figure 5.16: Natural gas utilisation pathways

Methanol is produced from natural gas through complex chemical processes and can be used either in combination with gasoline in methanol-gasoline blends (up to 15 vol. %), or directly as pure methanol as a fuel for internal combustion engines. While high blend proportions and pure methanol require an engine retrofit, low concentrations can be used in conventional petrol vehicles with no need for engine modification. The fuel costs of those vehicles are 30–50 % lower than for gasoline vehicles. The major drawbacks of this technology are an insufficient refuelling infrastructure together with GHG emissions during methanol production.

GTL, also known as Gas-To-Liquid, is derived from natural gas using Fisher-Tropsch synthesis. The advantage of those fuels is their similarity to conventional diesel in terms of physiochemical properties, so there is no need for engine retrofit nor refuelling infrastructure modifications. However, the current production costs of such fuels are higher than conventional diesels, which prevents their commercialisation.

Hydrogen on the other hand can be derived from natural gas by reforming for a minor expenditure and offers the benefit of zero emissions. However, implementing hydrogen into fuel cells could get very expensive. By the end of 2016, there is only one serially-produced hydrogen fuel cell vehicle which is the Toyota Mirai. Other hydrogen fuel cell vehicles are still for demonstration purposes only.

SNG, also known as "synthetic natural gas" or "substitute natural gas", together with biomethane are yet other alternatives with properties basically identical to those of natural gas. Synthetic natural gas is produced from fossil fuels or biomass (bio-SNG) by thermo-chemical gasification. Biomethane is generated via the anaerobic digestion of a biomass. The use of a biomass reduces greenhouse gas emissions to a minimum, as it is a carbon-neutral fuel. Both bio-SNG and biomethane are sometimes referred to as "Green gases". They allow non-fossil combustion and open up the prospect of CO_2 neutral mobility, including extending the use of the existing gas infrastructure. Consequently, there is no urgent need to get rid of combustion engines, but instead there is a chance to use a proven technology in a smarter, more sustainable way.

5.7 Conclusion on Natural Gas as a Transport Fuel

In conclusion, the environmental benefits of natural gas are well established. Gas as a transport fuel is a proven, mature, and reliable technology with readily available passenger vehicles, trucks and ships at competitive costs. As it has been shown in the chapters above, the use of NGVs results in lower greenhouse gas emissions, fewer local pollutants, and reduced noise.

Thus, it contributes to cleaner and healthier ambient air. It is a substantially welcome development for urban areas. Over the last ten years, natural gas as a transportation fuel has seen significant success in terms of adoption in various countries around the world and in the CEE region. NG in transportation also brings economic advantages, as it offers the lowest total costs of ownership for high mileage vehicles. Despite the unexpected fall of crude oil prices in 2013–2015, which decelerated NGV expansion, crude oil prices started to rise again in the second half of 2016. It is expected that over the long term the crude oil price will continue to rise as oil reserves are being depleted. The stringent emission standards of EURO 6 make diesel vehicles technically overcomplicated and lead to a further increase of their total cost of ownership.

These conditions provide NGVs a perfect opportunity to demonstrate their real value and to secure recognition within the transportation market. Future development will also be driven by Directive 94/2014/EU on the deployment of alternative fuels infrastructure that should help all Member States of the CEE region to implement a dense network of refuelling stations for natural gas vehicles by the year 2030. Reliable legal and regulatory frameworks for investments in CNG and LNG passenger vehicles, trucks, ships and refuelling infrastructure and equal, non-discriminatory, transparent terms for all kinds of fuels are needed and should be supported by policy makers. Investment costs can be optimised through the integrated development of refuelling points at the existing petrol filling stations and the existing gas infrastructure, such as via pipelines, LNG terminals, and distribution grids.

Concerning the marine usage of LNG, the IMO regulation on sulphur content in marine fuel oil should boost the use of LNG.

The future development of NGVs will increase their market share in road transportation, which will result in the increased utilisation of NG as fuel for NGVs. Together with an increase of LNG utilisation in maritime transport, this represents an important opportunity for the TSOs to facilitate the transmission of additional volumes of NG for transportation sector or at least to compensate for the decline of gas consumption for heating due to efficiency measures in house construction. In any case, the use of natural gas and green gases in transportation is an occasion to target and expand the TSOs' businesses in the CEE region and to make another step towards reaching the EU climate targets in an efficient way.

6 Conclusions

Image courtesy of FGSZ

This is already the third edition of the Gas Regional Investment Plan for Central and Eastern Europe (CEE GRIP). It provides a specific regional view emphasising the regional gas infrastructure outlook, specific assessments, and the basis for the identification of potential future gas infrastructure needs in the CEE region. The EU-wide Ten-Year Network Development Plan 2017 (TYNDP 2017) and the current CEE GRIP are strongly linked due to their use of the same harmonised data set. Therefore, the analysis performed in this report can complement the findings in the TYNDP 2017[1].

Generally, the CEE region is mostly characterised by its high dependence on Russian gas, its vulnerability to Ukrainian or Belarusian gas transit disruptions, and limited or poor competition. The CEE GRIP provides other analyses beyond the ones performed in the TYNDP 2017 by more deeply exploring these regional characterisations. The ability of the transmission network in the CEE region was stressed with extreme scenarios represented by the simultaneous disruption of the gas supply routes via Ukraine and Belarus and a disruption of the whole Russian gas supply source.

The assessment results show that the region is dependent on the Russian gas source. The assessment also shows that the countries in southeastern Europe (Croatia, Hungary, Romania, and Bulgaria) and Poland are the most vulnerable countries when the region is confronted with simulated gas disruptions. The mitigation or elimination of these problematic findings will depend on the implementation of projects that will enhance the diversification of gas sources and will strengthen the gas interconnections between countries in the region in the upcoming decade.

