TEN-YEAR NETWORK DEVELOPMENT PLAN

2018

SYSTEM ASSESSMENT REPORT

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1 INTRODUCTION

For this TYNDP 2018, ENTSOG has carried out another extensive assessment of the European gas system to identify potential investment needs and how projects submitted to TYNDP can help mitigating these needs. To prepare this new edition, ENTSOG has also made significant adaptations compared to TYNDP 2017 to continuously improve the assessment and meet stakeholders' expectations.

COST-BENEFIT ANALYSIS METHODOLOGY 2.0 (CBA METHODOLOGY 2.0)

TYNDP 2018 assesses the infrastructure in accordance with the new Cost-Benefit Analysis Methodology developed by ENTSOG and approved by the European commission on 1 December 2018.

This new CBA methodology aims at delivering a comprehensive assessment bringing more clarity with a reduced number of indicators and an easier interpretation of the results. Thi is done with with the introduction of a new approach to supply assumptions, the implementation of a market layer in ENTSOG modelling, and further monetisation of the indicators.

ENTSOG AND ENTSO-E JOINT SCENARIOS

For the first time, TYNDP 2018 edition assesses the potential investment needs against the common scenarios developed jointly with ENTSO-E, the association of electricity TSOs, ensuring consistency between the Ten-Year Network Development Plans of both energy carriers.

The different scenarios developed by the ENTSOs aim at representing a range of different possible futures to capture the needs for investment and the impact of projects along different storylines. All scenarios are on track to meet the EU decarbonisation targets by 2030, taking different pathways.

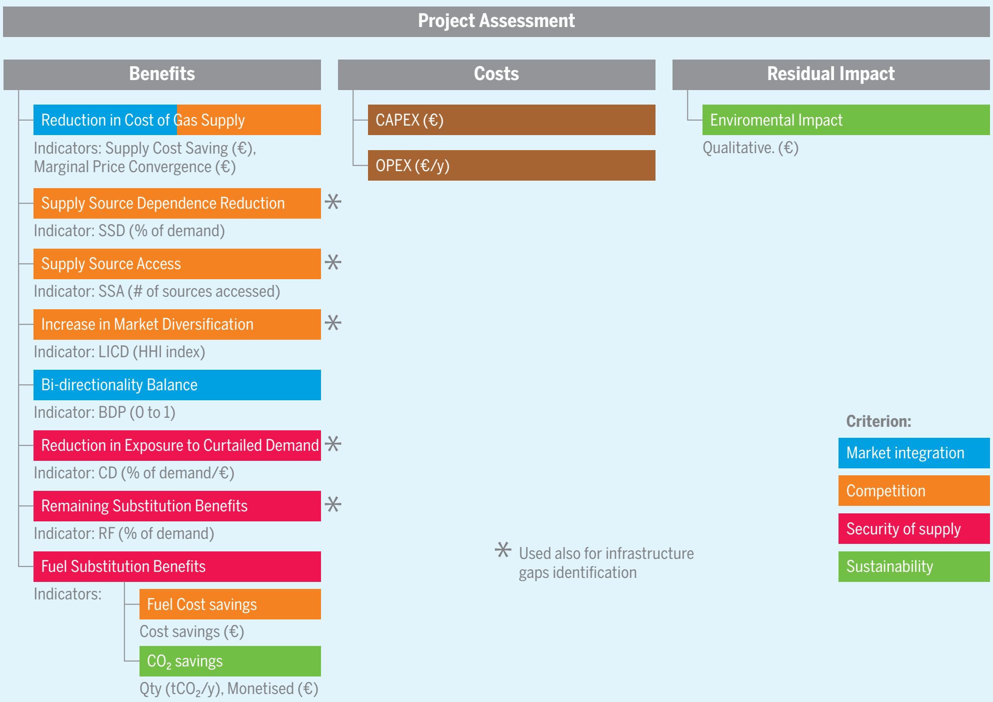

Figure 1.1: Assessment metrics and Regulation criteria

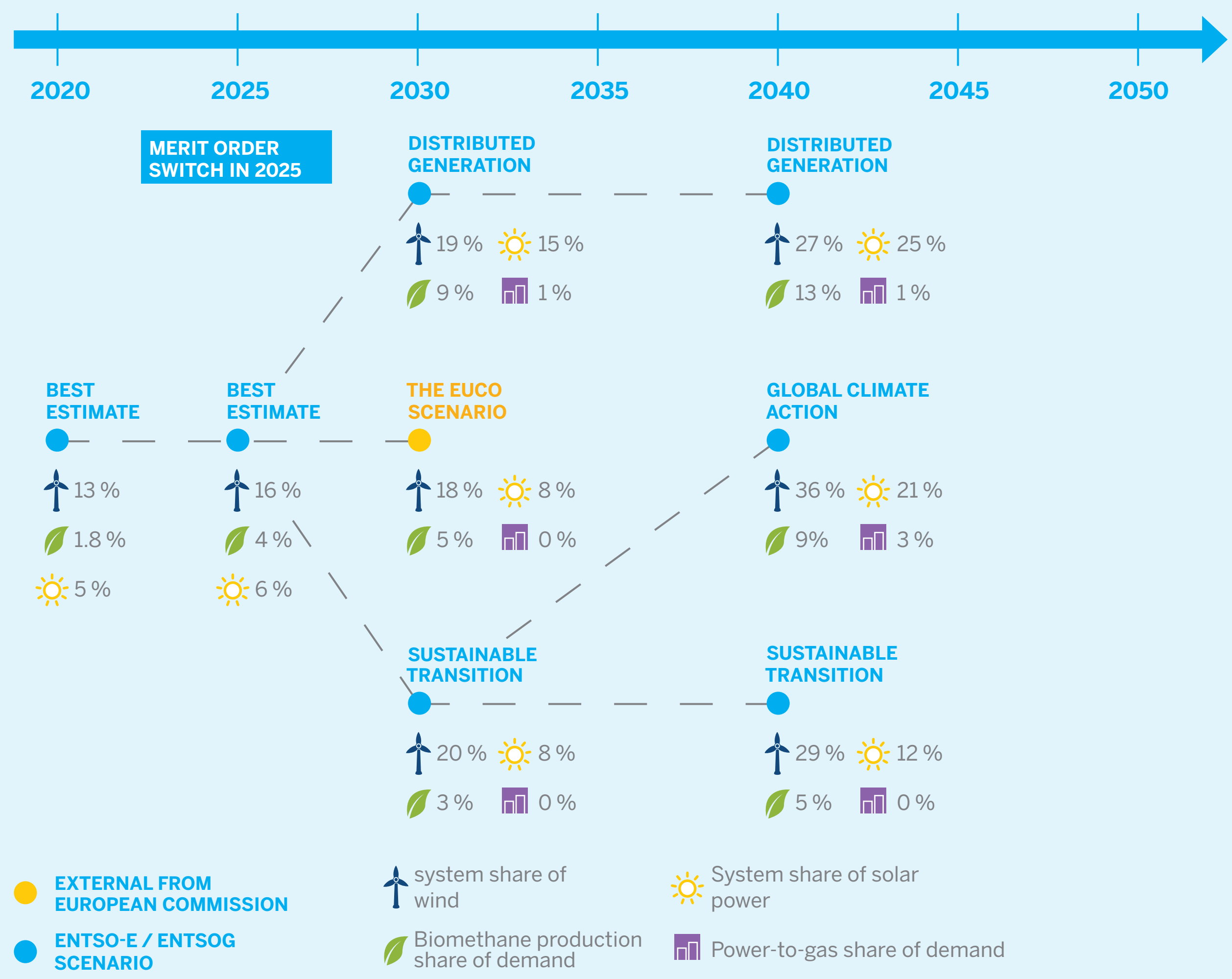

Figure 1.2: The scenario building framework for the TYNDP 2018.
Renewable Energy Systems (RES) share of demand for electricity and gas

The Best Estimates scenarios for 2020 and 2025 reflect national and European regulation currently in place, with a sensitivity analysis on the merit order of coal and gas in the power sector.

FOR 2030 AND 2040, THE LONGER-TERM SCENARIOS ARE:

- **Sustainable Transition (ST)** reflecting a quick and economically sustainable CO_2 reduction by replacing lignite and oil in the power sector and in part transport sector,
- **Distributed Generation (DG)** reflecting a more decentralised approach with a higher penetration of renewable gases, and renewable energy in general,
- **Global Climate Action (GCA)** representing a global effort towards full speed decarbonisation with increased energy efficiency and decreasing gas demand,
- **External Scenario (EUCO 30)**, the core policy scenario of the European Commission achieving Climate and Energy targets by 2030.

Further details about the scenarios and the methodology used by the ENTSOs (including the data) in their joint scenario building exercise can be found in the TYNDP scenario report[1].

1) https://entsog.eu/publications/tyndp#ENTSOG-TEN-YEAR-NETWORK-DEVELOPMENT-PLAN-2018

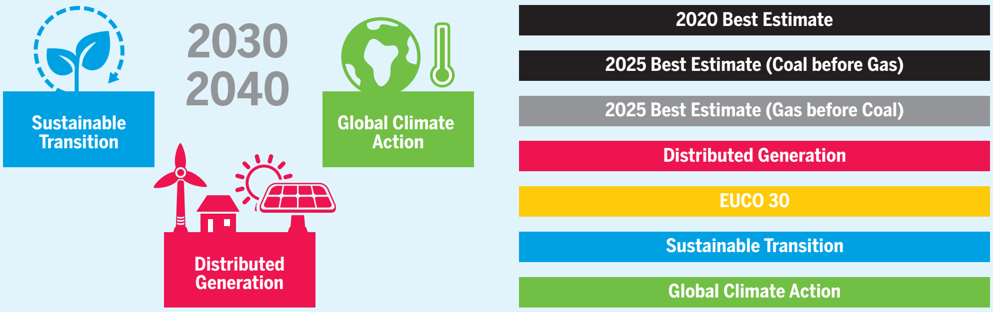

Figure 1.3: Abbreviations and colour code of the different scenarios

INFRASTRUCTURE LEVELS

The selection of the proper level of development of infrastructure is key for the identification of infrastructure gaps and a reliable system and project assessment.

Low infrastructure level, the reference

The low infrastructure level is formed by existing infrastructure and projects with FID status representing the minimum level of infrastructure development considered for the identification of infrastructure gaps and against which to assess projects.

TYNDP 2018 assesses what the current infrastructure, complemented with FID projects, already achieves and which are the remaining gaps that may trigger additional investment.

Advanced and PCI infrastructure levels

Once the infrastructure gaps are identified, the assessment of the European gas system is complemented by assessing the overall further impact of additional infrastructure levels:

– the Advanced infrastructure level including existing infrastructure and projects with FID and Advanced status (projects to be commissioned before 2025, which have started the permitting process or their Front-End Engineering Design). The advanced criteria is further elaborated in the Infrastructure chapter (Annexe A),

– the PCI infrastructure level gathering all the projects from the 3rd PCI list, although it includes projects of very different maturity.

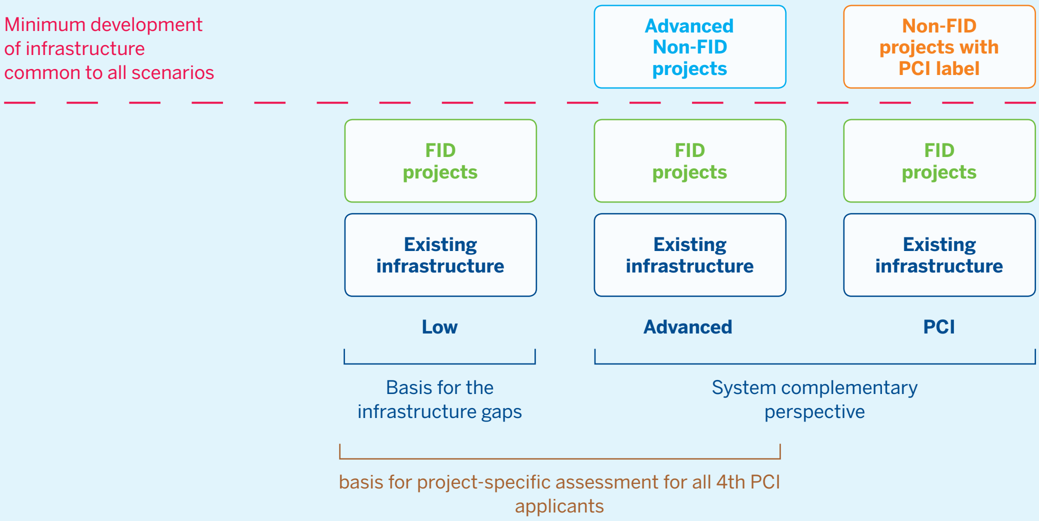

Figure 1.4: Infrastructure Levels

2 ASSESSMENT OF REASONABLE INFRASTRUCTURE NEED AND INVESTMENT GAPS (LOW INFRASTRUCTURE LEVEL)

The Low infrastructure level is the basis for the identification of priority areas facing an investment gap. It consists of the existing infrastructure and the FID projects. forty two FID projects have been submitted for this TYNDP edition.

The following Tables 2.1 and 2.2 list those projects. The FID projects represent an overall investment around 35 Billion €. It incorporates large scale projects for which costs have been publicly reported (including Nord Stream 2 and TANAP) which represent a large share of the overall costs of FID projects.

FID projects with direct impact in the low infrastructure level

Code	Project name	Country	Project commissioning year first
LNG-F-147	Revythoussa (2nd upgrade)	Greece	2018
LNG-F-163	Gran Canaria LNG Terminal	Spain	2027
LNG-F-178	Musel LNG terminal	Spain	2020
LNG-F-183	Tenerife LNG Terminal	Spain	2021
LNG-F-229	Zeebrugge LNG Terminal – 5th Tank	Belgium	2019
LNG-F-272	Upgrade of LNG terminal in Świnoujście	Poland	2023
TRA-F-1028	Albania - Kosovo Gas Pipeline	Albania	2022
TRA-F-1138	South Caucasus Pipeline – (Future) Expansion – SCP-(F)X	Azerbaijan	2018
TRA-F-1193	TAP interconnection*	Italy	2019
TRA-F-1228	Interconnection with UGS in Cornegliano Laudense	Italy	2018
TRA-F-1241	Interconnection with production in Gela	Italy	2020
TRA-F-137	Interconnection Bulgaria – Serbia	Bulgaria	2022
TRA-F-190	Poland – Slovakia interconnection	Slovakia	2021
TRA-F-208	Reverse Flow TENP Germany	Germany	2018
TRA-F-212	Gas Interconnection Poland-Lithuania (GIPL) – PL section	Poland	2021
TRA-F-214	Support to the North West market and bidirectional cross-border flows	Italy	2018
TRA-F-221	TANAP – Trans Anatolian Natural Gas Pipeline Project	Turkey	2018
TRA-F-230	Reverse Flow Transitgas Switzerland	Switzerland	2018
TRA-F-241	MONACO section phase I (Burghausen–Finsing)	Germany	2018

Table 2.1: FID projects with direct capacity impact in the low infrastructure level

Code	Project name	Country	Project commis-sioning year first
TRA-F-247	North – South Gas Corridor in Western Poland	Poland	2020
TRA-F-275	Poland – Slovakia Gas Interconnection (PL section)	Poland	2021
TRA-F-298	Rehabilitation, Modernization and Expansion of the NTS	Bulgaria	2021
TRA-F-334	Compressor station 1 at the Croatian gas transmission system	Croatia	2019
TRA-F-341	Gas Interconnection Poland–Lithuania (GIPL) (Lithuania's section)	Lithuania	2021
TRA-F-358	Development on the Romanian territory of the NTS (BG–RO-HU-AT)-Phase I	Romania	2019
TRA-F-378	Interconnector Greece–Bulgaria (IGB Project)	Bulgaria	2020
TRA-F-45	Reverse capacity from CH to FR at Oltingue	France	2018
TRA-F-51	Trans Adriatic Pipeline	Greece	2019
TRA-F-895	Balticconnector	Estonia	2019
TRA-F-902	Capacity increase at IP Lanžhot entry	Slovakia	2019
TRA-F-915	Enhancement of Estonia–Latvia interconnection	Estonia	2019
TRA-F-918	Capacity4Gas – CZ/SK	Czechia	2020
TRA-F-928	Balticconnector Finnish part	Finland	2019
TRA-F-937	Nord Stream 2	Germany	2019
TRA-F-941	Metering and Regulating station at Nea Messimvria	Greece	2019
TRA-F-954	TAG Reverse Flow	Austria	2019
UGS-F-1045	Bordolano Second phase	Italy	2020
UGS-F-242	Cornegliano UGS	Italy	2018
UGS-F-260	System Enhancements – Stogit – on-shore gas fields	Italy	2027
TRA-F-286	Romanian-Hungarian reverse flow Hungarian section 1st stage	Hungary	2019
TRA-F-752	Capacity4Gas – DE/CZ	Czechia	2019

Table 2.1: FID projects with direct capacity impact in the low infrastructure level

FID projects without direct impact in the low infrastructure level

Code	Project name	Country	Project Commis-sioning year First
TRA-F-1271	Compressor Station Krummhoern	Germany	2022
TRA-F-329	ZEELINK	Germany	2023
TRA-F-331	Gascogne Midi	France	2018
TRA-F-340	CS Wertingen	Germany	2019
TRA-F-43	Val de Saône project	France	2018

Table 2.2: FID projects without direct capacity impact in the low infrastructure level

2.1 SUSTAINABILITY

Supporting Renewable Energy Sources

The European gas infrastructure can achieve the supply and demand adequacy with different supply mixes and different shares of renewable gases over the whole-time horizon for all demand scenarios[2]. The infrastructure, and in particular gas storages, offer the necessary flexibility to make use of the full potential of renewable generation and cope with challenging situations such as peak days under climatic stress.

Regarding the sustainability pillar of the EU Energy Policy, gas infrastructures already offer a flexible system able to support the development of renewable energies. These infrastructures are able to transport a low carbon fuel to support the development of intermittent renewable power production and enable a large-scale injection of non-fossil gas (biogas/biomethane or gas from power-to-gas processes). Gas infrastructures provide the advantage of storing renewable energy as well as transporting energy at relatively low costs. New investment may allow further integration of renewable sources and achieve further level of decarbonisation.

Power to Gas

Power to Gas projects are not assessed as part of TYNDP 2018 as they are not eligible for the project collection and their potential are covered only partially. However, as part of their cooperation[3], and in view of further assessment, ENTSOG and ENTSO-E consider the electricity system and the gas system could be considered as complementary to each other:

- The electric system allows the production of large quantities of renewable energy, but it has limitations to provide long term electric storage.
- On the other hand, the gas system's ability to store large quantities of renewable energy is very high.
- The electric system is a fast, real time system and as such, it is featured with limited long-term flexibility, whereas the gas system is flexible, also long-term and can provide its flexibility to the electric system. The continuously growing penetration of the renewables increases the need for electricity ancillary services to cope with the large amount of volatile energy and thus has a significant impact on the technical and financial aspects of the electricity system operation. Therefore, from a system perspective, a coupling of electricity and gas will result in a more stable overall system as a whole. In addition, the societal costs of the combined sectors could eventually decrease because:
- the complementary characteristics of the two sectors support each other so that RES can be integrated more efficiently,
- existing infrastructure which will require some adaptations could potentially be used (e.g. gas grid and gas storage),
- continued utilisation of existing end user technology, when conversion is not cost efficient or fast enough,
- gas storage (in addition to a number of hydro power storage systems which could also be expended) is the only known seasonal storage with sufficient capacity, and
- synthetic gases are valuable energy carriers for heating, transportation and the chemical industry, together with biomethane and decarbonised gas.

The European Commission and the European Council support the approach of implementing P2G facilities from the system perspective.

Additional elements related to sustainability criteria are available in the TYNDP 2018 ENTSOG and ENTSO-E Joint Scenario Report (CO_2 emissions savings related to the different scenarios, electricity generation, power-to-gas and biomethane).

2) See SoS chapter for more details.

3) ENTSO-E and ENTSOG joint paper: Power to Gas – A Sector Coupling Perspective (https://www.entsog.eu/public/uploads/files/publications/Press %20Releases/2018/ENTSOs %20Position %20on %20Sector %20Coupling_Madrid %20Forum.pdf)

2.2 SECURITY OF SUPPLY NEEDS

Security of supply needs are assessed be measuring the ability of the European gas system to ensure the continuity of gas supply to all countries under various stress conditions.

This section assesses the resilience of the European gas system to cope with various stressful events:

- Climatic stress
- Supply route disruptions
- Infrastructure disruptions

The resilience of the gas system is measured by calculating the Remaining Flexibility (RF indicator) of the system when coping with the various stressful events and, be it the case, the level of demand curtailment (CR indicator: curtailment rate) to which the EU is exposed. Those indicators are calculated at country/balancing zone level over the whole time horizon of the TYNDP assessment.

Remaining flexibility measures the resilience of a Zone as the additional share of demand each country can cover before no longer being able to fulfil its demand without creating new demand curtailment in other Zones.

Demand curtailment is the value of the unsatisfied demand. The curtailment rate is the ratio between demand curtailment and demand.

Demand elasticity

When assessing the impact of a climatic stress on the gas infrastructure, the demand is considered static and no elasticity in the demand is considered. This assumption is necessary to perform a consistent assessment across the different years and the different scenarios of the TYNDP.

Indeed, as observed in past events, a high demand event, especially if combined with a tight supply or infrastructure situation may trigger a demand reaction to the increase of prices, hence resulting in a reduction of the demand. However, such demand elasticity is subject to various assumptions that differs from one country to the other, and that ENTSOG cannot access. Therefore, for the sake of consistency and transparency, the level of exposure to demand curtailment is always presented in percentage of the demand assuming no demand reaction to the different stressful events.

2.2.1 CLIMATIC STRESS

Climatic stress conditions result in high gas demand situations and are therefore challenging for the gas system. The ability of the system may be challenged to cope with:

- a peak day demand also considered as the design case for most of the gas infrastructures,
- a 2-week cold spell when the average demand is relatively lower compared to a peak day, but having a longer duration and being still higher than the demand in average climatic conditions.

Peak day (see figure 2.1)

The assessment shows that the EU gas system is resilient to peak demand situations for all scenarios.

In the longer term though, from 2025 onwards, in the low infrastructure level, Croatia is exposed to an increasing demand curtailment in all scenarios due to infrastructure limiting the flow from Slovenia and Hungary. This exposure is the result of an increasing demand in Croatia driven by the power generation[4)]. Infrastructure reinforcement may be required to cope with high demand situations in Croatia.

FYROM is exposed to a demand curtailment in 2020 and 2025 due to infrastructure limiting the flow from Bulgaria. The situation is mitigated from 2030 onwards (except for Sustainable Transition in 2030).

In Sustainable Transition scenario, Western Europe shows a rather low level of Remaining Flexibility in 2030 and in 2040 due to a highest gas demand displacing higher carbon fuels for power generation and transportation, and to a limited penetration of renewable gas sources not compensating the decrease in the national production. For the same reason, in Sustainable Transition scenario in 2040, Poland show a rather low level of Remaining Flexibility.

In most of the countries, penetration of renewable gas sources are compensating the decline of conventional production in Distributed Generation scenario, EUCO 30 and Global Climate Action scenario, supporting the European security of gas supply. However, renewable gases do not compensate for the decrease of conventional national production at EU level in Sustainable Transition scenario, resulting in an increasing need for seasonal flexibility ensured by gas storages. Figure 2.1 shows the simulation results for a Peak Day.

4) see TYNDP 2018 Scenario Report Annex I

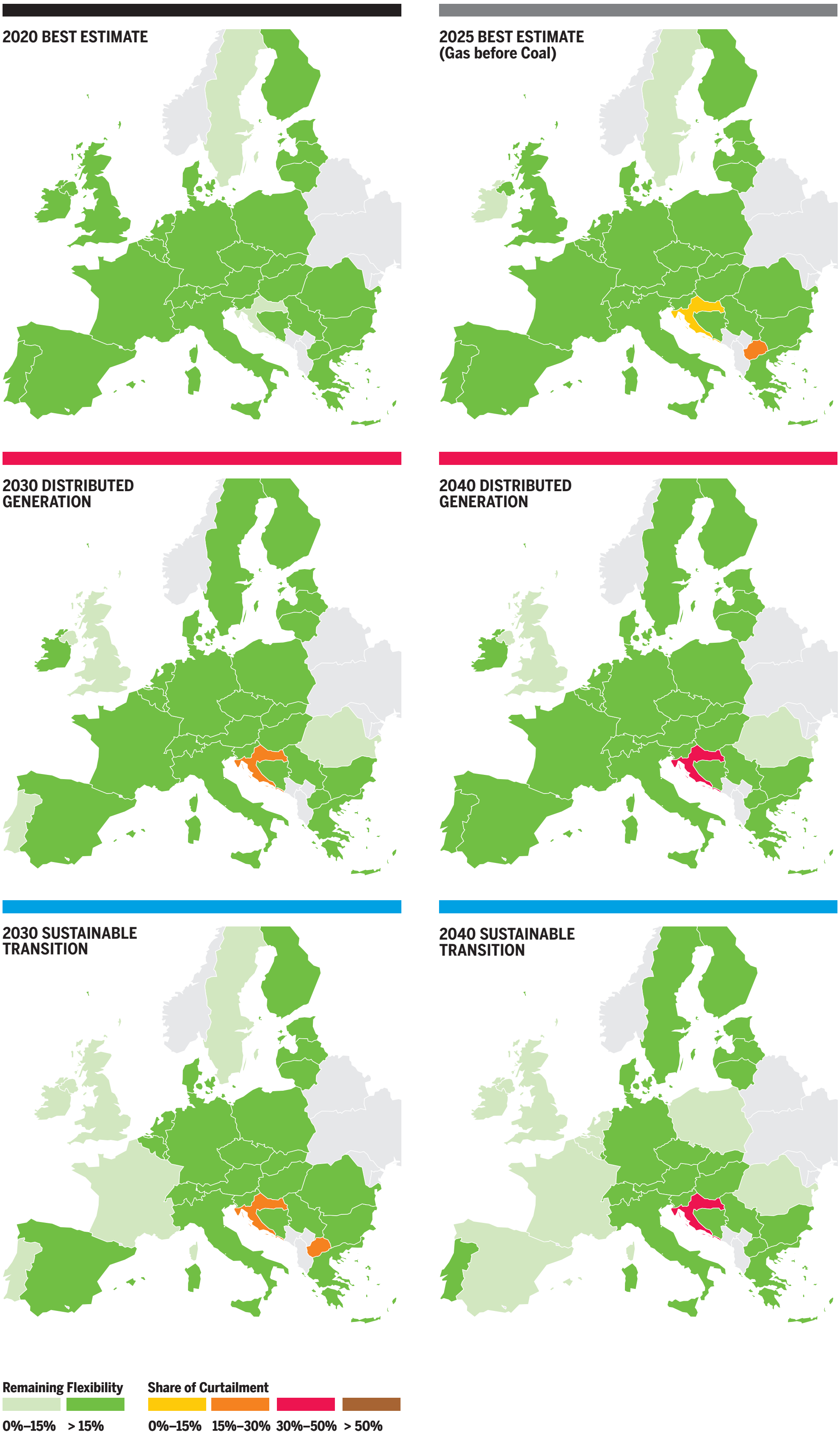

Figure 2.1: Climatic Stress for Peak Day

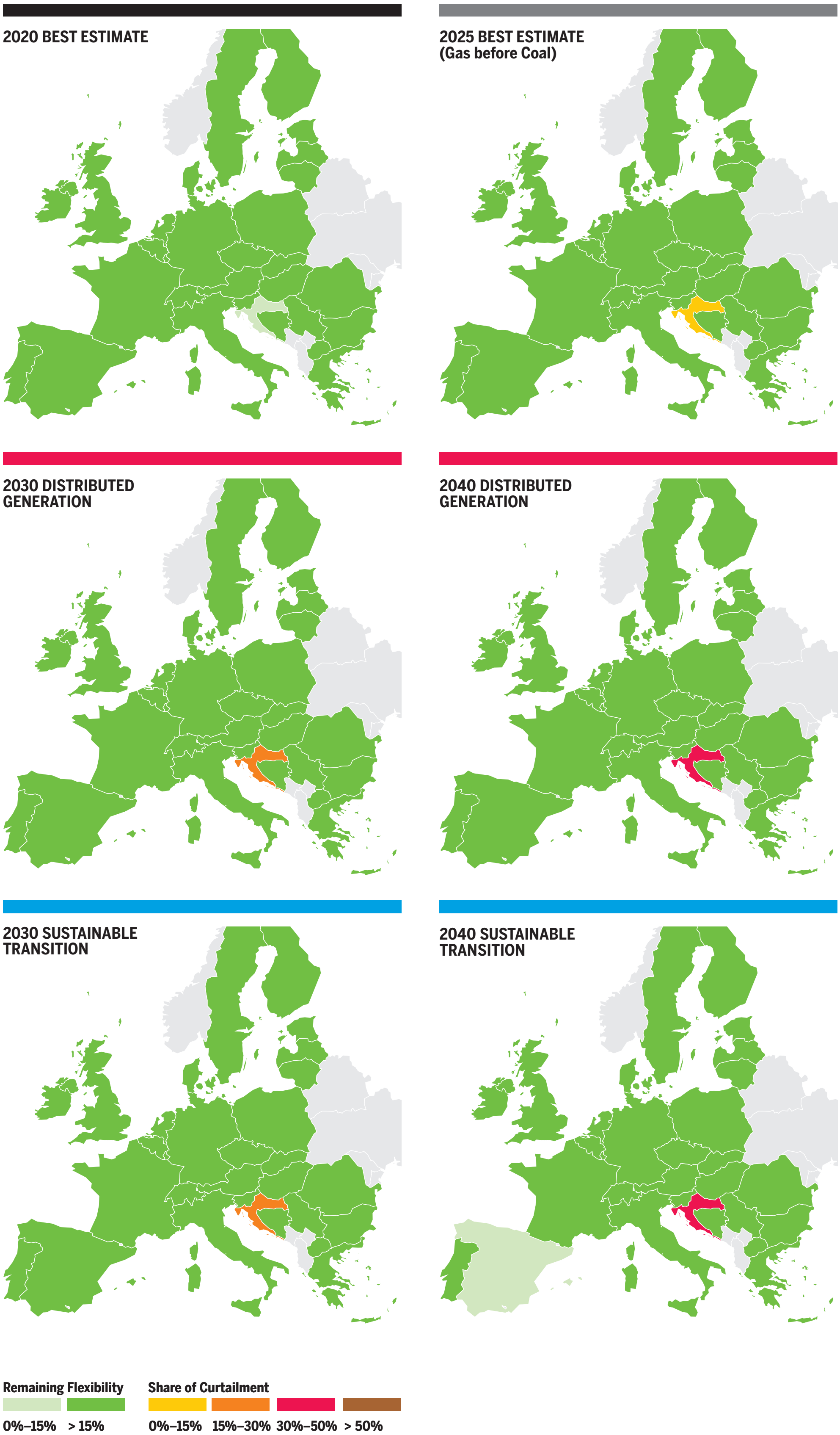

Figure 2.2: Climatic Stress under a 2-Week Cold Spell situation

2-week cold spell (see figure 2.2)

The European gas system is resilient to a 2-week cold spell in all the scenarios along the TYNDP time horizon.

As observed in the peak day, from 2025 onwards, in the low infrastructure level, Croatia is exposed to an increasing demand curtailment in all scenarios. This exposure is the result of an increasing demand in Croatia driven by the power generation.

Conclusion about Climatic Stress (Peak Day and 2-Week Cold Spell)

The European gas system is well connected to the various supply sources (imports and indigenous) and the infrastructure – including gas storages and LNG terminals – offers the necessary flexibility to cope with the highest demand situations in all scenarios, including Sustainable Transition characterised by the highest gas demand. Regarding Distributed Generation scenario, considering an intermediate demand with the highest penetration of renewable energy, the system shows the highest Remaining Flexibility on EU average in 2040 with almost all countries above a threshold of 15 % in case of a peak day.

However, considering the LOW infrastructure level, some infrastructure reinforcements may be required to reduce the exposure of Croatia to a possible demand curtailment during peak day situations as of 2025.

2.2.2 SUPPLY ROUTE DISRUPTIONS

Most of the gas consumed in Europe is imported through pipelines and LNG cargos. The disruption of a supply route can have a significant impact on the infrastructure and its ability to satisfy the demand.

This section investigates the additional impact of a supply route disruption during a high demand situation (climatic stress).

The assessment focuses on the disruptions listed in the Union-wide simulation of gas supply and infrastructure scenarios carried out for the risk assessment defined in Article 7, Regulation (EU) 2017/1938 (hereafter SOS Regulation) concerning security of gas supply. More specifically, those disruption cases expected to show a risk of demand curtailment in the Union-wide simulation are assessed in this section:

1. Ukraine route
2. Belarus route
3. Imports to Baltic states and Finland
4. Algerian import pipelines

Note: the assessment is limited to the impact of a supply disruption occurring during a peak day and a 2-week cold spell. The SOS Regulation consider also disruption with longer duration as assessed in the Union-wide SoS simulation report.

For disruptions simulations, demand curtailment follows the logic of unified allocation. In unified allocation, all member States within the risk group defined in Annex I of Regulation 2017/1938 cooperate by avoiding a demand curtailment to the extent possible by transporting other supply and furthermore by sharing the curtailment equally in such a way that they try to reach the same curtailment rate.

From the assessment, the gas infrastructure results to be resilient to disruptions. However, all analysed routes lead with some specific demand curtailments in some of the scenarios on the long term. Additionally, the Ukraine transit disruption leads to demand curtailment from 2020 in all scenarios.

Results are presented for Design Case and 2-Week Cold Spell and aim at identifying the additional effects of a route disruption to the situation observed under climatic stress conditions.

Ukraine Transit Disruption

This assessment considers the disruption of all gas imports via Ukraine during climatic stress situations.

This case considers the disruption of the transit through Ukraine and the risk group is formed by Austria, Bulgaria, Croatia, Czech Republic, Germany, Greece, Hungary, Italy, Luxembourg, Poland, Romania, Slovenia and Slovakia.

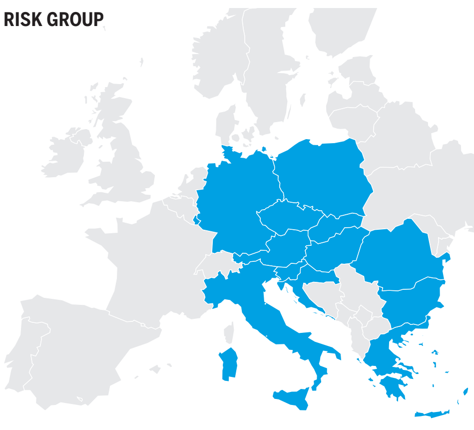

Figure 2.3: Risk group for Ukraine transit disruption

Peak Day (see figure 2.4)

During a peak day, the Ukrainian transit disruption simulation results show a potential demand curtailment in Bosnia and Herzegovina, Bulgaria, Croatia, Hungary, Romania, FYROM and Serbia[5]. Infrastructure gaps can be observed between these countries and the surrounding EU countries.

The situation is getting worse in 2025 with a risk of demand curtailment which is increasing lightly. The situation improves for Bulgaria but worsens for Romania, Serbia, FYROM, Croatia and Hungary.

The commissioning of Bulgaria/Serbia and Greece/Bulgaria interconnectors allow for cooperation with northern countries.

Greece is not significantly affected by a Ukrainian route disruption thanks to the expansion of the Revythoussa LNG terminal.

In Romania, results show an infrastructure limitation, and therefore an infrastructure gap, preventing Romania from cooperating efficiently with its neighbouring countries and therefore further mitigating the situation.

The EU gas system resilience does not improve in South-Eastern Europe in 2030. However, if Western Europe generally shows a relatively high level of Remaining Flexibility in 2030 and 2040 in all scenarios except for Sustainable Transition, South-Eastern Europe is still exposed to demand curtailment.

In Sustainable Transition Western Europe is affected by the Ukraine route disruption and is showing a very low Remaining Flexibility in some countries (France, Spain, Portugal, United Kingdom, Ireland, Belgium and the Netherlands). The overall European curtailment is rather significant being around 1,200 GWh/d starting from 2030.

The overall evenly distributed level of demand curtailment in South-Eastern Europe in 2030 and 2040 in all scenarios, and especially in Sustainable Transition, shows that the infrastructure allows for a good cooperation between the concerned countries except for Romania where infrastructure reinforcement may be required to reduce its level of exposure. However, the overall level of demand curtailment in the region, despite the possibility of cooperation between the different countries, shows a high dependence of the region to the gas imported via the Ukraine route.

The simulation results show that in case of disruption of Ukraine transit route, Europe has not sufficient capacities of alternative import routes from Russian supply to be able to satisfy its demand and keep exporting gas to Ukraine, resulting in an overall shortage of around 1,100 GWh/d of gas in 2030 and 2040 in Sustainable Transition scenario (including Germany and Italy for around 600 GWh/d in 2030 and around 450 GWh/d in 2040).

In Distributed Generation and Global Climate Action scenarios, the reduction in demand combined with a higher penetration of renewable gases shows that the interconnections between European countries allow gas storages together with the LNG terminals to provide the necessary flexibility to cope with a Ukraine route disruption occurring during a peak day and fully mitigates the exposure to an import limitation. However, infrastructure limitations continue to expose Romania, Bulgaria, FYROM, Bosnia, Croatia and Serbia to a risk of demand curtailment.

2-week cold spell (see figure 2.5)

Under a 2-week cold spell and Ukraine route disruption, results show that the EU gas infrastructure is resilient with 3 exceptions.

Bulgaria is exposed in 2020 to a risk of significant rate of demand curtailment, but anticipated increase of national production and the new infrastructure commissioned before 2025 mitigate the situation in the following years of the assessment.

Romania is exposed to a risk of demand curtailment from 2025 onwards for all scenarios, with a curtailment rate over 20 % in 2030 and over 30 % in 2040 for all scenarios whereas its neighbouring countries are not exposed. This identifies an infrastructure gap concerning Romania against its resilience to a Ukraine route disruption during a 2-week high demand event.

FYROM is also exposed to demand curtailment in 2025 and in 2030 in Sustainable Transition scenario to a 30 % level of demand curtailment. In 2040, the risk is mitigated in all scenarios.

For all scenarios and over the whole time horizon of the assessment, Croatia is not additionally impacted by a 2-week disruption of the Ukraine route. Interconnections between European countries allow gas storages together with the LNG terminals to provide the necessary flexibility to cope with a Ukraine route disruption occurring during a 2-week cold spell.

5) Although Croatia and FYROM are exposed to demand curtailment in climatic stress conditions, they are additionally impacted by a Ukraine transit disruption

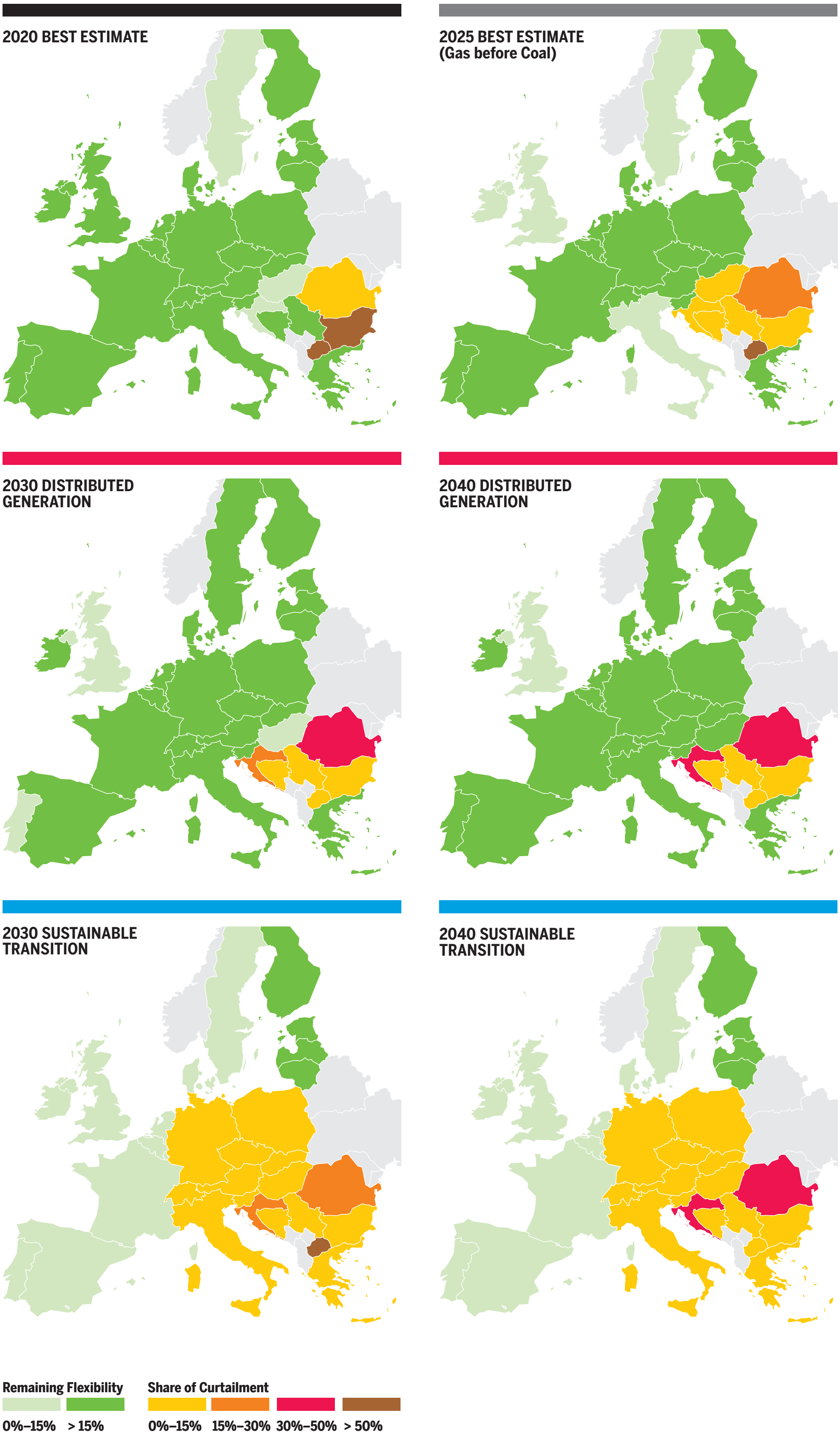

Figure 2.4: Ukraine Transit Disruption – Peak Day

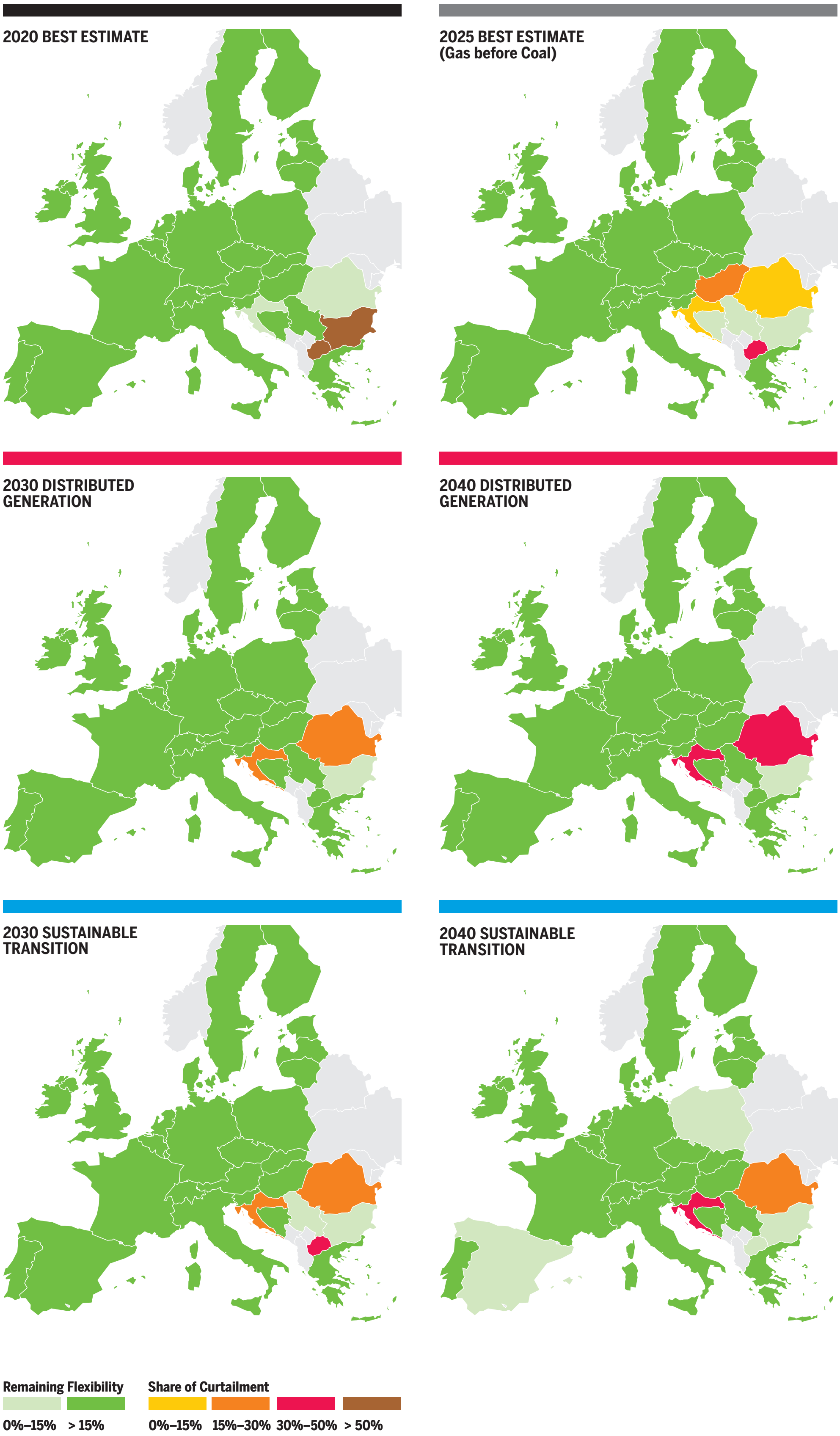

Figure 2.5: Ukraine Transit Disruption – 2-Week Cold Spell

Belarus Transit Disruption

This assessment considers the disruption of all gas imports via Belarus during climatic stress situations and the risk group is formed by Czech Republic, Belgium, Finland, Estonia, Germany, Latvia, Lithuania, Luxembourg, Netherlands, Poland and Slovakia

Peak day (see figure 2.7)

Under a Belarus transit disruption, most of the gas system is resilient but Poland and Lithuania, directly connected to Belarus, are exposed to demand curtailment in 2030 and 2040 in Sustainable Transition scenario and to a lesser extent, Lithuania is also exposed in Distributed Generation scenario.

In 2030 Distributed Generation scenario and in 2040 in all scenarios, due to Swinoujscie LNG terminal project, Poland and Latvia show a relatively high remaining flexibility whilst Lithuania is facing demand curtailment. This indicates an infrastructure gap preventing Lithuania from receiving support from its neighbouring countries to satisfy its demand.

In 2040 in Sustainable Transition scenario, demand is increasing in Poland and the country is exposed to a significant risk of demand curtailment together with Lithuania. This indicates another possible infrastructure gap in Poland in 2040 in case the Sustainable Transition scenario would materialise.

In case of a Belarus route disruption and considering the decommissioning of Klaipėda LNG FSRU in 2024, the new interconnection capacity between Poland and Lithuania is not sufficient to prevent Lithuania from demand curtailment in 2040 in all scenarios.

In addition, in 2040 in Sustainable Transition scenario, infrastructure reinforcement would help Poland to cope with a disruption of imports from Belarus.