The CEE GRIP Regional N-1 analysis is based on the security of supply analysis according to the REG 994/2010 but modified for regional purposes. The calculation assumes the disruption of gas supplies via Ukraine and Belarus both in the summer and winter periods. An interruption of the gas route through Ukraine would be expected to have a negative impact on Bulgaria and Romania during the winter period 2017/2018. However, if planned infrastructure projects are implemented in subsequent years, it will have a positive effect on the N-1 value which will be above one in these countries. Due to geographical reasons, a disruption of gas supplies via Belarus only affects Poland, but the assessment shows positive results over the entire time range.

Regarding the summer period, the CEE GRIP Regional N-1 analysis resulted in the identification of a problem in Bulgaria for a gas supply disruption via Ukraine in summer 2017, as a deficit of gas causes the inability to fill the Bulgarian underground storage facilities. This potential situation could lead to a deepening of the problem identified during the winter period 2017/2018, because the underground storage facilities would be empty. Some potential problems were also identified in Hungary and Romania in summer 2017, if a gas supply disruption via Ukraine lasted more than 45 and 138 days, respectively. And in Hungary during summer 2020, a Ukrainian disruption should not last longer than 37 days. All these identified problems are fully resolved by the commissioning of the planned projects in the following years. The other countries in the CEE region are able to cover their gas demands and to meet the injection requirements of underground storage facilities while facing Ukrainian or Belarusian gas supply route disruptions.

1) The EU-wide Ten-Year Network Development Plan 2017 is available under the following link:
http://www.entsog.eu/publications/tyndp#ENTSOG-TEN-YEAR-NETWORK-DEVELOPMENT-PLAN-2017

As a special part of this report, a whole chapter tackles the future potential and challenges of natural gas as a perspective fuel. Economic growth is associated with increased transportation demands. However, due to urbanisation tendencies, metropolitan cities often suffer from vehicular overcrowding and from the resulting harmful pollutants produced by commercial diesel vehicles, especially when used in a stop-and-go mode. Lately, emissions legislation has become more and more demanding and stringent, which is mainly the reason why natural gas is gaining more interest as a transportation fuel. The future expected increase in the usage of natural gas in the transportation sector, as low-emission GHG fuel alternative, encourages the TSOs to facilitate the transmission of NG volumes used in transportation, to further foster extended gas supply in the CEE region, and to make another step towards reaching the EU climate targets in an efficient way.

The CEE GRIP TSOs hope that you have found this report useful and informative and would like to warmly encourage all interested stakeholders to participate in the upcoming consultation and dedicated workshop which will be announced soon.


Image courtesy of NET4GAS

Abbreviations

2W	2-week high demand case (14 day uniform risk)
BGn	Bulgaria
CEE GRIP	Gas Regional Investment Plan for Central and Eastern Europe
CEE region	Central and Eastern Europe region
CNG	Compressed Natural Gas
DC	1-day Design Case (Peak Day)
DEg	Balancing Zone of GASPOOL (Germany)
DEn	Balancing Zone of NetConnect Germany
DLR	Deutsches Zentrum für Luft und Raumfahrt
DPF	Diesel Particulate Filter
DR	Disrupted Rate
DQ	Disrupted Quantity
ENTSOG	European Network of Transmission System Operators for Gas
EU	European Union
ESW-CBA	Energy System Wide Cost-Benefit Analysis
FID	Final Investment Decision
GHG	Greenhouse Gas
GTL	Gas-To-Liquid
GWh/d	Gigawatt hour per day
IP	Interconnection Point
JEC	Joint Research Centre
LNG	Liquefied Natural Gas
NG	Natural Gas
NGV	Natural Gas Vehicle
non-FID	Without Final Investment Decision
NP	National Production
PCI	Projects of Common Interest
PM	Particulate Matter

REG 347/2013	Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009
REG 715/2009	Regulation (EC) No 715/2009 of 13 July 2009 on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005
REG 994/2010	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
RF	Remaining Flexibility
RussiaAll	Disruption of the Russian gas supply source
SCR	Selective Catalytic Reduction
SNG	Synthetic Natural Gas
SoS	Security of Supply
TCO	Total Cost of ownership
TEN-T	Trans-European-Network for Transport
TSO	Transmission System Operator
TYNDP	EU-wide Ten-Year Network Development Plan
UGS	Underground Gas Storage
UkraineBelarus	Simultaneous disruption of the gas supply routes via Ukraine and Belarus
UN	the United Nations
VOC	Volatile Organic Compounds

Country Codes (ISO)

AT	Austria	**IT**	Italy
BG	Bulgaria	**LT**	Lithuania
BY	Belarus	**PL**	Poland
CZ	Czech Republic[1)]	**RO**	Romania
DE	Germany	**RS**	Serbia
DK	Denmark	**RU**	Russia
GR	Greece	**SI**	Slovenia
HR	Croatia	**SK**	Slovakia
HU	Hungary	**UA**	Ukraine

1) On 17 May 2016 the Permanent Mission of the Czech Republic to the United Nations (UN) informed the UN that the short name to be used for the Czech Republic is Czechia. The name Czechia is not replacing the full official name of the Czech Republic. For more information please see web page of the Ministry of Foreign Affairs of the Czech Republic (www.mzv.cz).

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Well-to-Wheels analysis of future automotive fuels and powertrains in the European context

DLR – Deutsches Zentrum für Luft- und Raumfahrt e.V.,
Institut für Verkehrsforschung,
in collaboration with:
- Institut für Energie- und Umweltforschung Heidelberg GmbH (IFEU)
- Ludwig-Bölkow-Systemtechnik GmbH (LBST)
- Deutsches Biomasseforschungszentrum gGmbH (DBFZ)

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