In scenarios with higher penetration of renewable (Distributed Generation and Global Climate Action scenarios), Poland is not exposed to demand curtailment, even if its demand is increasing over time.

In case of Belarus disruption, results show that the reduction in the overall import capacity from Russia cannot be fully compensated by the other Russian supply import routes in Sustainable Transition scenario. As a consequence, the other supply sources have to be used at their maximum potentials and gas storages and LNG tanks at their maximum capacities to ensure the security of supply of Europe.

However, in Distributed Generation and Global Climate Action scenarios, the overall decrease of EU demand combined with the higher penetration of renewable gases limits the need for imports and allows for more flexible use of storages and LNG tanks during a peak day.

2-week cold spell (see figure 2.8)

During 2-week high demand situations, results show that EU gas system is resilient to a Belarus route disruption.

However, in 2030 EUCO 30 and in 2040 in Sustainable Transition scenario, due to an increase of demand combined with a limited penetration of renewable production, some infrastructure limitations expose Poland and Lithuania to a risk of demand curtailment, showing possible infrastructure need.

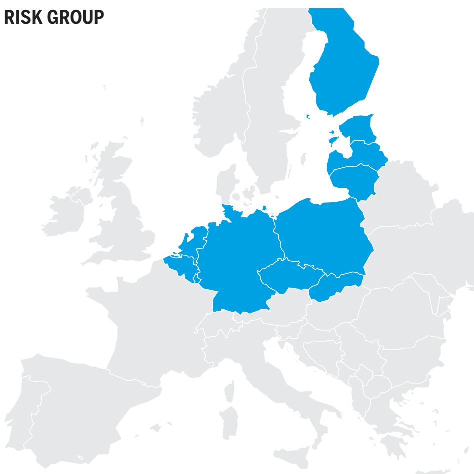

Figure 2.6: Risk group for Belarus transit disruption

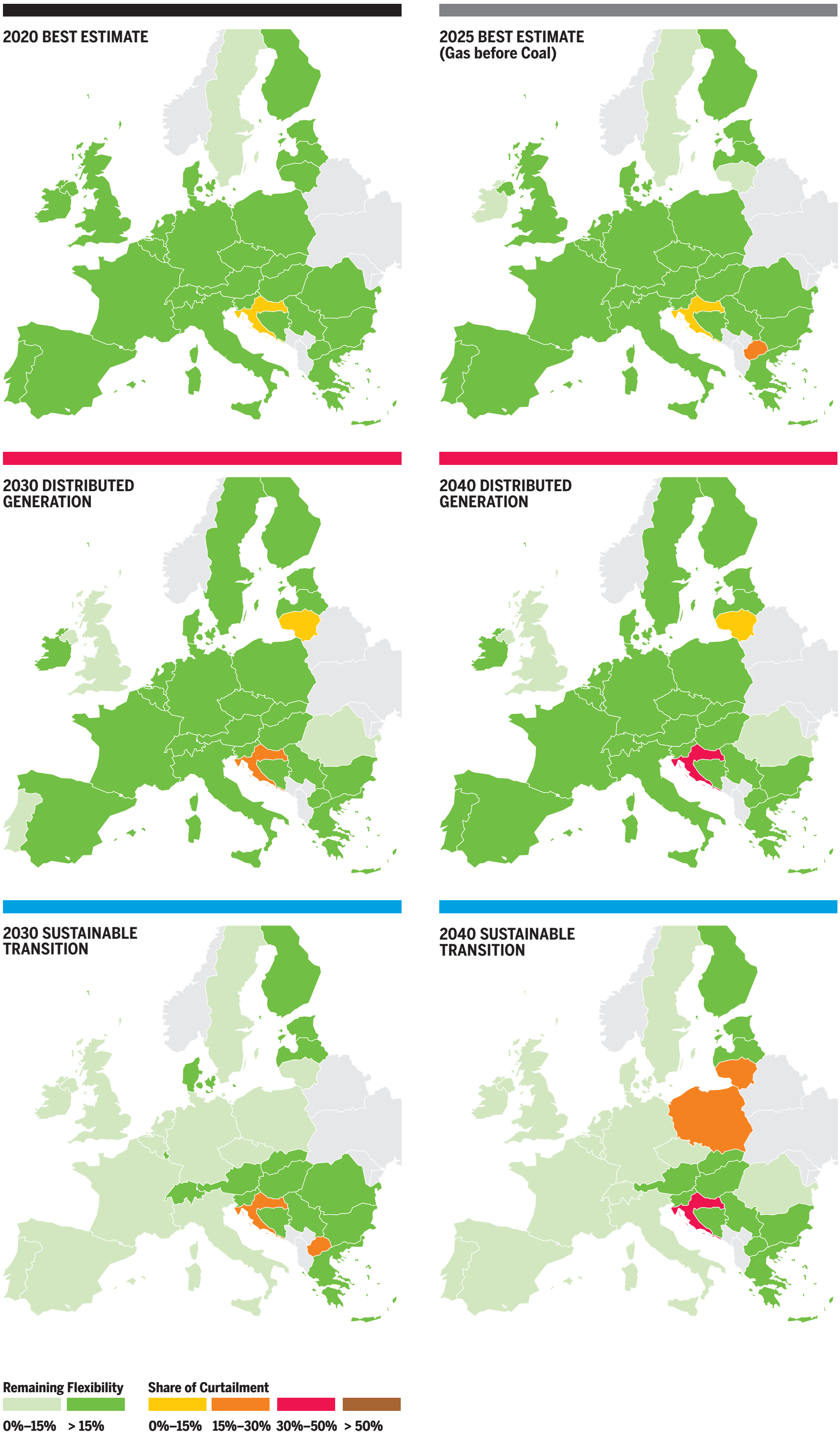

Figure 2.7: Belarus Transit Disruption – Peak Day

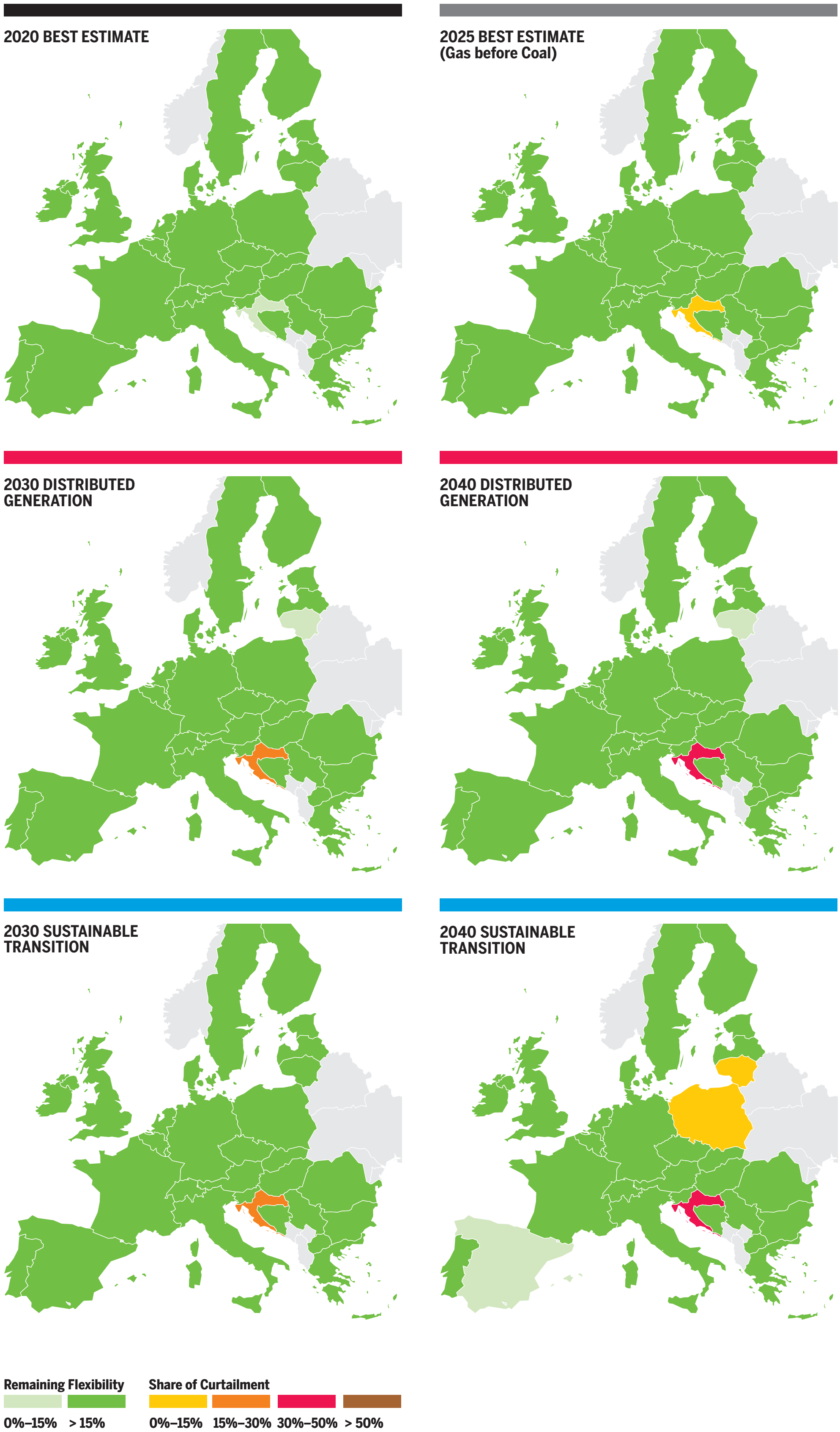

Figure 2.8: Belarus Transit Disruption – 2-Week Cold Spell

Disruption of pipeline imports to the Baltic States and Finland

This assessment considers the disruption of all imports in Finland, Estonia and Latvia during climatic stress situations and the risk group is formed by Estonia, Finland, Latvia, Lithuania and Czech Republic, Belgium, Germany, Luxembourg, Netherlands, Poland and Slovakia[6].

Peak Day (see figure 2.10)

The results show that Finland and Estonia are exposed to a high risk of demand curtailment (CR > 50 %) from 2020 onwards. Simulations show an infrastructure limitation, and therefore a gap, between Latvia and Estonia in all scenarios over the whole time horizon of the assessment. The interconnection capacity from Latvia to Estonia limits the cooperation of Latvia with Finland and Estonia. However, in all scenarios Finland and Estonia share the same level of demand curtailment, showing the interconnection between Finland and Estonia allows for an efficient cooperation.

Lithuania is not exposed to a risk of demand curtailment in 2020 since it has access to LNG via the Klaipėda FSRU that is considered to be decommissioned in 2024. However, GIPL project to be commissioned in 2021 connects Poland to Lithuania and therefore creates a possibility for cooperation between both countries from 2022 onwards. The overlapping of the 2 projects between the commissioning of GIPL and the decommissioning of Klaipėda allows Lithuania to be exposed to a limited risk of demand curtailment.

On the other hand, the new connection between Lithuania and Poland (GIPL) and the possibility for cooperation between both countries from 2022 creates the possibility that Poland and the rest of Europe can help limiting the exposure to a risk of demand curtailment in Lithuania in 2030 and 2040 (less than 5 %). In 2030, for Sustainable Transition scenario, Lithuania is not exposed to demand curtailment and shows some remaining flexibility.

However, in 2040 the higher demand for Poland in Sustainable Transition can result in some infrastructure limitations and may expose Poland to a limited level of demand curtailment.

2-week cold spell (see figure 2.11)

During a 2-week cold spell, simulation results show similar conclusions than for a Peak Day. Estonia and Finland can cooperate, but an infrastructure limitation prevents Estonia and Finland to further mitigate their level of exposure to demand curtailment (> 40 %) in all years of the assessment and for all scenarios.

Lithuania and Poland however, shows no risk of demand curtailment during a 2-week high demand situation.

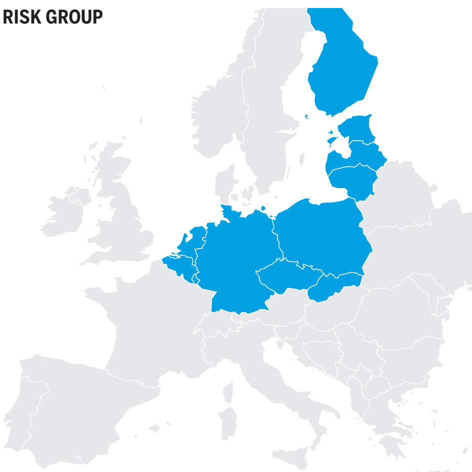

Figure 2.9: Risk group for Baltic states and Finland disruption

6) Compared to ENTSOG EU-wide SoS simulation, the risk group for Baltic States and Finland considered in TYNDP 2018 has been extended to other countries belonging to Belarus risk group. The FID project GIPL is part of the low infrastructure level and connects the Baltics states and Finland group to Poland and therefore allow for cooperation between all concerned countries.

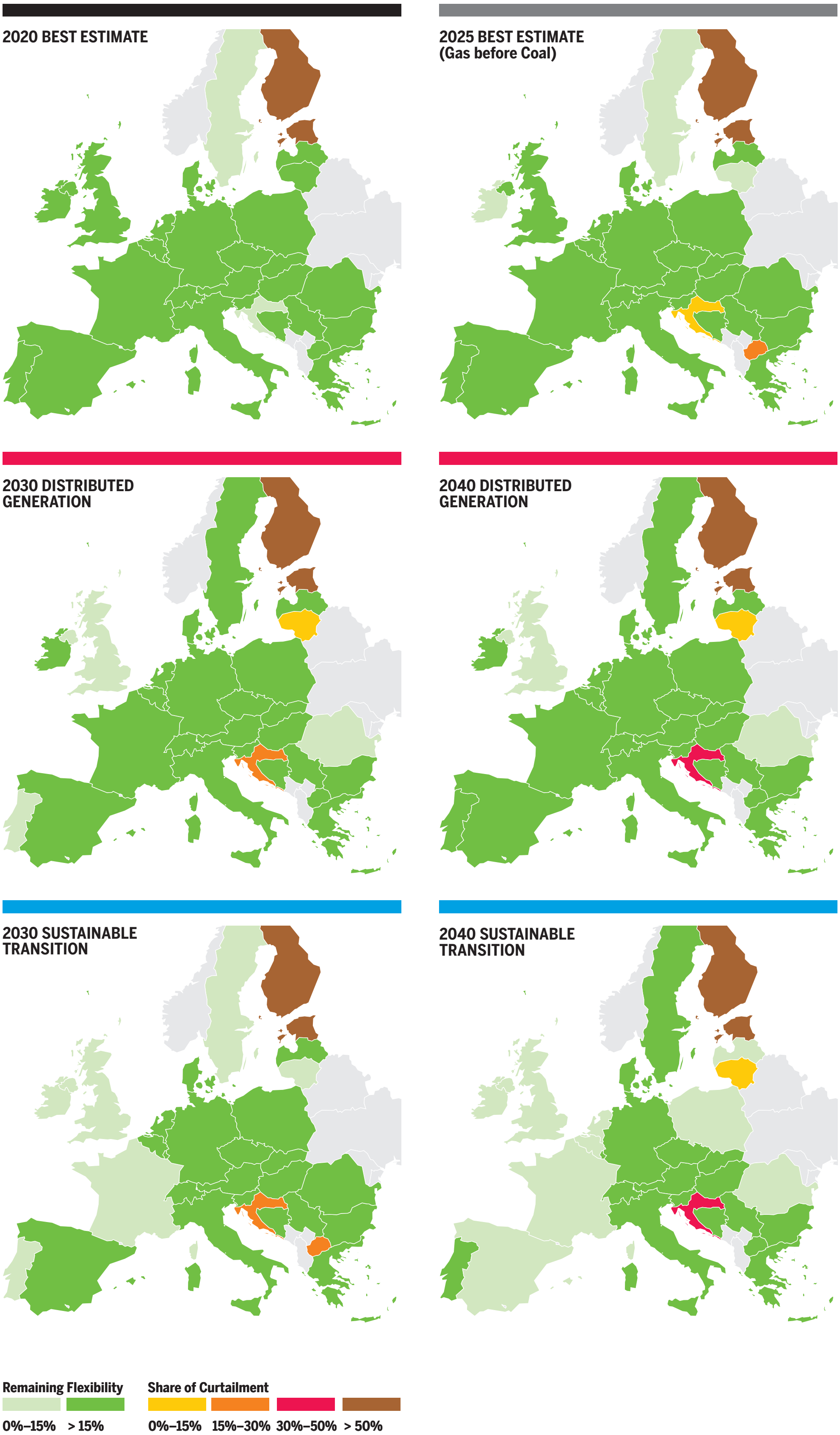

Figure 2.10: Disruption of pipeline imports to the Baltic States and Finland – Peak Day

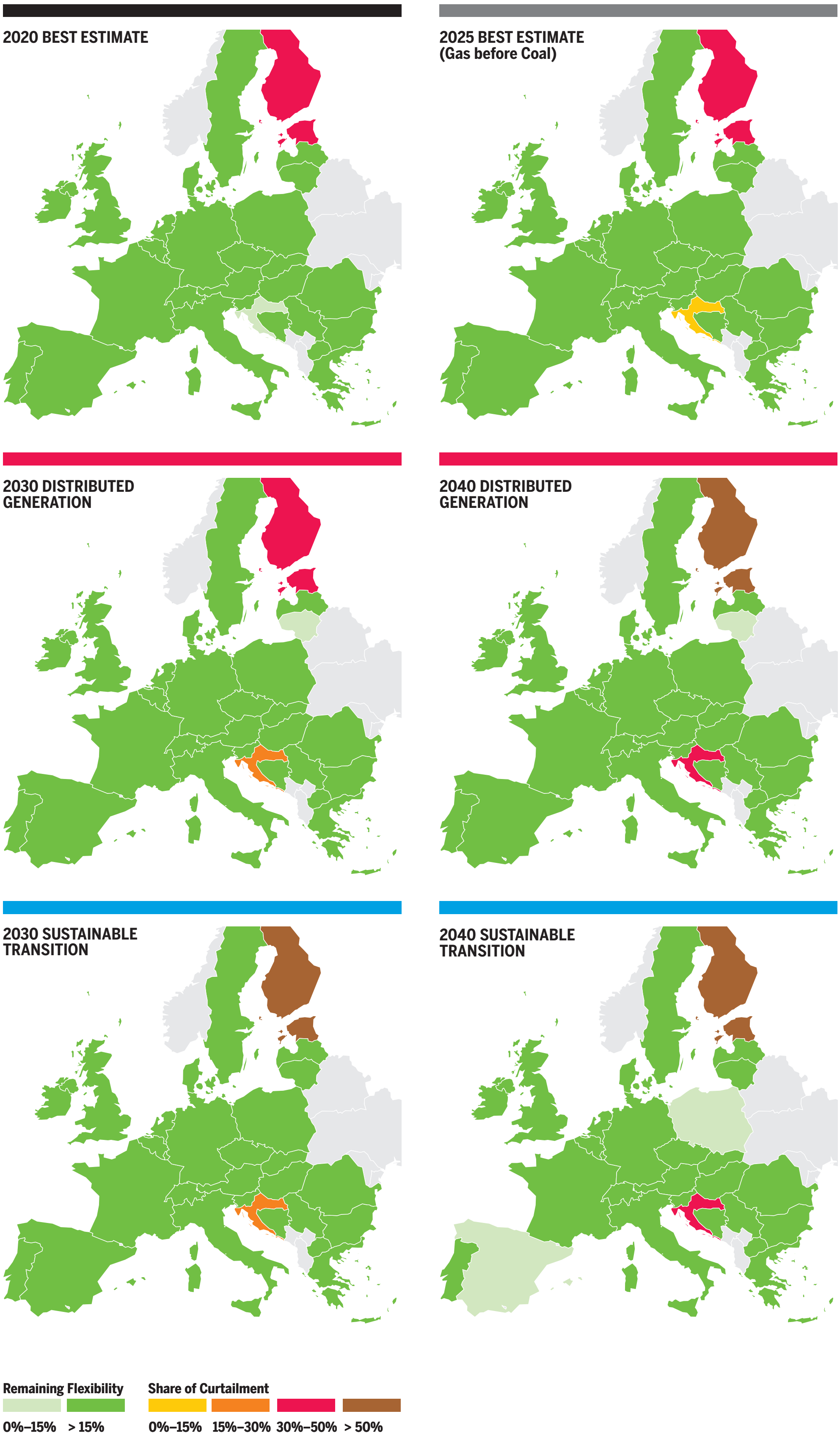

Figure 2.11: Disruption of pipeline imports to the Baltic States and Finland – 2-Week Cold Spell

Algerian Pipeline import routes Disruption

The simulation considers the disruption of all the imports pipelines from Algeria to the EU during climatic stress situations (peak day and 2-week cold spell) and the risk group is formed by Austria, Croatia, France, Greece, Italy, Malta, Portugal, Slovenia and Spain.

The Import pipelines from Algeria to EU disrupted in this case are:

1. MEG Pipeline between Algeria and Spain
2. MEDGAZ Pipeline between Algeria and Spain
3. TRANSMED Pipeline between Algeria and Italy

Results show that for all scenarios, until 2030, the European gas system is resilient to a disruption of all import pipelines from Algeria. As of 2030, whilst the EU is generally resilient, even if locally the Iberian Peninsula may be exposed to a limited risk of demand curtailment in all scenarios resulting from an increasing demand in all scenarios.

The exposure of Croatia to a risk of demand curtailment is a consequence of the climatic conditions and not related to the supply disruption as described in section 2.2.1.

Figure 2.12: Risk group for Algerian pipeline import routes disruption

following the significant increase in Peak Demand in the Iberian Peninsula (+40 % compared to 2020) combined with a locally limited level of penetration of renewable gases production.

In all scenarios, the increasing demand in Spain, and to a lesser extent in Portugal in 2030, may result in infrastructure limitations exposing the Iberian Peninsula to demand curtailment.

Peak Day (see figure 2.13)

The European infrastructure is generally resilient to a disruption of all import pipelines from Algeria.

However, from 2025 onwards, Spain and Portugal may be exposed to a limited risk of demand curtailment that could increase in 2040 in the Sustainable Transition scenario

2-week cold spell (see figure 2.14)

The EU gas system is resilient to a disruption of all pipelines from Algeria during a 2-week cold spell.

However, in 2040 in Sustainable Transition scenario, Spain and Portugal are exposed to a limited level of demand curtailment (< 10 %).

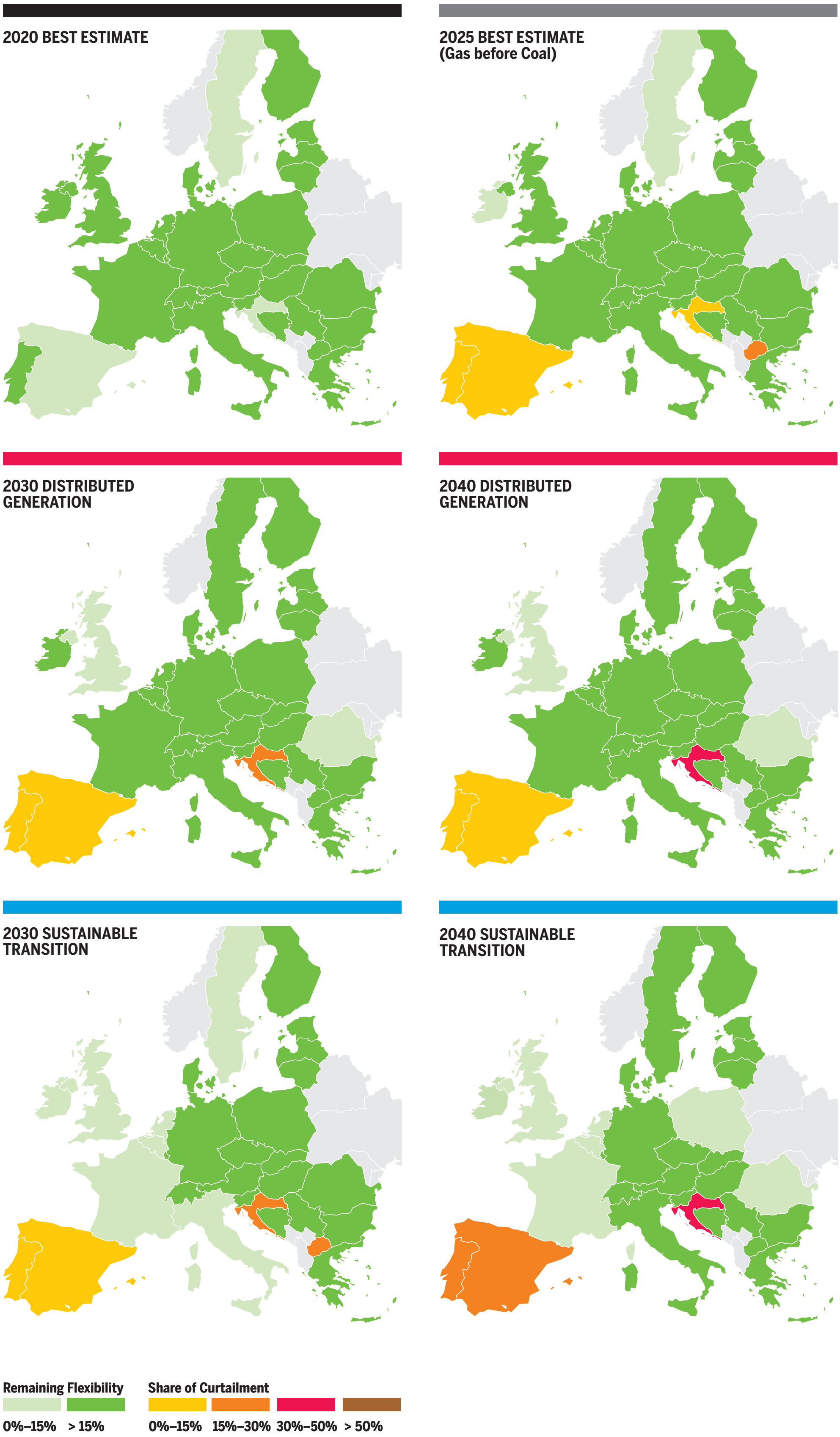

Figure 2.13: Algerian Pipeline import routes Disruption – Peak Day

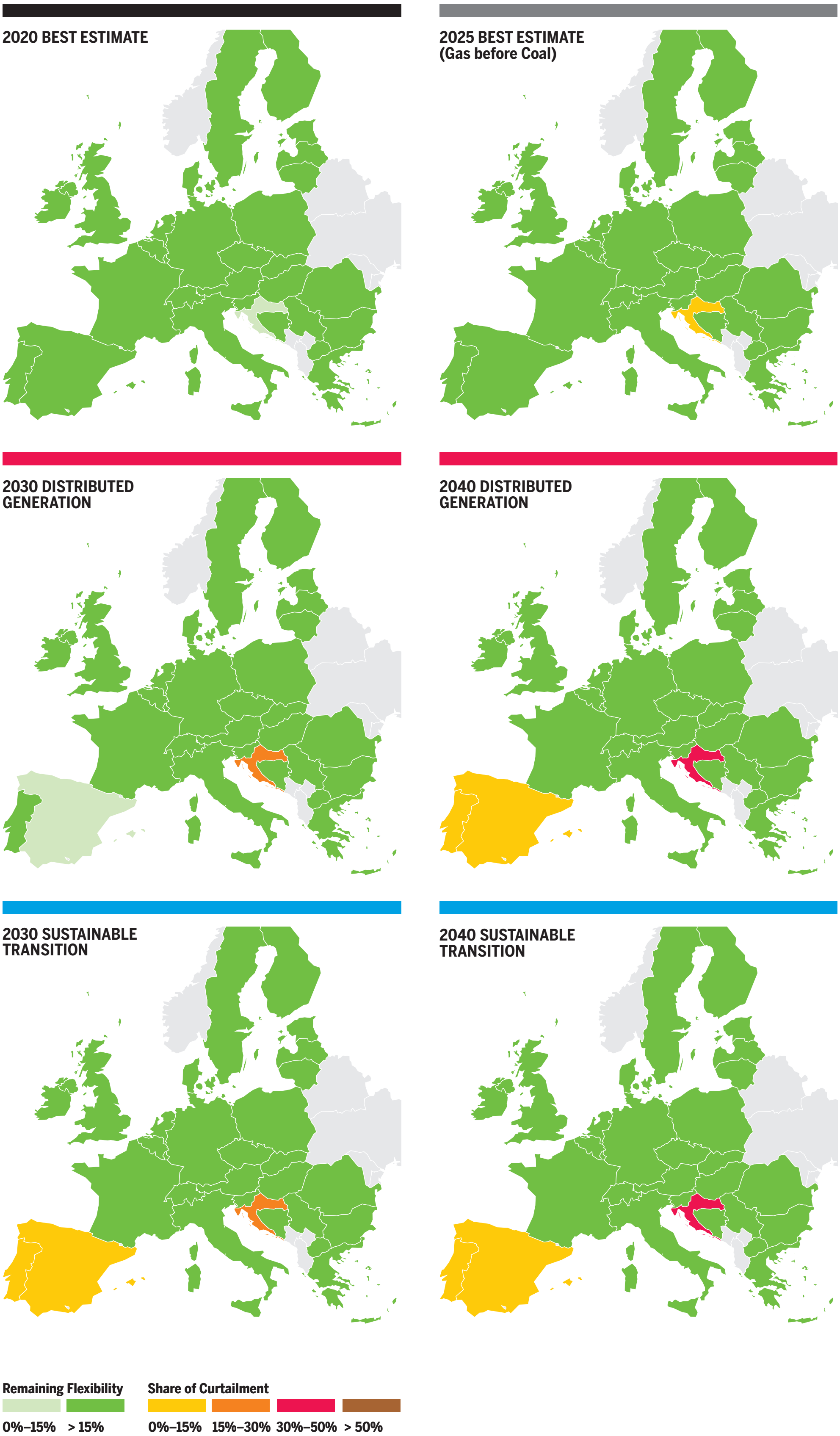

Figure 2.14: Algerian Pipeline import routes Disruption – 2-Week Cold Spell

Supply mixes under high demand situations

Under high demand situations the supply and demand balance depend on a significant share of storage injection. Over time the storages together with LNG and Russian supply replace the disappearing flexibility from National production. Also, in some scenarios as Global Climate Action or Distributed Generation the decrease in the supply from conventional National Production is replace by renewable gases. This is sensitive to the demand evolution explored in the scenarios. The charts in figures 2.17 – 2.19 illustrate the evolution in the different scenarios.

Russian gas is the only source showing an increasing share in the different scenarios analysed configuration. Regarding LNG, available LNG flexibility in the tanks is used in addition to the LNG deliveries from carriers. The volumes in tanks are the difference between the operative fill level of the LNG tanks and their technically required minimum fill level. In total, when the regasification capacities are fully used on the peak day as the other supply sources, Europe relies on storages to ensure at the minimum 36 % of the gas supply in peak day events in Distributed Generation scenario and at the minimum 43 % in Sustainable Transition scenario.

Picture courtesy of TAP

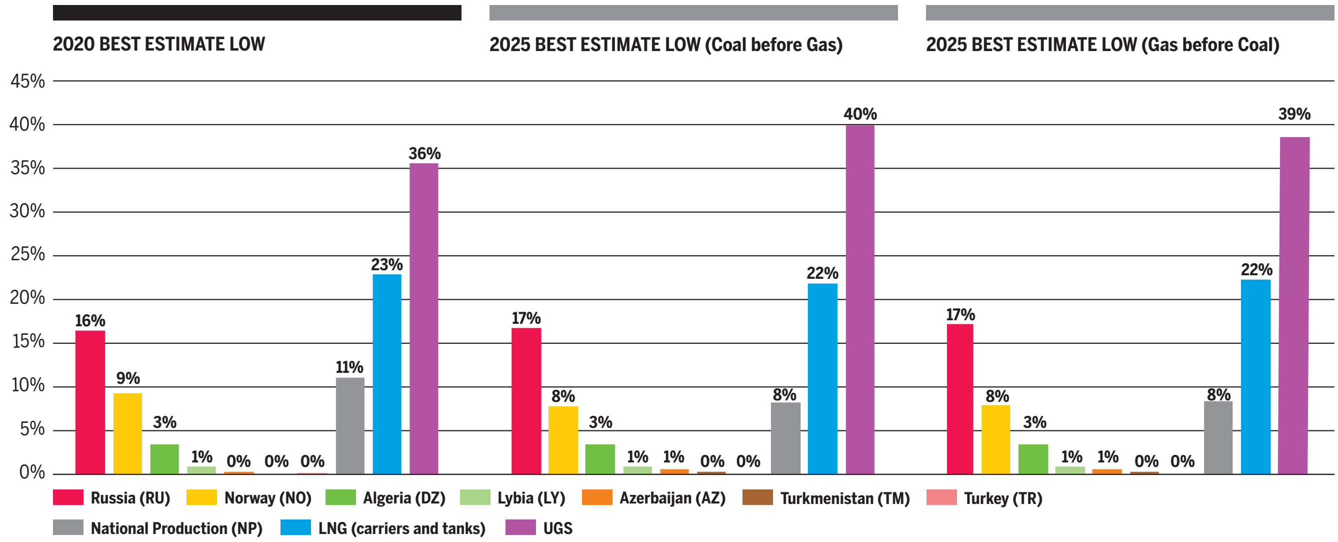

Figure 2.15: Supply Mix on Peak Day for 2020/2025

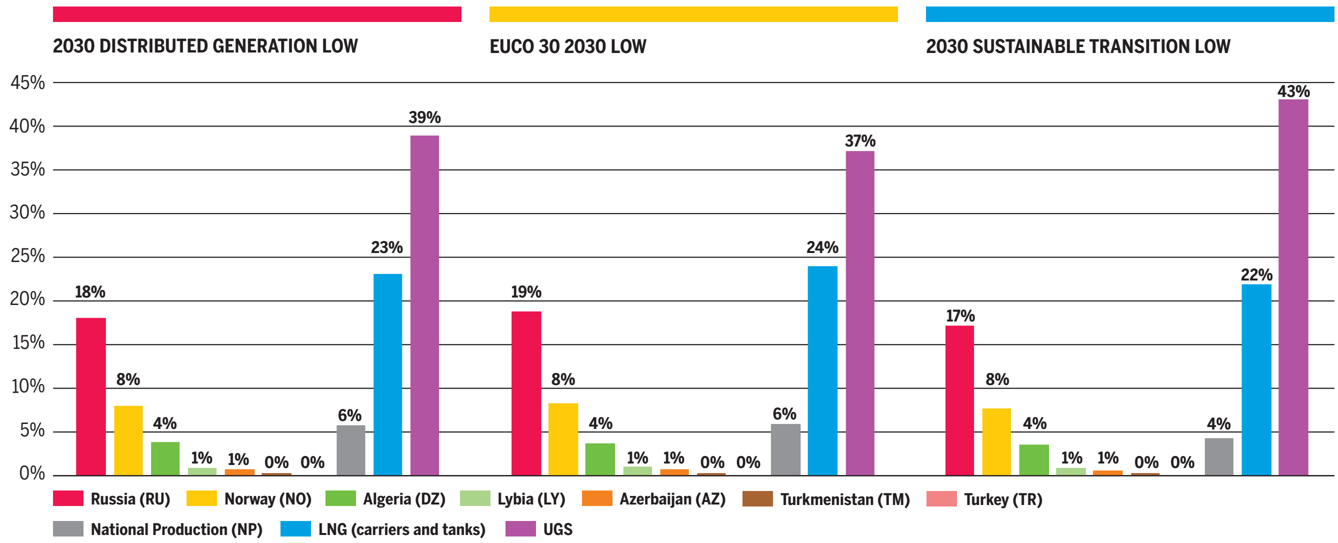

Figure 2.16: Supply Mix on Peak Day for 2030

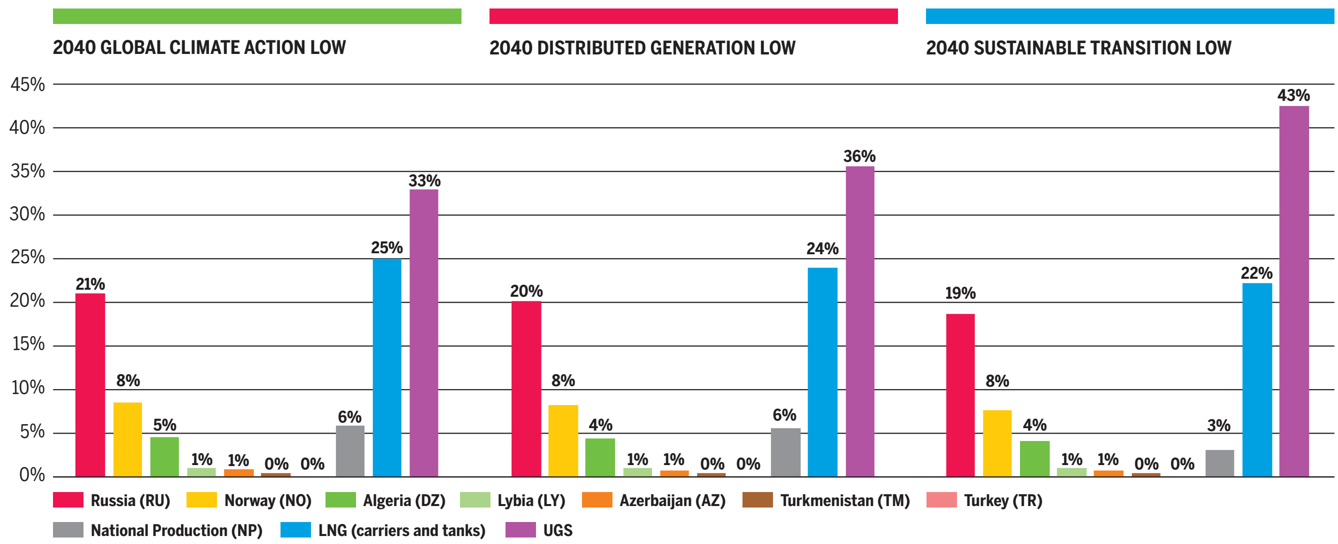

Figure 2.17: Supply Mix on Peak Day for 2040

2.2.3 SUPPLY ADEQUACY IN NORTH-WEST EUROPE: THE CHALLENGE OF L-GAS AREAS

Status of L-gas production and related conversion plans

While most of Europe is supplied with high-calorific gas (H-gas), specific areas covering parts of the Netherlands, Germany, Belgium and France are supplied with low-calorific gas (L-gas) coming from the Groningen field (Netherlands), German fields and H-gas conversion facilities (e. g. by injection of nitrogen). These L-gas demand and supplies are connected through specific infrastructures with limited connections to the respective neighboring H-gas network. The average yearly L-gas energy demand is currently about 600 TWh/y.

The decline of the European production is an EU-wide concern. It is even more significant with regard to L-gas production due to the fact that L and H-gas are not substitutable and due to the limited number of L-gas production fields. Earthquakes related to the production of the Groningen field in the previous years have led the Dutch authorities to limit the production for the coming years while leaving some flexibility to adapt to cold situations.

Considering on the one hand the foreseen end of the Dutch L-gas exports to Belgium, France and Germany by 2030 as well as the declining German L-gas production, and on the other hand the current L-gas demand in Belgium, France and Germany (around 330 TWh/y), it is necessary to engage a continuous process of converting areas currently supplied by L-gas to H-gas. Belgium, France and Germany have prepared national conversion plans coordinated at bilateral and multilateral levels (e. g. the Gas Platform), and have started with the first steps of the planned conversion sequence. The foreseen conversion process includes the development of specific gas transmission infrastructure (or adaptation if existing) to integrate the L-gas and the H-gas networks and to bring H-gas supplies to the L-gas areas to be converted. Main infrastructure projects related to L/H conversion are further described in the North-West Gas Regional Investment Plan (NW GRIP) and the respective National Development Plans.

On 8 January 2018 a new gas production induced earthquake occurred at Zeerijp in the province of Groningen. After this earthquake the State Supervision of the Mines in the Netherlands gave the advice to reduce the gas production from the Groningen field as fast as possible to a maximum of 12 bcm. Following this advice, the Dutch Minister has decided to reduce the Groningen production as fast as possible to 12 bcm followed by a further decline to 0 bcm and terminate the production from the Groningen field by 2030.

To achieve this, in addition to the conversion plans in Belgium, France and Germany, the Netherlands will invest in a new nitrogen plant at Zuidbroek which can produce pseudo L-gas as of the second quarter 2022. In addition, additional nitrogen will be purchased which can produce pseudo L-gas from gas year 2020 – 2021. Furthermore, industrial clients in the Netherlands will be converted from L-gas to H-gas. These measures to reduce the Groningen production were published in an addendum of the national network development plan 2017, which was published in June 2018.

In the meantime, the Gas act in the Netherlands has been altered with the purpose that the production from the Groningen field will never be more than is required from a security of supply perspective. This means that the blending stations of GTS will produce baseload and the Groningen field with the other sources (storages) will cover the rest of the market.

In addition to these volume reducing measures, the Minister also decided to close the production clusters in the Loppersum region. This decision will reduce the capacity of the Groningen field by approximately 25 %. This reduced capacity has been used in the calculations in this TYNDP 2018.

L-gas in the TYNDP simulations

Since the previous TYNDP 2017, ENTSOG has endeavored to improve the modelling tool by separating the H- and L-gas markets in Belgium, France and Germany in its topology , and hence capturing the specific nature of L-gas transport.

In line with the improved topology, the demand data used for this TYNDP 2018 has been collected both for H-gas and for L-gas separately. To reflect the planned conversion processes in Belgium, France and Germany, the concerned TSOs have submitted the L-gas demand with a decreasing trend, in line with the projected decrease in L-gas export capacity from the Netherlands. At the same time the H-gas demand is showing a comparable increase.

Because of the match between decreasing L-gas demand in Belgium, France and Germany (assuming the realisation of the planned L/H conversion infrastructure projects and corresponding market conversion)


Picture courtesy of Fluxys TENP

and decreasing export capacities for L-gas from the Netherlands, the EU system wide analysis in TYNDP 2018 does not show a specific infrastructure gap related to the decreasing L-gas production. This system-wide analysis shows that the security of supply risks related to the decrease in L-gas production and related export capacities in the Netherlands will be mitigated by the L/H conversion projects in the concerned countries.

As the current L-gas zones represent isolated systems, the materialization of the planned L/H conversion projects will allow them to be integrated into the global H-gas system which in turn will lead to an improvement in terms of Security of supply, Competition, Market Integration, and Sustainability:

- With the conversion of L-gas demand to H-gas, involved customers are not subject anymore to the security of supply risks related to L-gas supply.
- The current L-gas system with a very limited number of entry points will no longer be vulnerable to an infrastructure disruption when integrated into the existing H-has grid.
- Neither will it be mostly depending on indigenous L-gas supply, but rather have access to a number of supply sources identical to the H-grid in that country.
- Customers now supplied by L-gas will have access to H-gas instead of having to switch to other fuels.

The infrastructure projects related to the L/H conversion in respectively Belgium and France have been selected as Project of Common Interest in the 3rd PCI list following a dedicated CBA analysis based on TYNDP data and methodology. Thanks to the improved modelling methodology, ENTSOG will this time take care of the PS-CBA of these projects, that have again applied for the PCI label in the 4th PCI selection.

2.2.4 SINGLE LARGEST INFRASTRUCTURE DISRUPTION (SLID)

This section investigates the impact of the disruption of the single largest infrastructure of a country during a Peak day.

The SLID measures the curtailed demand following the disruption of the single largest infrastructure entering a given country (excluding storage and national production).

This simulation allows to identify potential infrastructure limitation for the considering country and the others European countries.

The simulation of the single largest infrastructures of the different countries look at the impact of such disruptions at a European level and replaces the former N-1 indicator of TYNDP 2017 that was a pure capacity-based indicator limited at country level.

The table of Single Largest Infrastructure Disruption for each country considered can be found in Annex D.

Northern boundaries of Europe

The largest infrastructures of Ireland and Sweden consider the interconnections to their only neighbouring countries. Therefore, their disruption result in a risk of significant demand curtailment (CR > 80 % for Ireland and Sweden) for all scenarios and all different assessment years.

The disruption of the Single Largest Infrastructure of Finland, could expose Finland and Estonia to a risk of demand curtailment of 40 % to 60 % depending the scenarios and years of the assessment.

Eastern Europe

Bulgaria is exposed to 60 % more demand curtailment in 2020, but a prospective increase of domestic production and the infrastructure commissioned before 2025 mitigates the situation from 2025 onwards in all scenarios.

Croatia (30 % to 40 % of demand curtailment), FYROM (100 %), Bosnia (100 %) and Romania (20 % to 40 %) are also additionally impacted by their Single Largest Infrastructure disruption compared to a Peak day. Additionally, in case of disruption of the Single Largest Infrastructure in Slovenia (around 50 % in all scenarios and years), Croatia is exposed to a curtailment rate from 20 % to 30 %.

Serbia is exposed to a high rate of demand curtailment in 2020 (70 %), but from 2025 onwards, the interconnection Bulgaria–Serbia helps mitigating the exposure down to 10 % in all scenarios. Additionally, the demand curtailment is also shared with Bosnia in the same proportions.

Greece is exposed to demand curtailment in case of disruption of its Single Largest Infrastructure in all years of the assessment and for all scenarios. The simulation shows a risk of demand curtailment of 25 % in 2025 increasing to 35 % in 2030 in Sustainable transition scenario and decreasing to 20 % to 30 % in 2040 depending on the scenario. The change in the exposure to demand curtailment in Greece follows the evolution of the peak demand in the different years and scenarios. Additionally, the demand curtailment is also shared with FYROM from 10 % to 30 %.

In case of disruption of the Single Largest Infrastructure in Slovakia, results show that Slovakia is resilient in all years and all scenarios of the assessment. However, In Sustainable Transition scenario in 2030 and 2040, the demand curtailment observed in Slovakia and other EU countries reflects an infrastructure limitation at EU level, not limited to Slovakia. Therefore, in case of disruption of the Single Largest Infrastructure in Slovakia, Europe has limited alternative import capacities from Russian supply to be able to satisfy its demand and keep exporting gas to Ukraine, resulting in an overall shortage of around 400 GWh/d of gas in 2030 and 2040 in Sustainable transition scenario.

In Distributed Generation and Global Climate Action scenarios, the reduction in demand combined with a higher penetration of renewable gases shows that the interconnections between European countries allow gas storages together with the LNG terminals to provide the necessary flexibility to cope with a Ukraine route disruption occurring during a peak day and fully mitigate the exposure to an import limitation.

Western Europe

The disruption of the Single Largest Infrastructure of UK would locally expose UK and Ireland to some demand curtailment in 2030 and 2040, limited to 10 % maximum in Sustainable Transition.

The disruption of the Single Largest Infrastructure of Spain would expose Spain and Portugal to a risk of demand curtailment in Sustainable Transition scenario in 2040 around 15 %. And in case of SLI of Portugal, Portugal is exposed to a risk of demand curtailment around 30 % depending of the different scenarios.

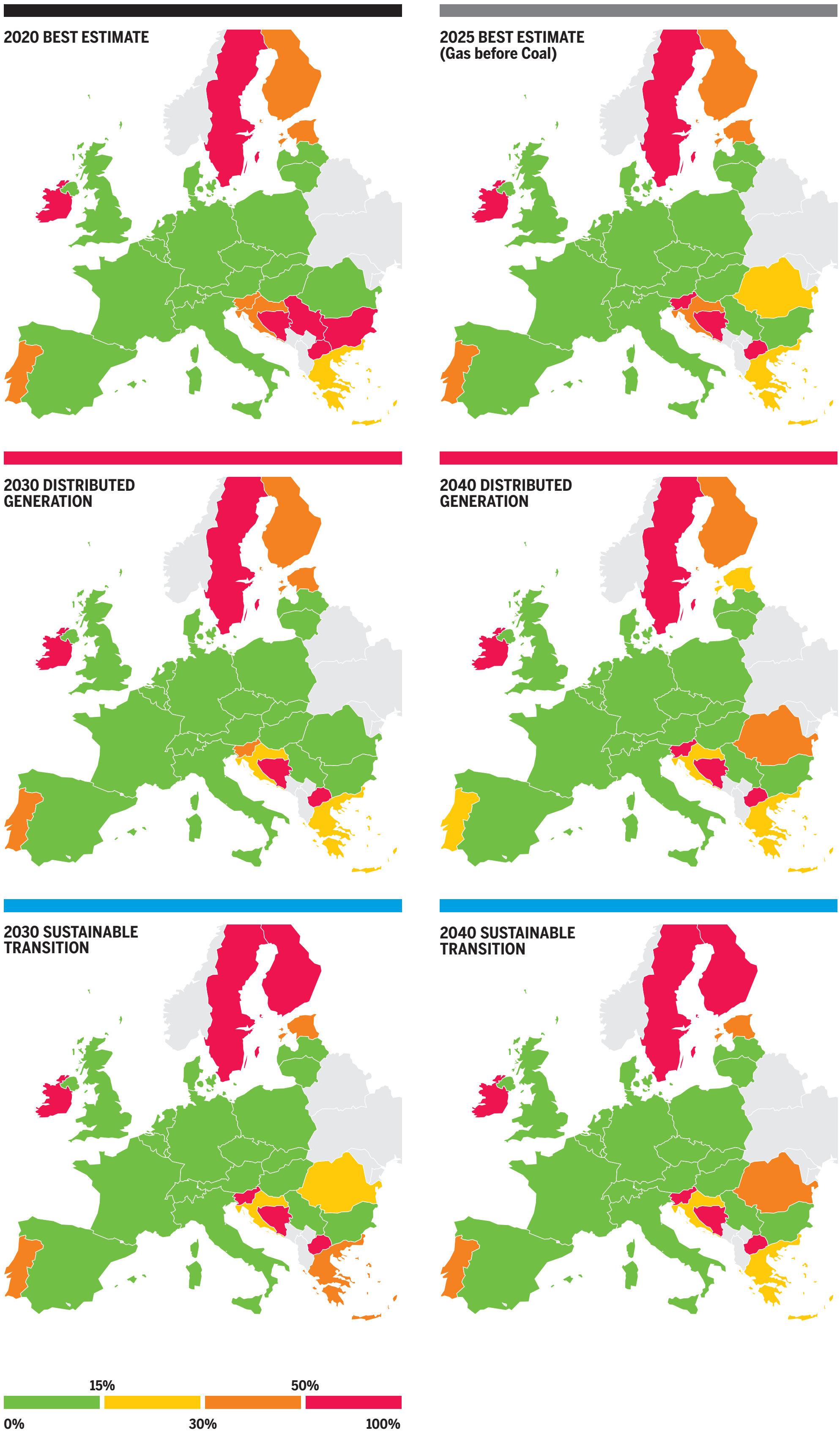

Figure 2.18: Maximum exposure to demand curtailment in case of disruption of a Single Largest Infrastructure

2.2.5 CONCLUSIONS ON SECURITY OF SUPPLY RELATED NEEDS

The existing gas infrastructure in Europe, along with the foreseeable reinforcements – having already taken the final investment decision – is already providing sufficient flexibility for transmitting supplies to the demand areas in most of Europe. Likewise, the penetration of renewable gases in Western Europe reduces the risks of dependence on large infrastructure. It can stand a high number of route disruption situations, as well as for most countries the disruption of the largest single infrastructure (SLID), including under a high demand situation. Nevertheless, the assessment of the security of supply related needs, under the low infrastructure level, shows that some additional capacity could be needed in the following areas:

- Countries in South-Eastern Europe which would need additional import and interconnection capacity (Bosnia and Herzegovina, Bulgaria, Croatia, FYROM, Hungary, Romania and Serbia) to cover the risk of a Ukraine route disruption.
- In Sustainable Transition Western Europe is affected by the Ukraine route disruption and is showing a very low Remaining Flexibility in some countries (France, Spain, Portugal, United Kingdom, Ireland, Belgium, Netherland). The overall European curtailment is rather significant being around 1,200 GWh/d starting from 2030 (including Germany and Italy for around 300 GWh/d in 2030).
- Poland and Lithuania could be exposed to demand curtailment for Belarus disruption for Sustainable Transition in 2040.
- Spain and Portugal could be exposed to demand curtailment for Algerian disruption for all the scenarios from 2030 onwards.
- Croatia on the long run, if their demand outlook materialises,
- Romania, the foreseen increased production would not be maintained over time (Romania increases its production until 2025 and then it decreases sharply).
- Bosnia and Herzegovina, Croatia, Estonia, Finland, FYROM, Greece, Ireland, Luxemburg, Portugal, Romania, Slovenia and Sweden, and potentially on the longer run Slovakia and Lithuania, to mitigate their exposure to the risk of disruption of their main infrastructure.

The assessment under the different scenarios shows a sensitivity of the different results based on the demand evolution.

2.3 COMPETITION NEEDS

2.3.1 SUPPLY SOURCES ACCESS

The access to different supply sources is a prerequisite for competition. The ability to have access to different supplies, as well as the volumes of these supplies, is taken into account for the identification of supply diversification needs.

The Supply Source Access indicator (SSA) measures the number of supply sources an area can access.

This supply source diversification ability is calculated from a market perspective, as the ability of each area to benefit from a decrease in the price of the considered supply source (such ability does not necessarily mean that the area has a physical access to the source).

The ability of an area to access a given source is measured through the supply source diversification indicator (SSDi). The SSDi is expressed as a percentage in the range 0 to 100 %, with e. g. 30 % corresponding to the supply cost of the area being 30 % responsive to a decrease in price of source S. The bigger the SSDi, the better the access to source S from a price perspective. A country has been considered as having a significant access to a supply source when the SSDi to this source is higher than 20 %, which means that a decrease in the price of this supply source would impact at least 20 % of the country supply bill. Alternatively, an SSDi of 0 % means the country gets no benefit from a low price of the concerned source.

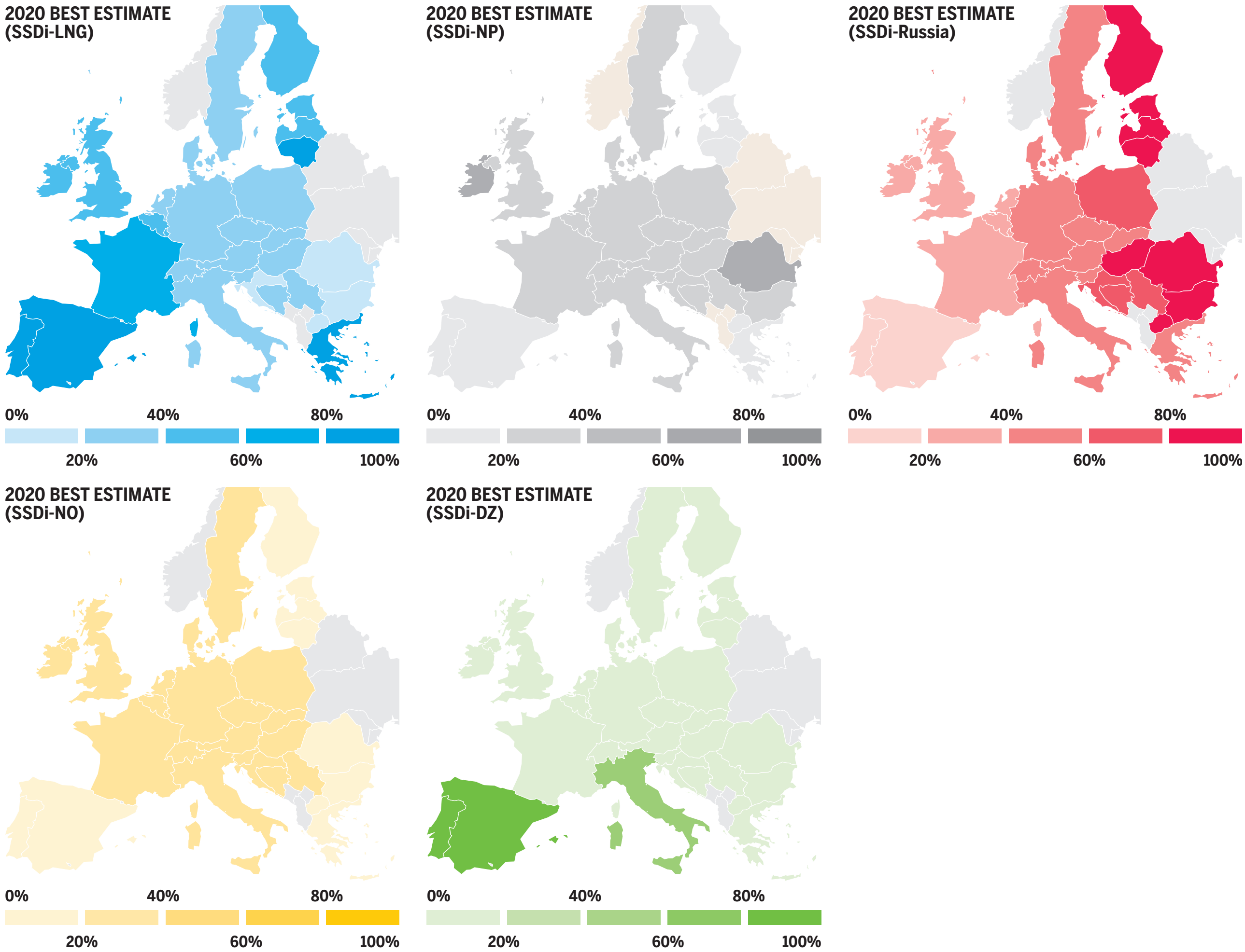

Figure 2.19: The situation of SSDi for each supply for Europe in 2020 Best Estimate

Of course, the indicated reference threshold has to be red considering the demand of each country. For the larger gas markets, a lower threshold could be relevant to indicate diversification provided by some supply sources.

Figure 2.19 shows the situation of SSDi for each supply for Europe in 2020. The detailed results from the following maps allow identifying how a different threshold would impact on the results. The approach is based on marginal gas prices and therefore a country is considered benefiting from a source when having the possibility to commercially access that source.

Figure 2.20 shows the number of sources for each country. The results are presented for Best Estimate in 2020, Best Estimate (gas before coal) in 2025, Distributed Generation in 2030 and 2040 and in Sustainable Transition in 2030 and 2040 in the low infrastructure level.

Simulation results show that a large majority of European countries can benefit from a decreasing price of at least 3 different sources for all years and scenarios. From 2020 onwards, there is a decrease of number of sources (4 to 3) due to decreasing national production.

However, Estonia, Hungary, Croatia and Greece access only 2 sources in 2030 Sustainable Transition scenario and 3 in Distributed Generation.

Finland access to Russia and LNG sources in 2020 but with higher demand in 2025 onwards, in all scenarios, Finland access only one source, Russia. LNG source is under 20 %.

Romania, FYROM, and the Iberian Peninsula never access more than 2 sources in all scenarios and for the whole time horizon of the assessment.

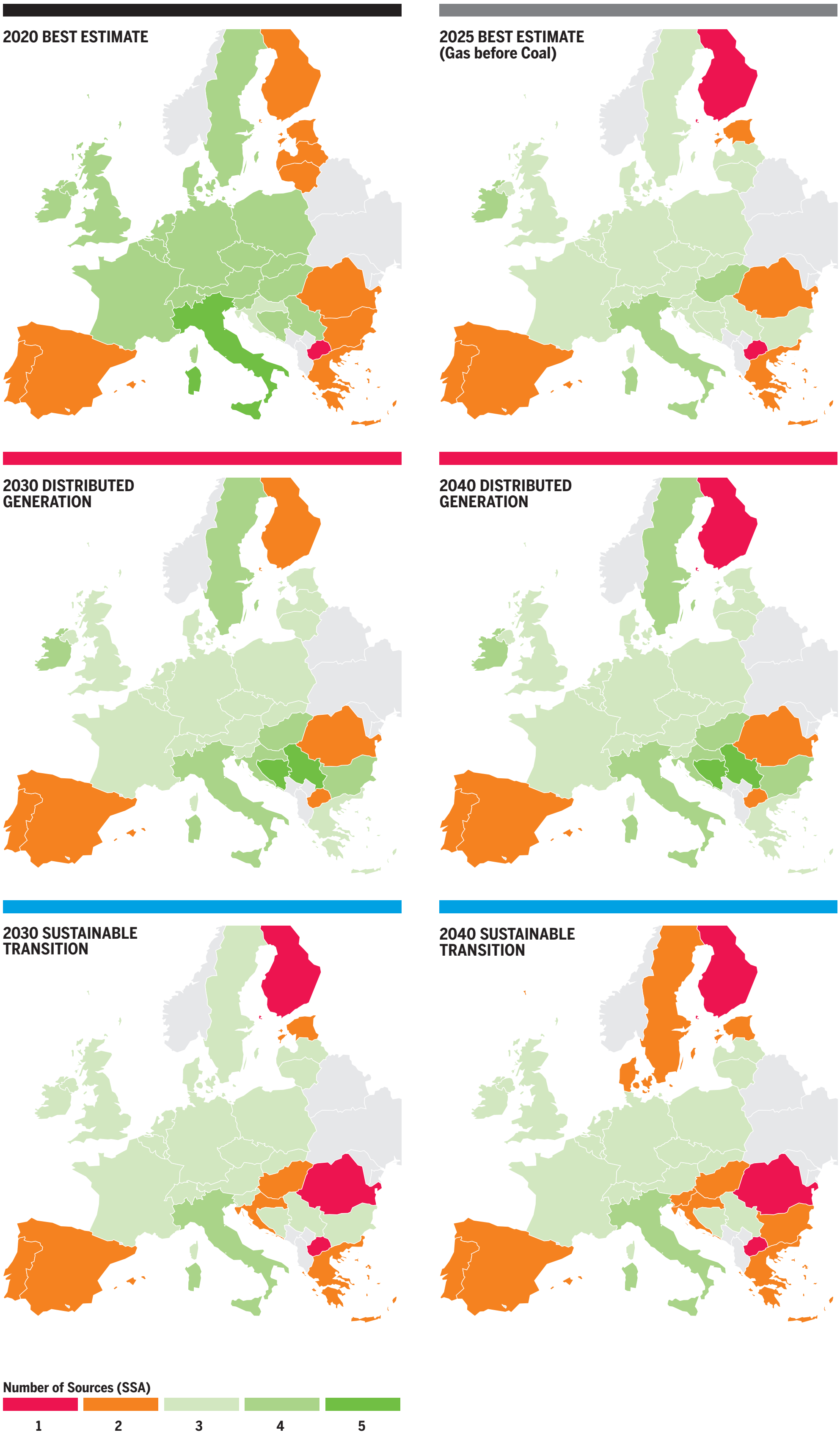

Figure 2.20: Number of supply sources per country

From 2025 onwards, the commissioning of the interconnection Bulgaria–Serbia, allows Bulgaria to access 3 sources including the Norwegian supply. Also, the commissioning of GIPL allows the Baltic states to access Norwegian supply.

For countries accessing LNG, LNG being a diversified source imported from different LNG basins and suppliers, it should be noted that the ability of a country to access a specific LNG basin/supplier is related to its supply contracts more than the ability of its infrastructure to access different LNG suppliers.

The following graphs informs in more detail the situation across Europe for the different SSDi per country and give the details of the Supply Source Access maps.

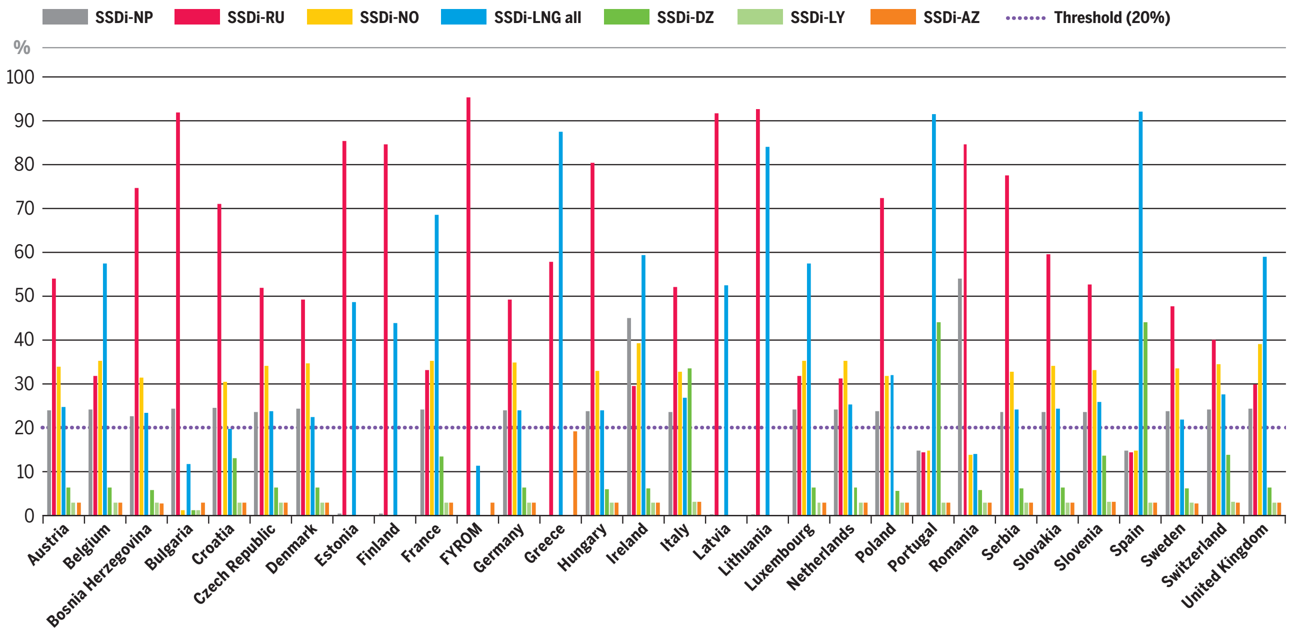

Figure 2.21: Best Estimate 2020 – SSDI indicator by country

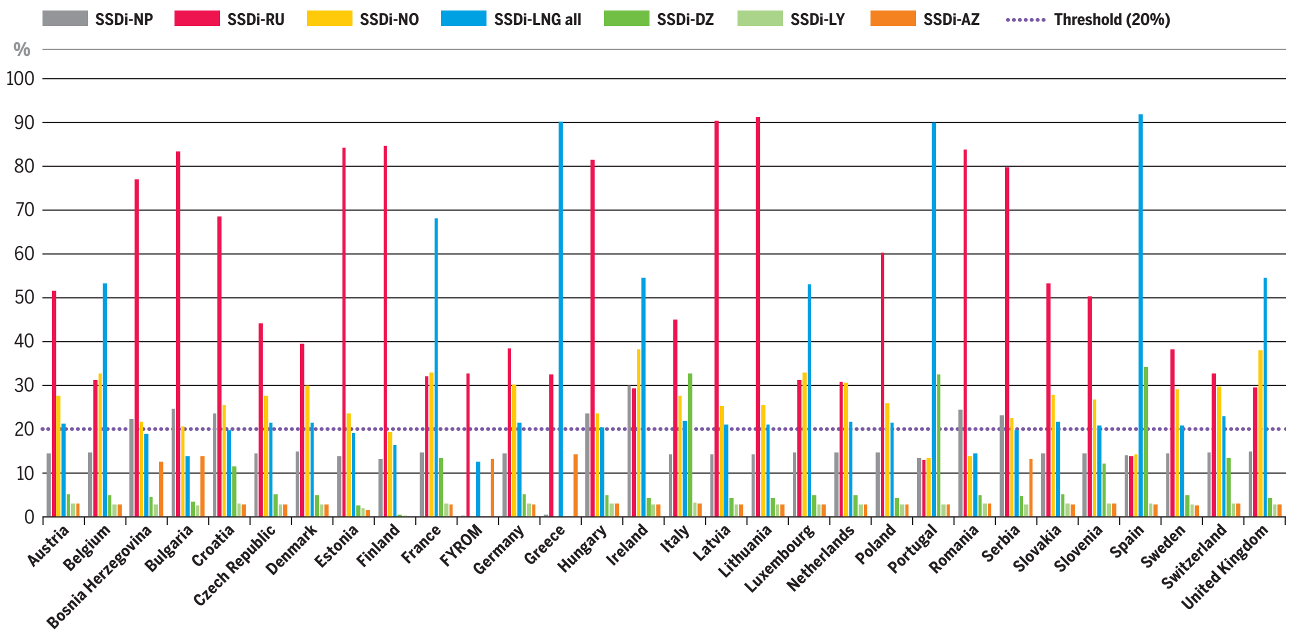

Figure 2.22: Best Estimate (Gas before Coal) 2025 – SSDI indicator by country

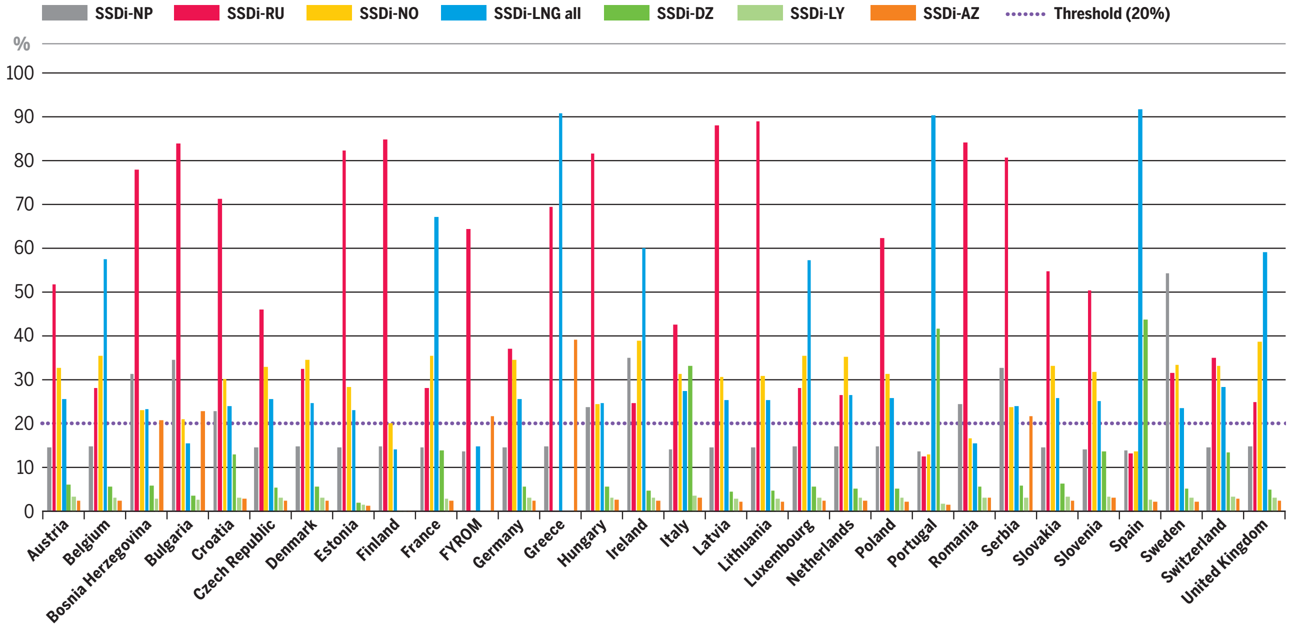

Figure 2.23: Distributed Generation 2030 – SSDI indicator by country

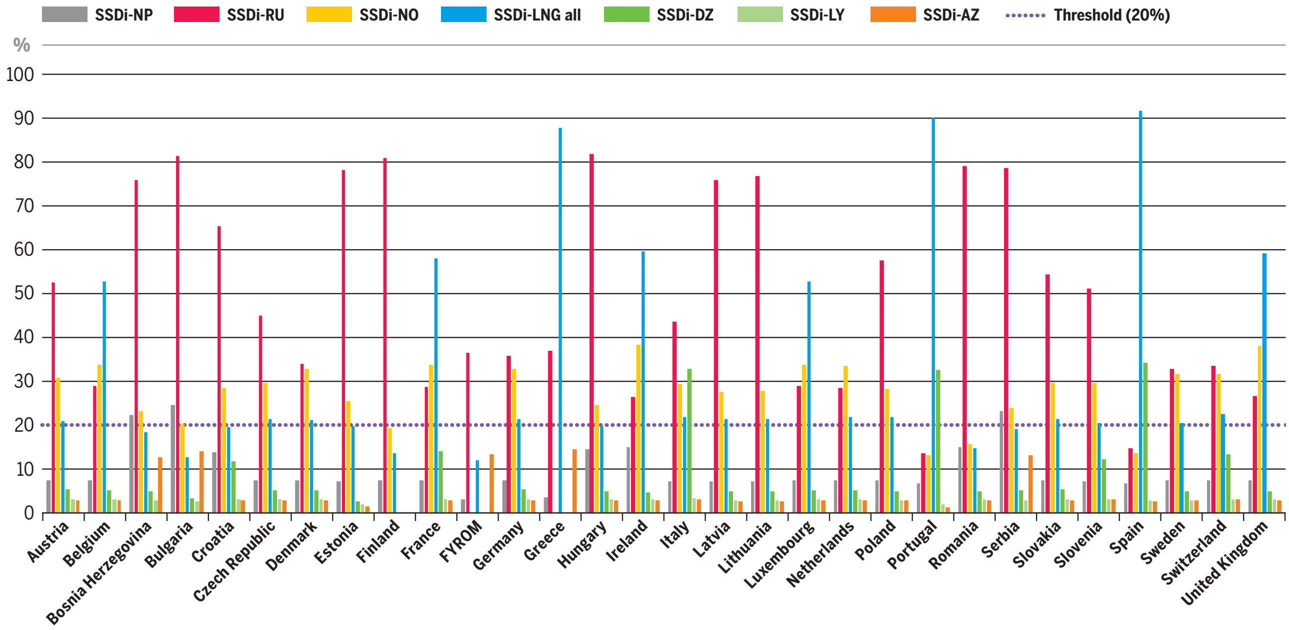

Figure 2.24: Sustainable Transition Scenario 2030 – SSDI indicator by country

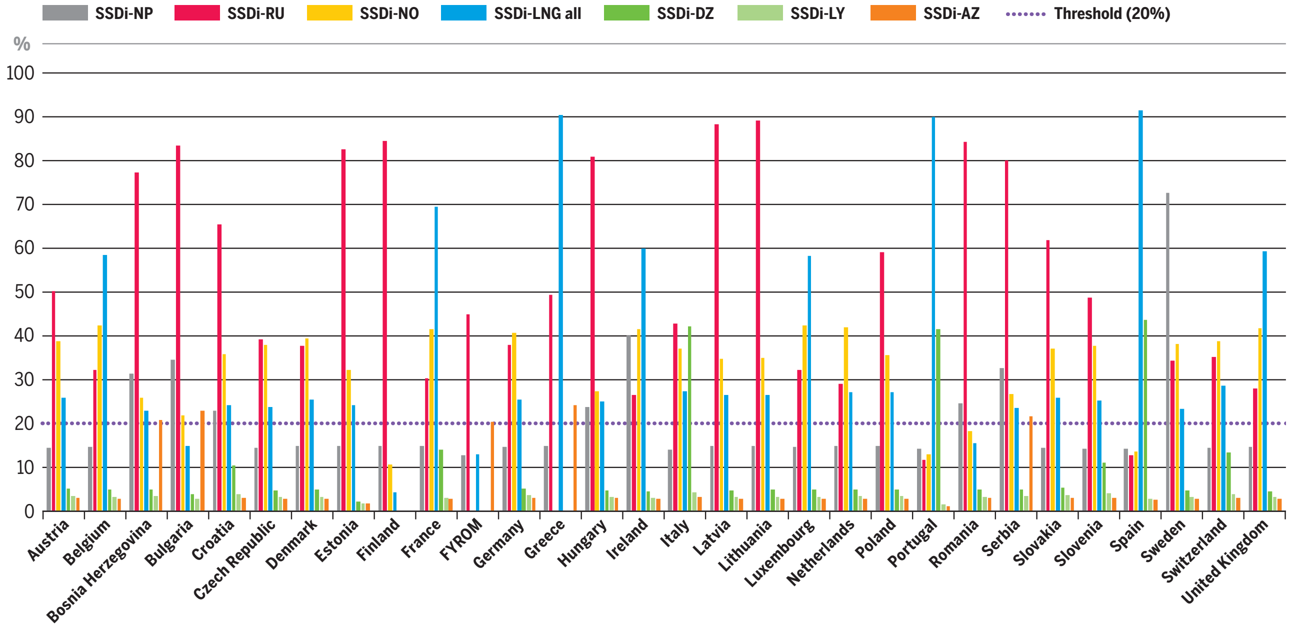

Figure 2.25: Distributed Generation 2040 – SSDI indicator by country

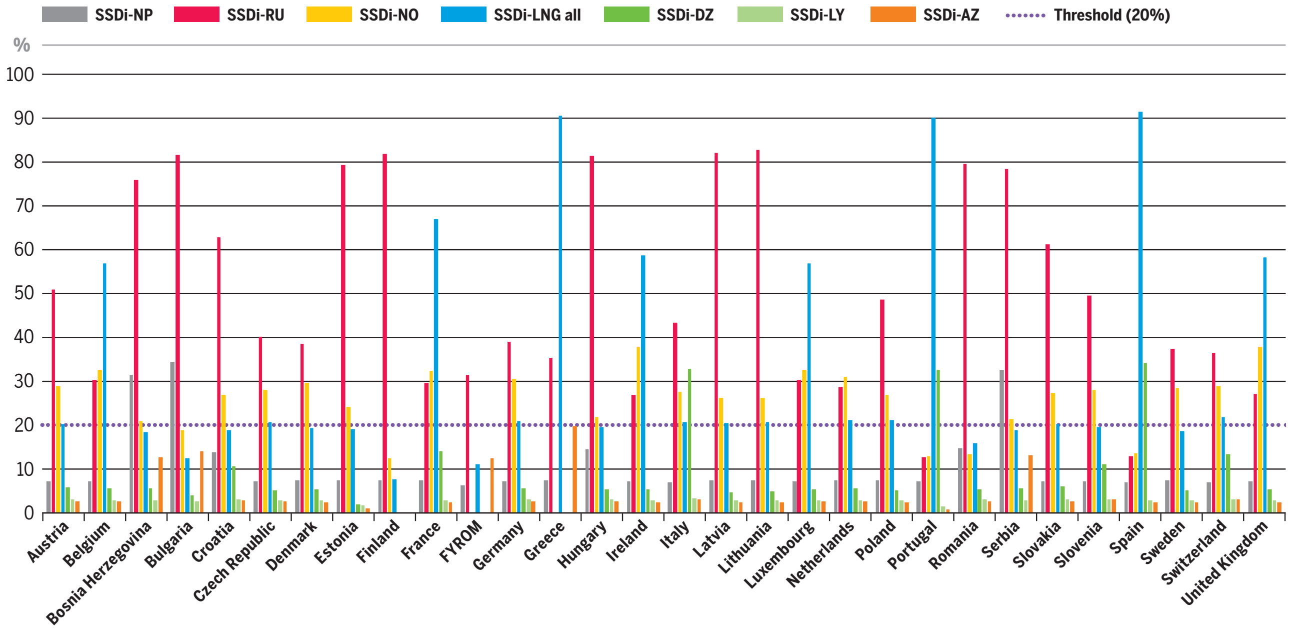

Figure 2.26: Sustainable Transition Scenario 2040 – SSDI indicator by country

2.3.2 SUPPLY SOURCE DEPENDENCE (SSD)

The Supply Source Dependence (SSD) should be understood as the minimum share of a given source in the supply mix, being the source share, which cannot be substituted by the other supply sources. The analysis is done over the whole year. It has both a European and a country-level dimension. On a European level, it relates to the overall demand and supply volumes that are available. The European level situation therefore reflects a supply gap and not an infrastructure gap.

The SSD is assessed independently for each extra-EU supply under the assumption that countries interact in a cooperative way.

As a consequence of such cooperative behaviour, different levels of dependence between neighbouring countries indicate an infrastructure limitation that can be only mitigated by infrastructure reinforcement.

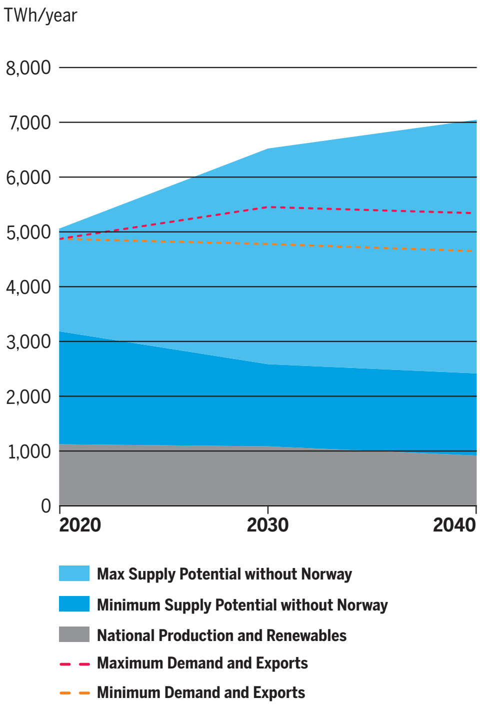

Figure 2.27: European Level Supply and Demand Adequacy with no supply from Norway

Norwegian Supply

The results for the SSD indicator for Norwegian supply show no dependence for all European countries on Norwegian gas. The other suppliers can satisfy the European demand and the infrastructure is sufficient to provide gas. As shown in Figure 2.27, the maximum supply potential without considering Norwegian supply can cover the evolution of demand in all scenarios.

Results show that Europe is generally not dependent on Norwegian gas and, at country level, the infrastructure network is well developed for all countries to access alternative sources.

Russian Supply

The results of SSD indicator for Russian supply show dependence for all of Europe on Russian gas in 2020 and 2025 and to a lesser extent in the other years and scenarios. Nevertheless, at EU level, the gas infrastructure allows to maximise the other sources. This indicates that the European-level situation is purely a supply gap, reflecting that Europe relies on a minimum share of Russian gas to achieve its supply and demand balance. The increasing flexibility of other sources over time reduces accordingly the dependence to Russian gas. Yet, some country-level limitations exist and are detailed below. As said, some areas show higher dependence to Russian gas.

In all scenarios, the Baltic region (Lithuania, Latvia, Estonia and Finland) is more dependent on Russian supply after the decommissioning in 2024 of the LNG FSRU in Klaipėda.

In 2020 in South-Eastern Europe, Bulgaria and FYROM higher dependence, reveal infrastructure limitation between these countries and their neighbours. However, from 2025 on, the wider sharing and decrease of the dependence in this region relates to the foreseen commissioning of a number of projects in the region (TAP, Interconnector Greece-Bulgaria and Interconnector Bulgaria-Serbia).

Romania, in 2020, reduce dependence with Russia related to its national production. But this dependence increases in 2025 onwards due to the announced decrease in national production and an infrastructure limitation with his neighbours.

Over time the increasing LNG potential is not sufficient to mitigate the supply gap in Sustainable Transition scenario. However, in Distributed Generation scenario, considering the lowest demand with a higher penetration of renewable gases, Eastern European countries (Finland, the Baltics, Poland, Czech Republic, Hungary, Slovakia and Croatia) show a significantly lower dependence to Russian supply.

In all scenarios, Eastern European countries listed above are showing a level of dependence significantly higher than the rest of Europe. This reveals an infrastructure limitation preventing those concerned countries to align their level of dependence with Western and Central Europe countries.

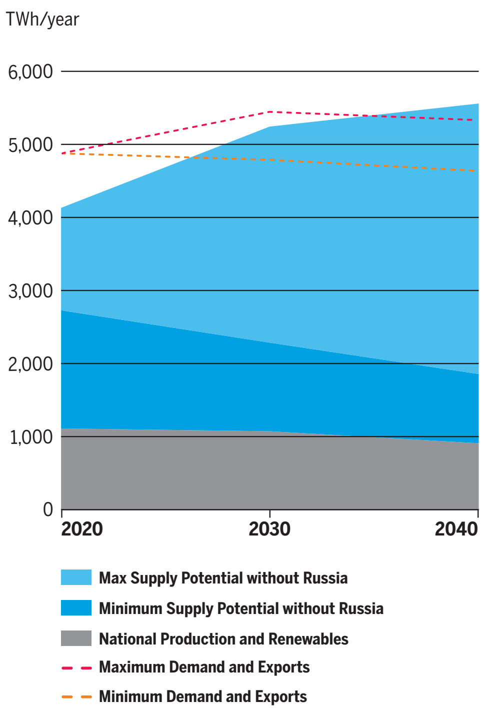

Figure 2.28: European Level Supply and Demand Adequacy with no supply from Russia

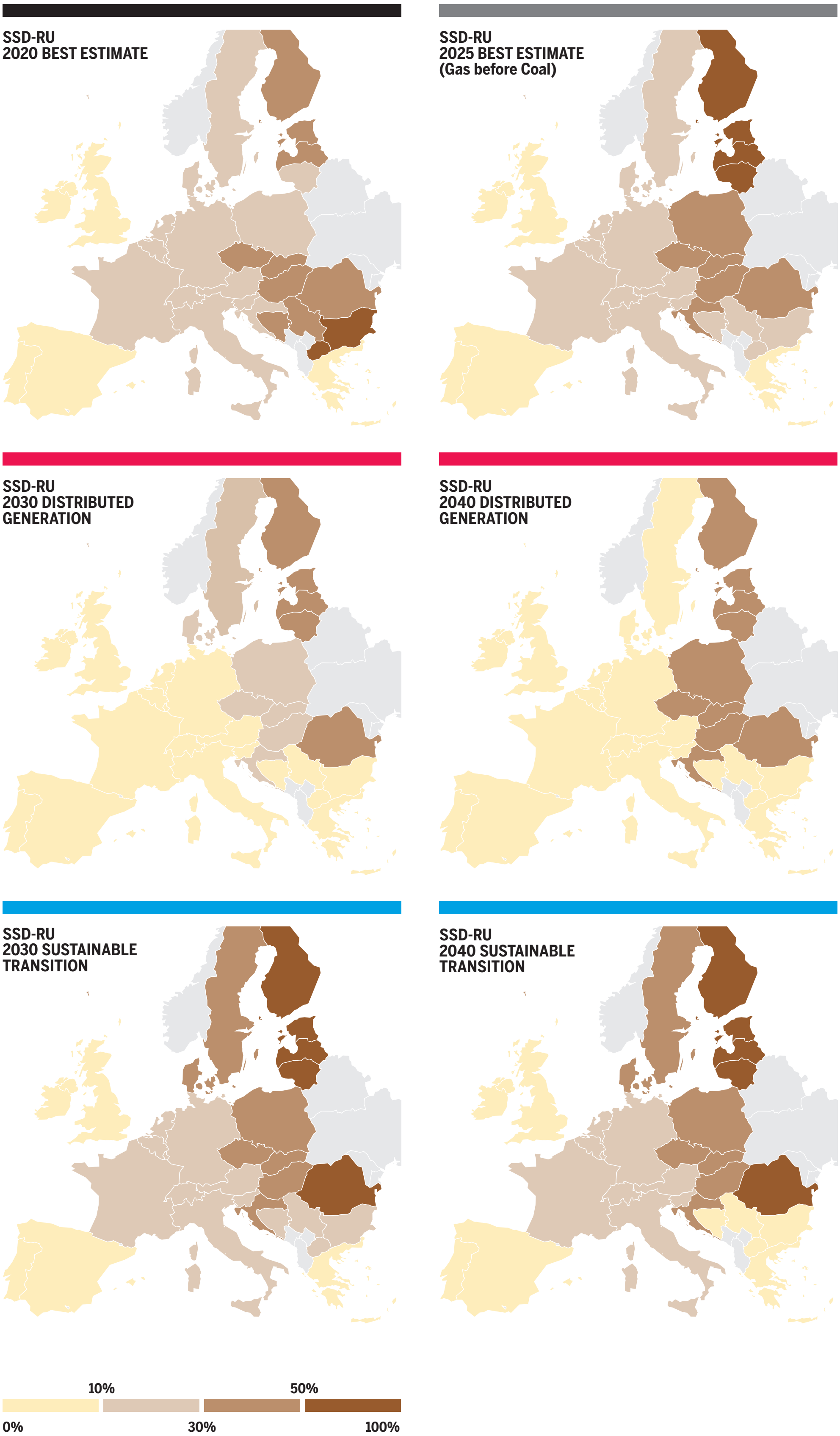

Figure 2.29: SSD RUSSIA – Scenarios and years – Maps results

LNG

The results of the SSD indicator for LNG supply show limited dependence for most of Europe on LNG. At EU-level, the gas infrastructure allows to maximise the other sources. This indicates that the European-level situation is purely a supply gap, reflecting that Europe relies on a minimum share of LNG to achieve its supply and demand balance. Yet, some country-level limitations exist and are detailed below.

The results for the SSD indicator for LNG show dependence for the Iberian Peninsula on the global LNG market, reflecting an infrastructure limitation preventing further substitution of LNG by pipe supply.

In Sustainable Transition scenario, for the most part of European countries, the overall increase in demand combined with a lower supply potential due to low penetration of renewable gas compared to the other demand scenarios, results show a general increase in the dependence of Europe to LNG (SSD around 13 %). Some suppliers have no more flexibility (Algeria, Libya and Norway), so this dependence is a supply gap and not infrastructure related. However, Azerbaijan, Russia and Turkey have still flexibility. The infrastructure limitation with these suppliers impact the most of European countries and the unified mode mitigate the dependence.

However, the eastern Countries showing high dependence to Russian supply show absolutely no dependence to LNG (Baltic Countries, Finland, Bulgaria, Bosnia Herzegovina, Hungary, Romania and Serbia).

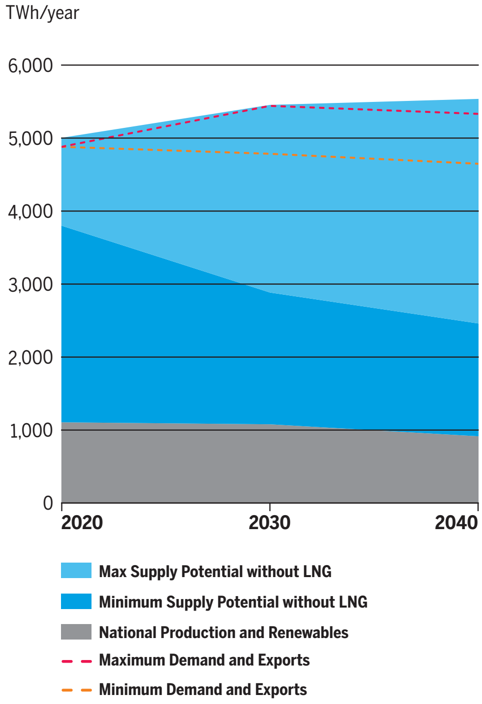

Figure 2.30: European Level Supply and Demand Adequacy with no supply from LNG

Figure 2.31 shows the results for SSD to LNG supply in Best Estimate, Distributed Generation and Sustainable Scenarios.

For countries accessing LNG, whilst LNG is a diversified source imported from different LNG basins, results regarding the dependence to the different LNG basins show that no country is dependent on a single LNG basin.

Picture courtesy of Enagás

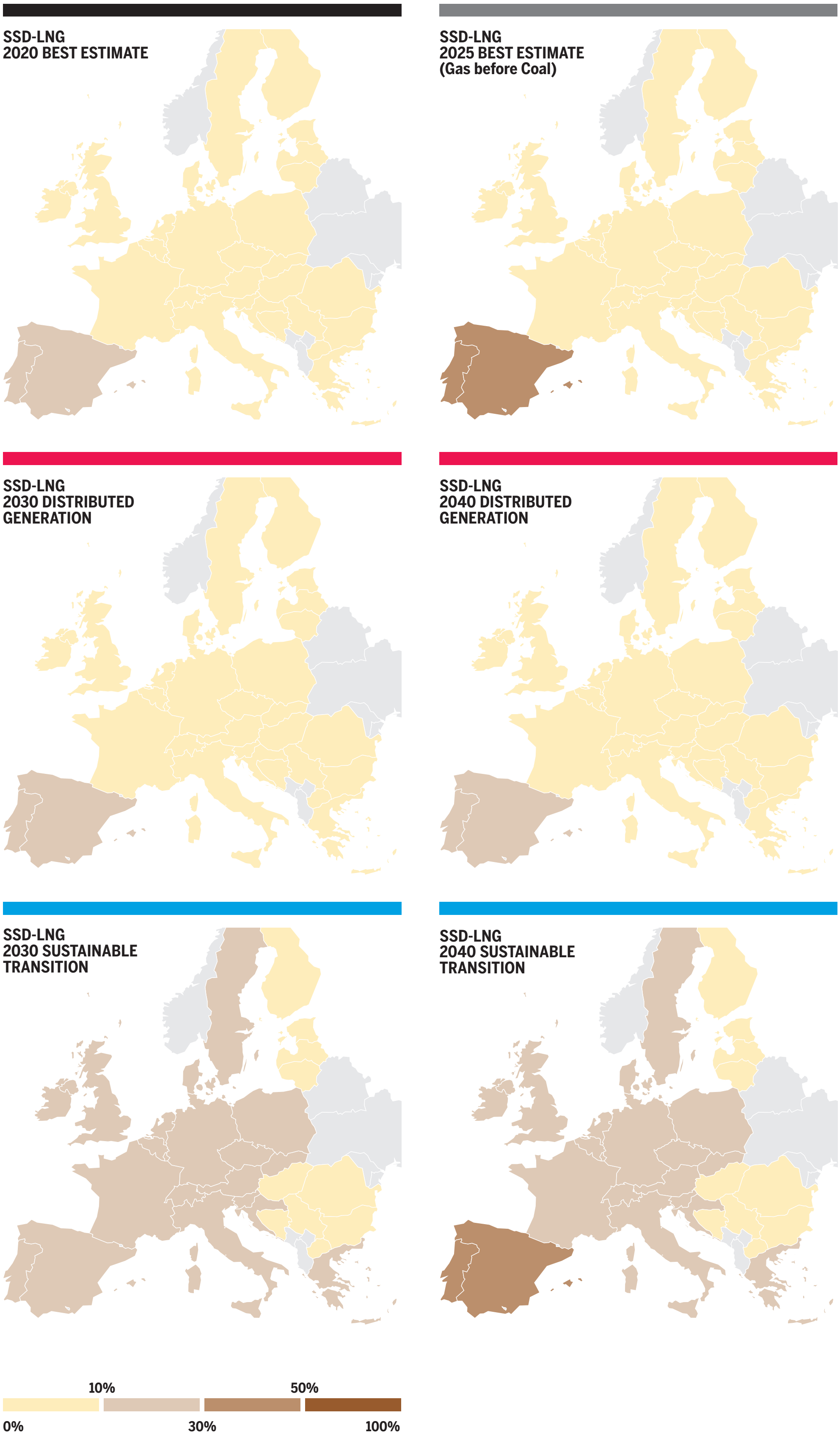

Figure 2.31: SSD LNG – All scenarios and years – Maps results

2.3.3 LICD – LNG AND INTERCONNECTION CAPACITY DIVERSIFICATION

This indicator was called Import Route Diversification in the previous TYNDP (2017). It was focused on how balanced the import capacity of a given country is.

The LNG and Interconnection Capacity Diversification (LICD) does not consider the capacities from import route and transit route but only the LNG terminals capacities and the interconnections capacities between European Countries.

Each border entry capacity is capped by the country average day demand (incl. gasification), to avoid results for a small demand country being distorted by a big transit capacity.

This indicator shows the diversification from the perspective of market integration. It measures the diversification of paths that gas can flow through to reach a market area.

The LICD is an HHI[7] indicator and ranges from 0 to 10,000. The lower the value, the better the diversification is. Where a country would have two borders the LICD cannot be lower than 5,000, and for a country having three borders the LICD cannot be lower than 3,333. See Annex F for detailed information about the indicators' formulae.

The results of the LICD indicator are independent from the scenarios. Since a large majority of the FID projects are to be commissioned between 2020 and 2025, the changes in LICD values differ only between these two time horizons.

Results show that the diversification improves in South-Eastern Europe between 2020 and 2025 due to the commissioning of a number of projects in the region (IGB, Interconnection Bulgaria – Serbia and Interconnection Slovakia – Poland).

Due to their limited number of borders, countries located at the boundaries of Europe generally show a higher index compared to Central Europe countries.

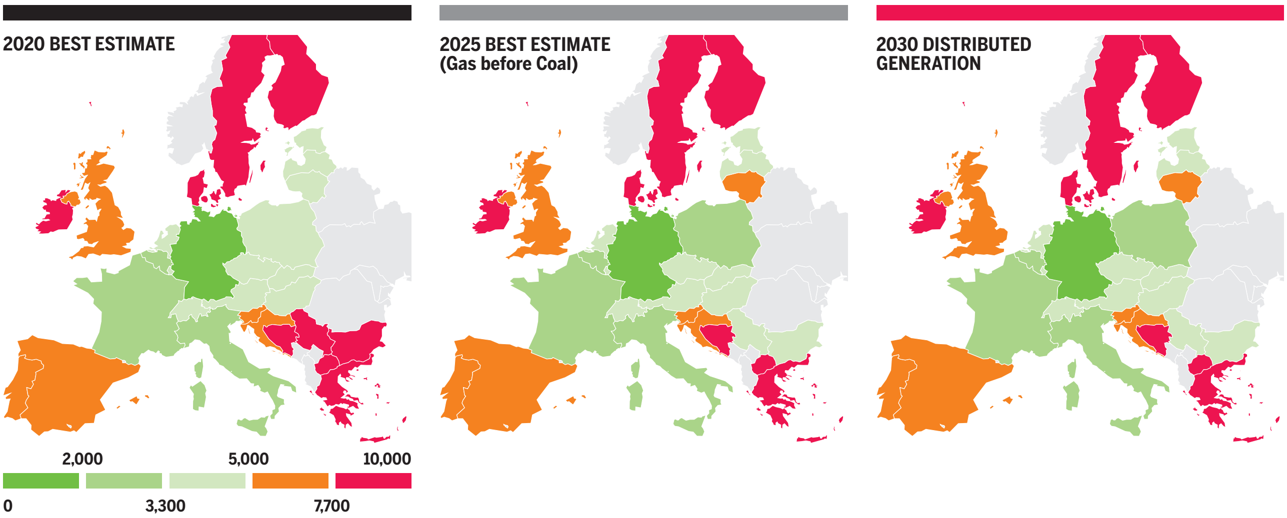

Figure 2.32: LNG and Interconnection Capacity Diversification – Maps results

7) Herfindahl-Hirschman Index

2.3.4 CONCLUSION ON COMPETITION NEEDS

The infrastructure gaps hampering competition are identified by assessing the ability of countries to prevent a too high dependence to a given source and symmetrically to benefit from diversified supplies. These results have been complemented with a monetary perspective (see Market Integration Needs, following chapter).

The SSDI and SSD indicators help support the analysis. The gas infrastructure generally allows most countries to cooperate in mitigating the dependence to a given source by ensuring access to diversified supplies. Nevertheless, the assessment of the competition needs, under the low infrastructure level, shows potential needs in the following areas, often resulting from the same limitations as identified in terms of security of supply:

- Cyprus and Malta which are currently completely disconnected from Europe mainland
- In the South-Eastern and Central-Eastern area
  - South-Eastern countries are highly dependent on Russian supply,
  - Several FID projects mitigate the infrastructure limitations in Bulgaria as of 2025 (Interconnexion Greece – Bulgaria in particular),
  - Romania faces infrastructure limitations with its neighbouring countries (Hungary, Bulgaria),
  - Greece faces infrastructure limitations in sharing LNG with neighbouring countries,
  - The Central-Eastern area faces an increasing dependence on Russian gas on the long run, highlighting some infrastructure gaps to limiting the diversification of supply sources.
- In the Western area
  - The Iberian Peninsula have access mainly to LNG and Algerian gas when other Western countries access more sources.
- In some instances, infrastructure limitations prevent countries with a direct access to LNG from sharing this access completely with neighbouring countries
- At European-level, a general degradation of the diversification potential over time related to the decrease of the European indigenous production can be compensated by the production of new gases for some scenarios (Distributed Generation, Global Climate Action) or new import routes.

Picture courtesy of REN

2.4 MARKET INTEGRATION NEEDS

2.4.1 MARGINAL PRICE

This section investigates how Marginal Prices of European countries are sensitive to contrasted supply price configurations and their ability to converge.

New features in TYNDP 2018[8]:

- New supply price methodology
- Tariffs included for the first time
- Long-term capacity bookings included for the first time

The Reference price per scenario and time horizon have been built using a full supply price methodology for the different supply sources using price information from IEA World Energy Outlook 2017 and is detailed in the TYNDP Scenario report.

Infrastructure tariffs used for this TYNDP reflects the current 2018 tariffs for Transmission and tariffs used for LNG and Storage are described in the Annex D.

Reference case

It is not expected that the reference supply prices or arbitrary price differentials selected will materialise in the future, nor that the prices determined in the EU's internal hubs by modelling will fully reflect internal demand and supply drivers. ENTSOG is aware that the actual development of prices is so volatile that the source used for the Reference price is probably already outdated at the time of publication of the TYNDP report and there are new forecasts available.

Interpretation of marginal prices

A difference in marginal price between two connected countries can be the result of a transmission tariff, an infrastructure limitation or both.

As reference marginal prices are different for every year and every scenario of the assessment, comparisons between countries, supply configurations or infrastructure levels are valuable only when comparing within the same year and same scenario.

For the purpose of maximising and minimising supply flows from individual sources in order to assess extreme transportation potentials of the grid a standardised approach has been defined. For the minimisation and maximisation of supplies the price curves of these supplies are set higher or lower by an arbitrary spread of 5 €/MWh making this supply more or less attractive. The import price of the other sources is not changed.

The following supply configurations were analysed:

- Russian gas supply maximised (low Russian price)
- Russian gas supply minimised (high Russian price)
- LNG supply maximised (low LNG price)
- LNG supply minimised (high LNG price)
- South gas supply gas maximised (low Azeri, Libyan, Algeria prices)

In the following maps, the reference price (0), used to compare the marginal prices, is the same average price used in the reference case for the same scenario and the same years. It is the middle price of the reference cases.

8) The definition and the methodology of infrastructure tariffs and Long Term Capacity Bookings used for the assessment are detailed in Annex D.

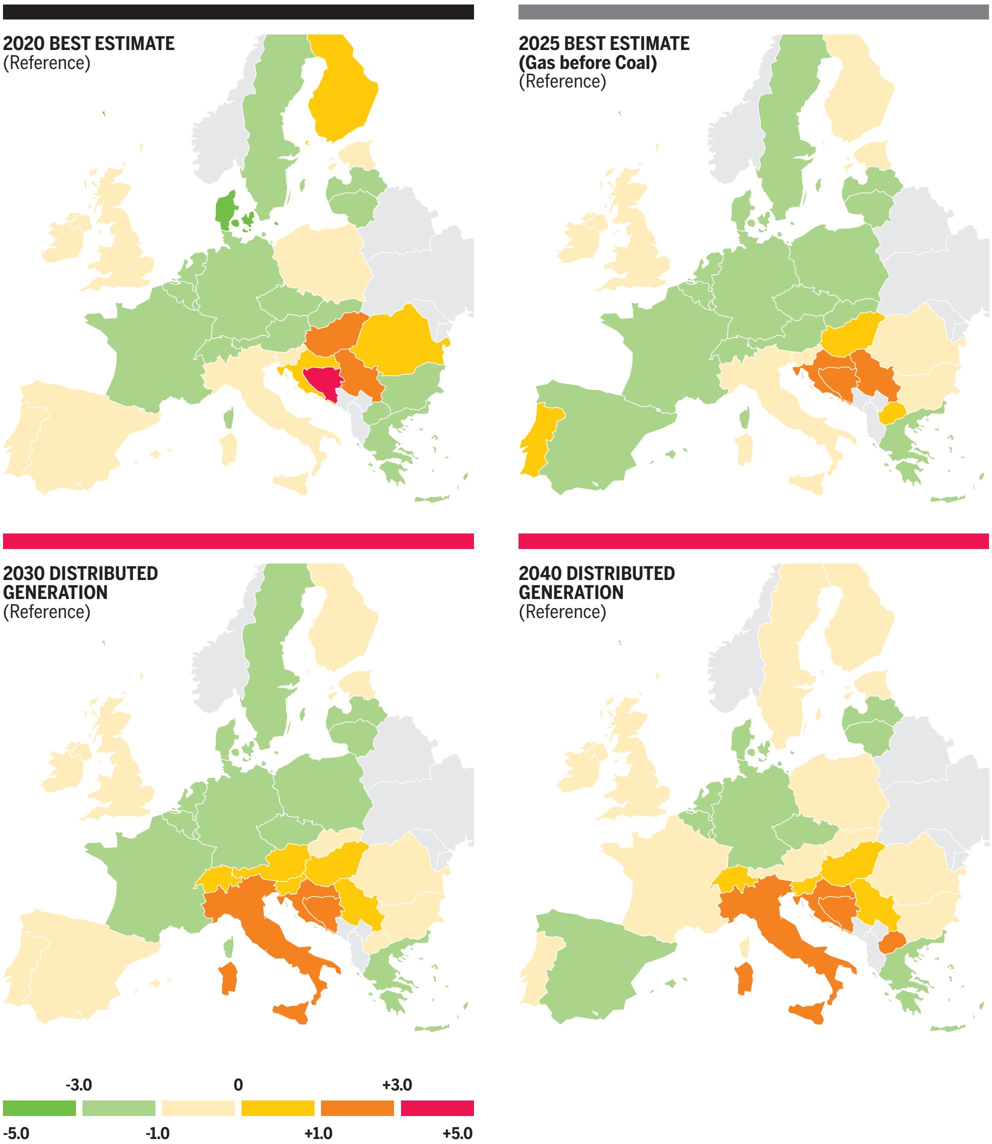

Figure 2.33: Marginal Price – Reference case

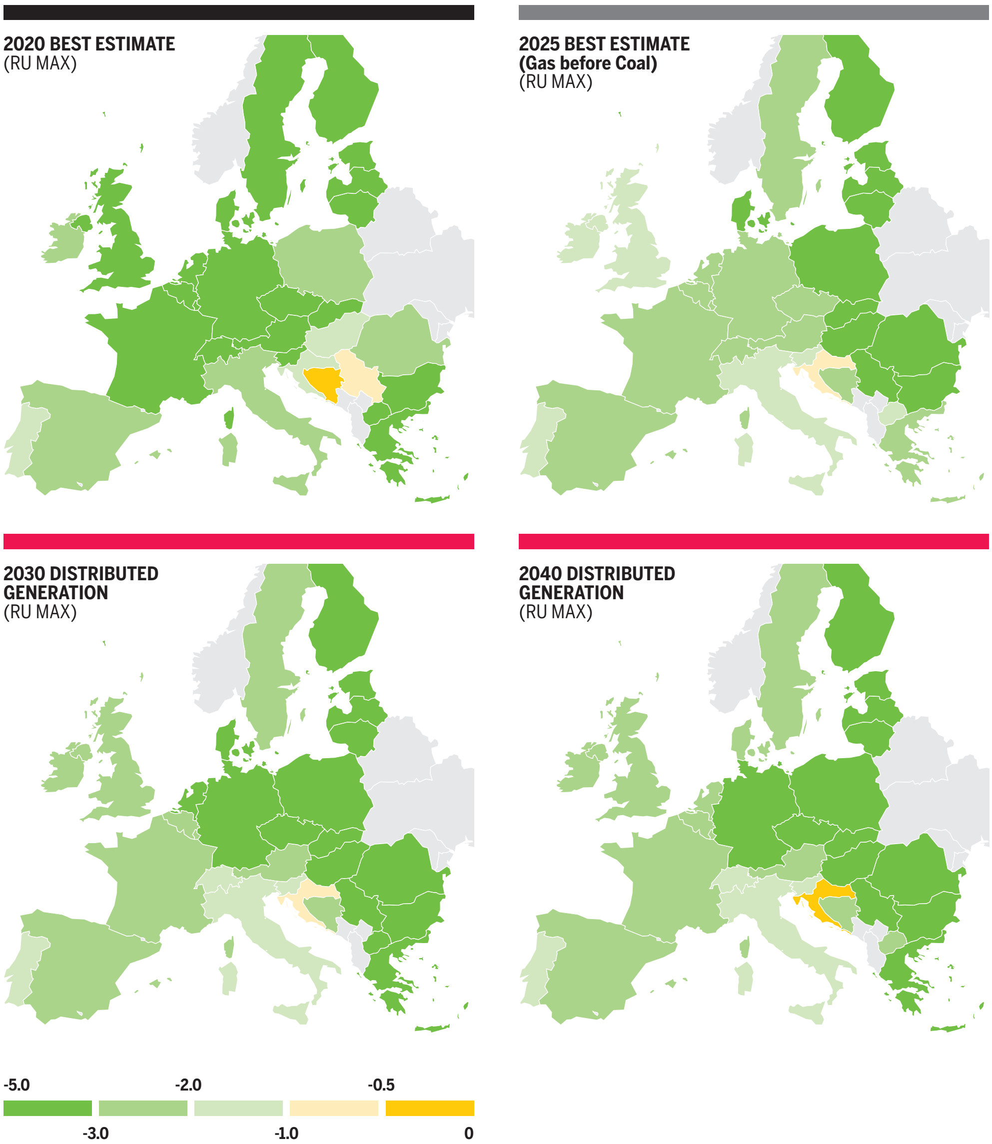

Figure 2.34: Marginal Price – Russian Maximisation (Low price)

Maximisation of Russian supply

A low price for Russian gas can have an influence on nearly all European countries in terms of country-level average supply price. The effect appears stronger for the Eastern part of the EU.

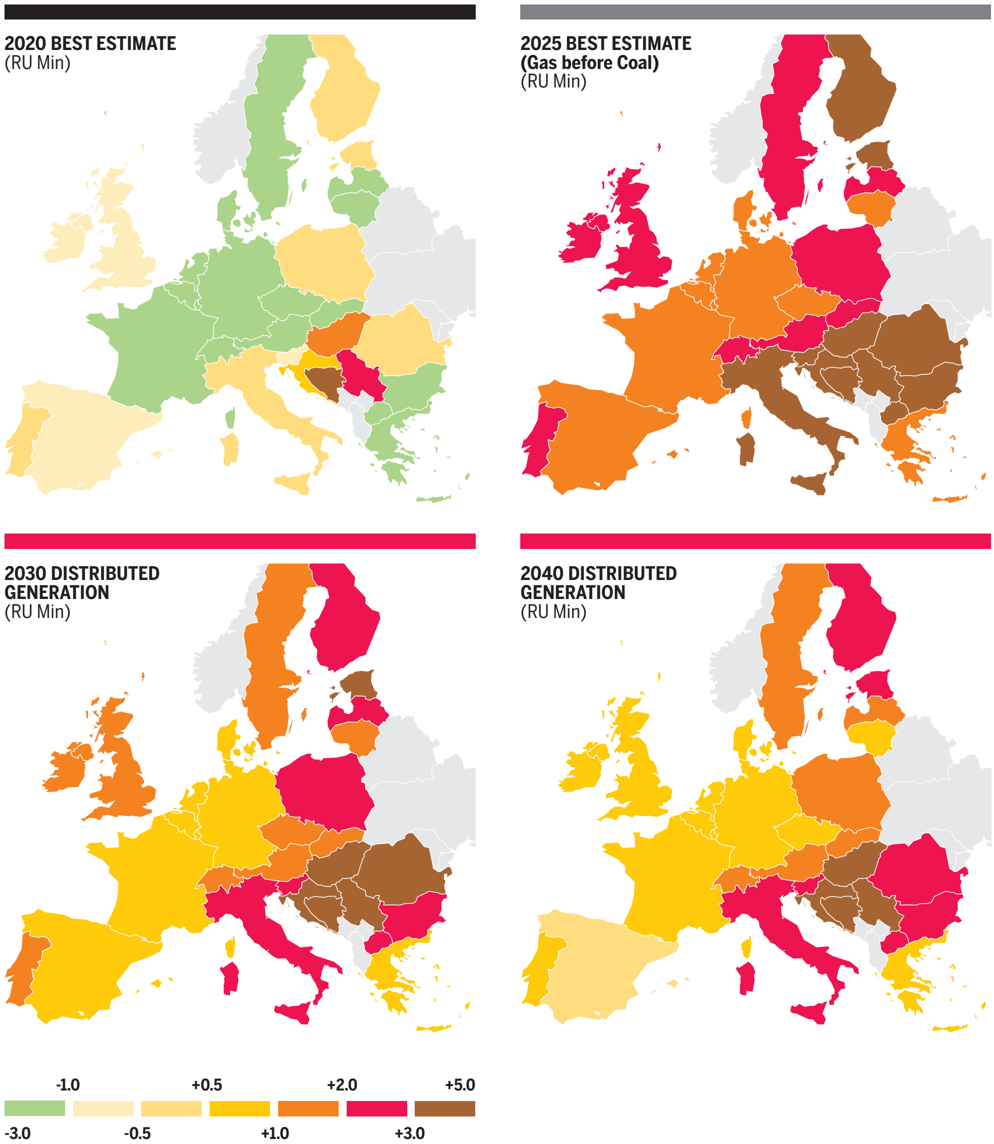

Figure 2.35: Marginal Price – Russian Minimisation (High Price)

Minimisation of Russian supply

In 2020, Best Estimate scenario, we obtain the same results than for reference case. For reference case, we already reached the lower boundary for Russian supply.

High price of Russian supply impacts all European countries. Countries of Eastern and South-Eastern Europe are more exposed while in Western Europe and Greece, the impact of an expensive Russian supply is less significant.

On the longer term, the overall increase of supply flexibility from the other sources reduces the impact of a high Russian supply price.

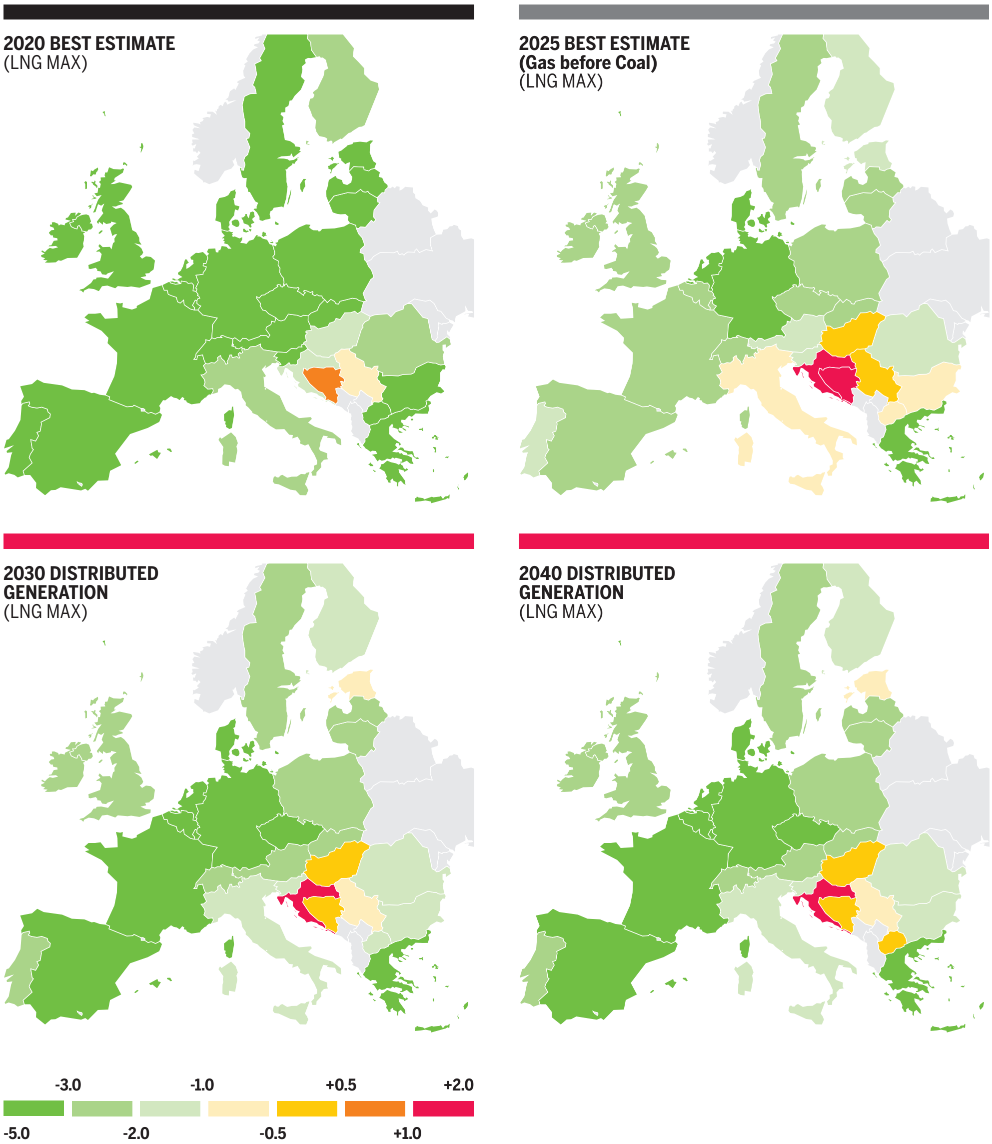

Figure 2.36: Marginal Price – LNG Maximisation – Low Price

Maximisation of LNG supply

Low LNG prices benefit most Europe in 2020. Countries with a direct connection to LNG supply are the first beneficiaries and depending on the available capacities and tariffs, this impact allows to propagate further to other countries.

In 2025, the difference in marginal price between Greece and Bulgaria is higher than the transmission tariff. Therefore, it shows some infrastructure limitation preventing Greece to share the benefits of a cheap LNG supply with the rest of Europe. Simulation results show that after 2025 a larger part of Europe can benefit from a cheap LNG supply: marginal prices are more aligned in almost all South-Eastern Europe.

The overall EU impact evolution over time is also enhanced by the increasing LNG supply potential in all scenarios.

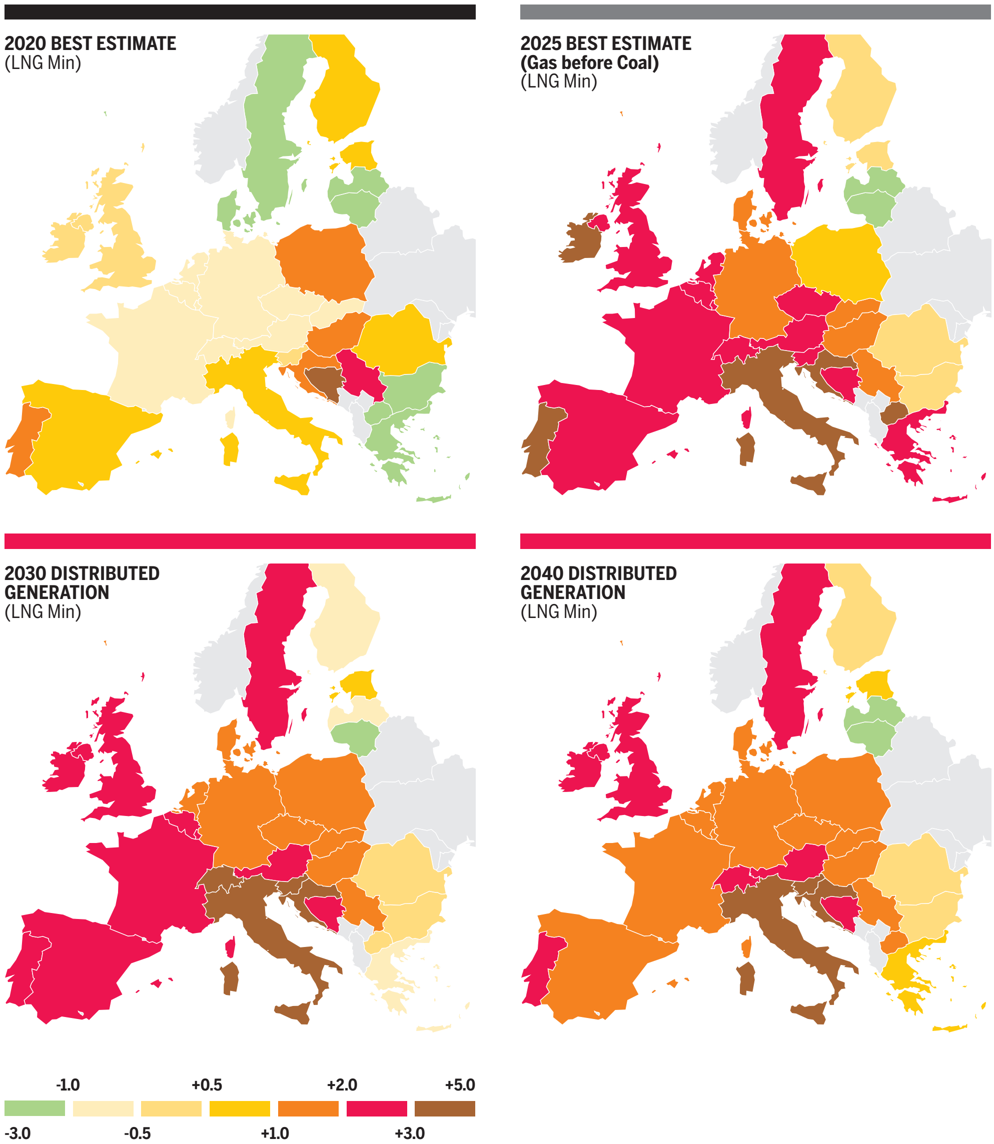

Figure 2.37: Marginal Price – LNG Minimisation – High Price

Minimisation of LNG supply

A high LNG price can influence the marginal price in most of Europe with a more limited impact on some Eastern European countries connected to the Russian supply that show lower marginal prices (Finland, Baltic Countries, Hungary, Romania and Bulgaria). These countries are locally less exposed to a high LNG supply price but cannot help reducing the exposure of their neighbouring countries.

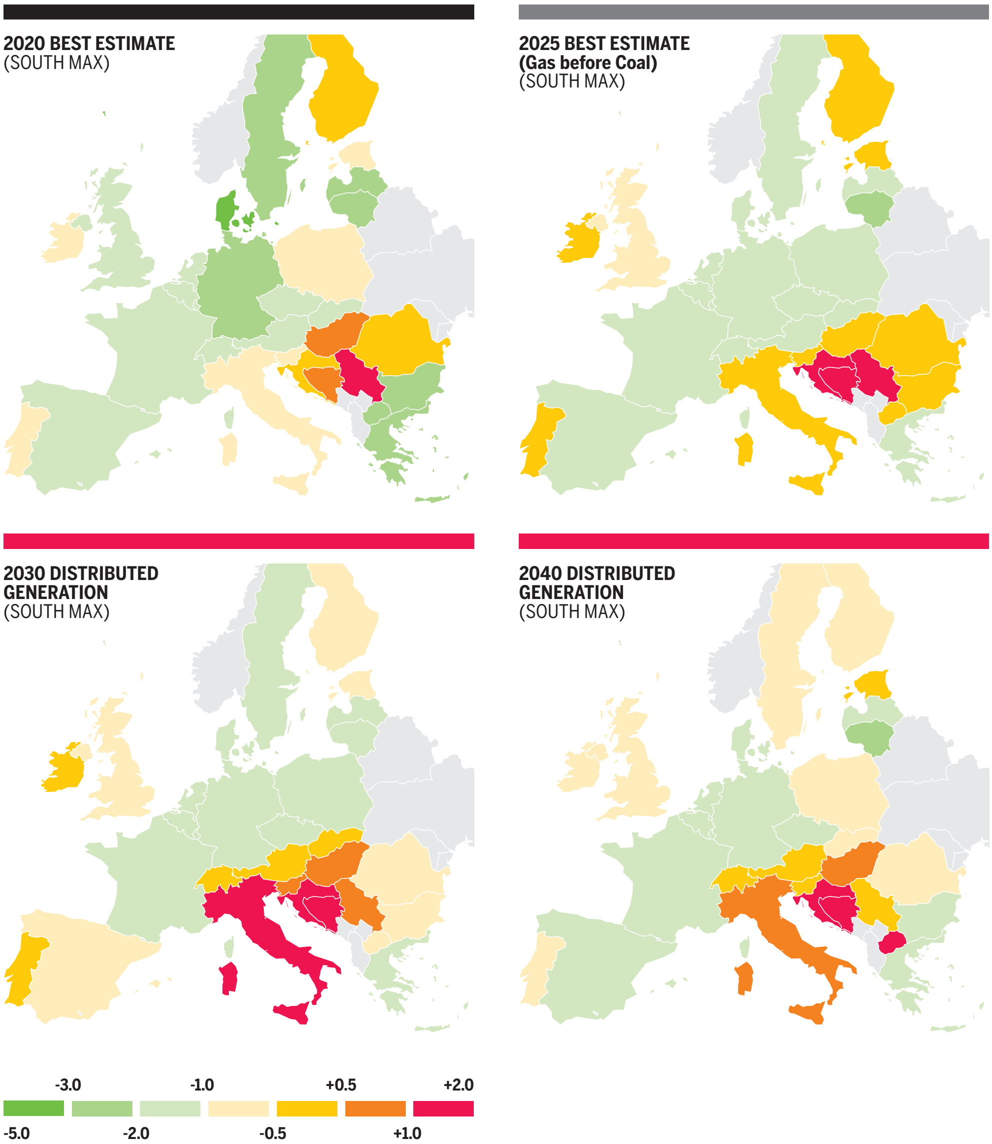

Figure 2.38: Marginal Price – South Max – Low Price

Maximisation of Southern gas supply

Since the Southern supply potential (Azerbaijan, Libya, Algeria) is small compared to the European demand, the estimated impacts of cheap South Countries gas on overall EU prices are limited and show no difference compared to reference case.

Annual EU supply mix per configuration

This part analyses the impact of contrasted EU supply mixes on the EU supply and demand balance and gas infrastructure. This is achieved through supply configurations intended at maximising or respectively minimising specific supply sources such as Russian gas and LNG.

The next figures show the EU annual supply and demand balance for the years 2020, 2025, 2030 and 2040 for these contrasted supply mixes and the range for each supply source.

At EU level, the low infrastructure level allows each source to reach its maximum potential, under the corresponding contrasted supply mix. At country level, some infrastructure limitations exist. They are identified in other parts of this chapter.

The infrastructure in the Low infrastructure level also provides high flexibility at EU level. This is shown by the wide range of possible supply mixes. This can be mainly observed on the long run, where the supply flexibilities are wider.

The low infrastructure level does not allow the internal market to make full use of the Romanian indigenous production over the whole time horizon.

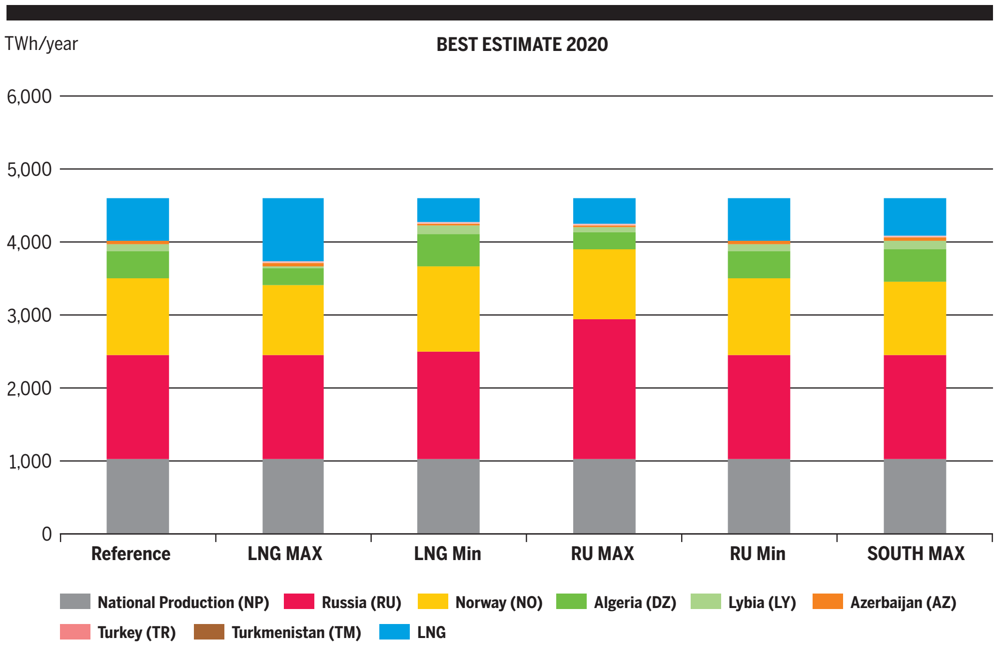

Figure 2.39: Annual EU supply mix per configuration 2020

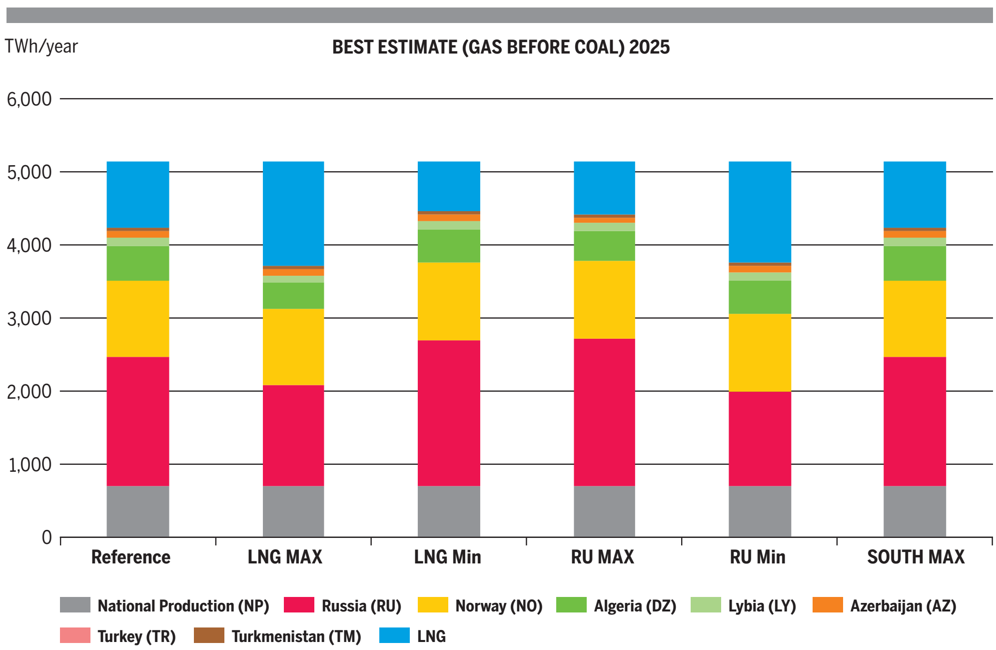

Figure 2.40: Annual EU supply mix per configuration 2025

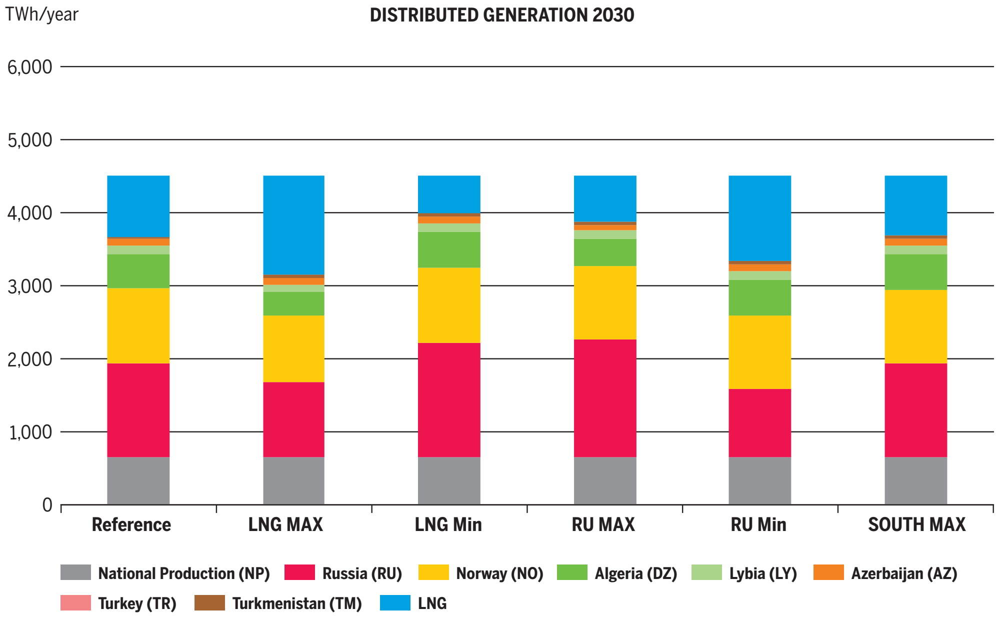

Figure 2.41: Annual EU supply mix per configuration 2030

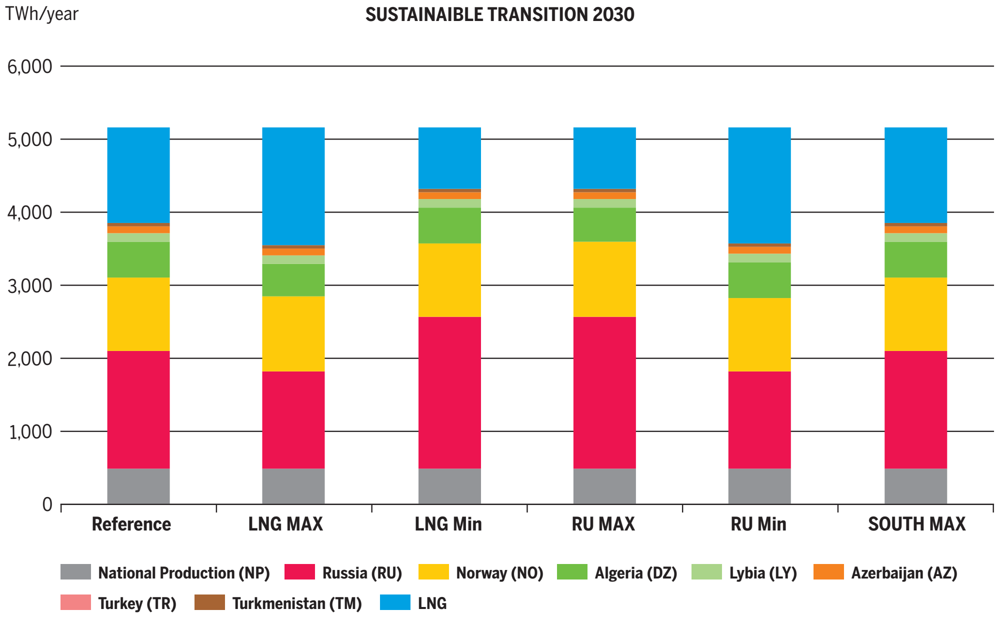

Figure 2.42: Annual EU supply mix per configuration 2030

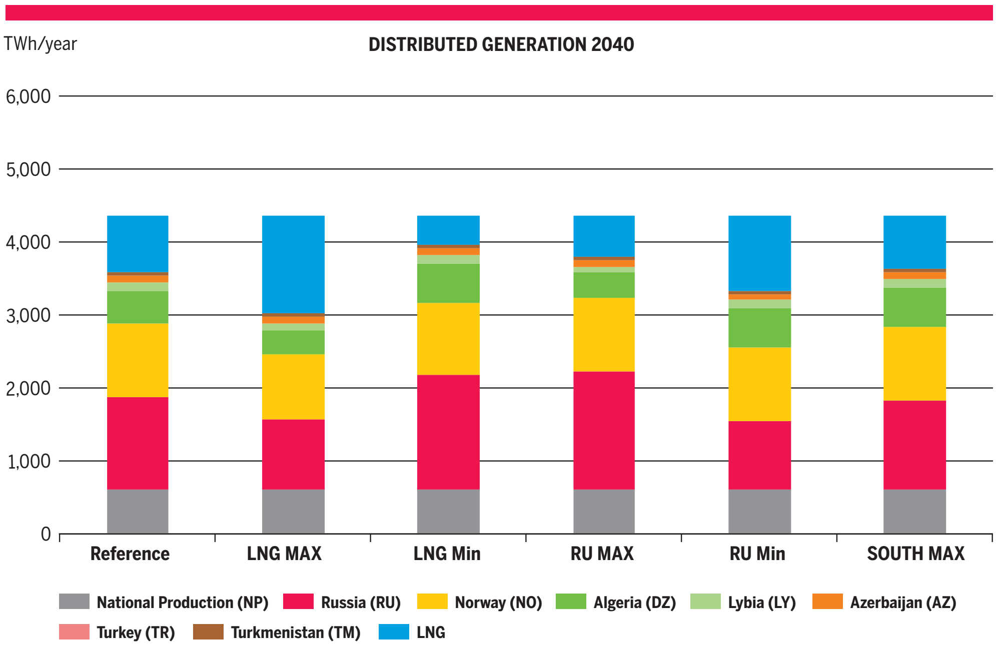

Figure 2.43: Annual EU supply mix per configuration 2020

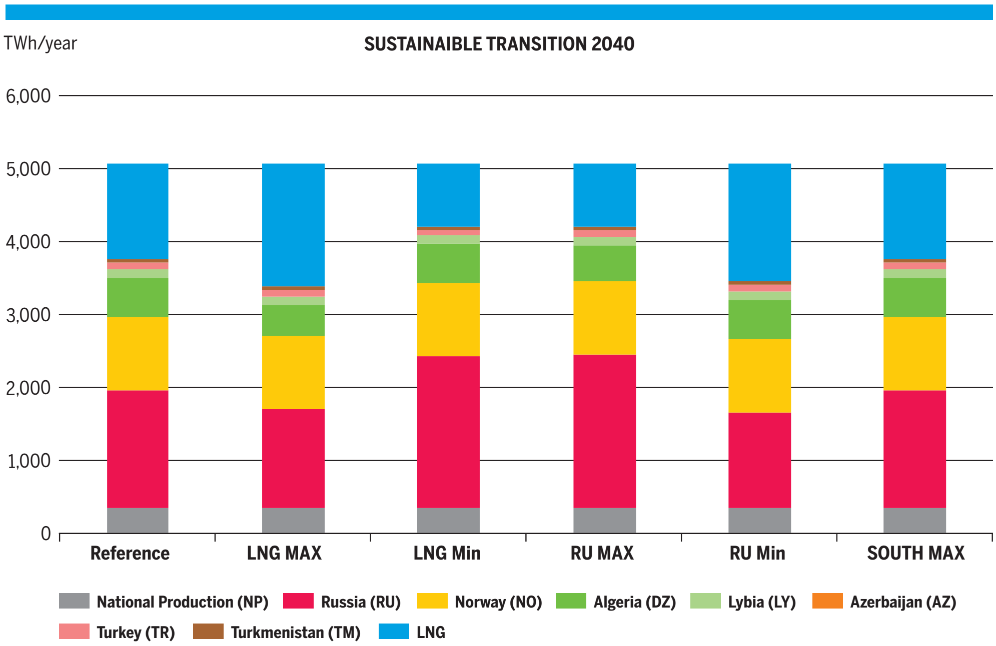

Figure 2.44: Annual EU supply mix per configuration 2025

		DZ	AZ	LNG	LY	NP	NO	RU	TR	TM
2020	BEST ESTIMATE	5%–10%	1%–1%	7%–19%	1%–3%	22%–22%	21%–25%	31%–42%	0%–0%	0%–0%
2025	BEST ESTIMATE (GAS BEFORE COAL)	7%–9%	2%–2%	13%–28%	2%–2%	14%–14%	20%–20%	25%–39%	0%–0%	1%–1%
	BEST ESTIMTE (COAL BEFORE GAS)	7%–10%	2%–2%	9%–28%	2%–3%	15%–15%	20%–22%	25%–41%	0%–0%	1%–1%
2030	EUCO 30	7%–10%	2%–2%	12%–29%	2%–3%	13%–13%	20%–22%	23%–39%	0%–0%	1%–1%
	DISTRIBUTED GENERATION	7%–11%	2%–2%	11%–30%	2%–3%	14%–14%	20%–23%	21%–36%	0%–0%	1%–1%
	SUSTAINABLE TRANSITION	9%–9%	2%–2%	16%–31%	2%–2%	10%–10%	20%–20%	26%–40%	0%–0%	1%–1%
2040	GLOBAL CLIMATE ACTION	8%–13%	2%–2%	8%–30%	2%–3%	15%–15%	19%–24%	23%–38%	0%–0%	1%–1%
	DISTRIBUTED GENERATION	8%–12%	2%–2%	9%–31%	2%–3%	14%–14%	20%–23%	21%–37%	0%–0%	1%–1%
	SUSTAINABLE TRANSITION	8%–11%	2%–2%	17%–33%	2%–2%	7%–7%	20%–20%	26%–42%	0%–0%	1%–1%

Figure 2.45: Range of EU supply mix per configuration

2.4.2 CONCLUSION ON MARKET INTEGRATION NEEDS

The TYNDP assessment concludes that, if liquid hubs were in place all over Europe, market were perfectly functioning, and diversification would allow a sufficient competition between supply sources, the infrastructure would presumably allow marginal prices to converge across most of Europe.

Nevertheless, previous sections results related to competition have also shown that inability to ensure sufficient diversification hampers competition in some areas of Europe. The assessment identifies infrastructure limitations in terms of market integration, and subsequently diversification of supplies, in particular for the following areas:

- Between Greece and countries further north.
- Between Poland and Baltic States.
- Between Poland and countries south of Poland.
- Between Romania and its neighbours.
- Between Croatia and neighbours.

Picture courtesy of Net4gas

3 ENERGY SYSTEM-WIDE COST-BENEFIT ANALYSIS OF ADVANCED PROJECTS

The previous section provided a thorough analysis of what the current infrastructure, complemented with FID projects, already achieves. It concludes that the Low gas infrastructure level already offers a high resilience and market integration. Nevertheless, some remaining needs can subsist in specific areas in order to achieve the European internal energy market. These needs persist on the long run while taking into account the evolution of the gas demand pattern to achieve the European energy and climate targets.

This section therefore assesses the overall further impact of the projects having an advanced status, by comparing the results of the Advanced infrastructure level to those of the Low infrastructure level. The projects of advanced status are defined as the ones that are planned to be commissioned until 2024 and in addition either the front-end engineering design phase or permitting phase has been started (see Infrastructure chapter for further details).

The 72 projects with advanced status are listed in Tables 3.1 and 3.2. Although having an advanced status, some of these projects may not all materialise.

Projects are taken into account in the assessment from the year following their commissioning.

The relevant capacities for this infrastructure level can be found in the Annex D.

Advanced projects with direct impact in the advanced infrastructure level

Code	Project name	Country	Project commissioning year First
LNG-N-1146	Cyprus Gas2EU	Cyprus	2020
LNG-N-198	Porto Empedocle LNG	Italy	2021
LNG-N-297	Mugardos LNG Terminal: Storage Extension	Spain	2022
LNG-N-30	Shannon LNG Terminal and Connecting Pipeline	Ireland	2022
LNG-N-32	Project GO4LNG LNG terminal Gothenburg	Sweden	2020
LNG-N-62	LNG terminal in northern Greece/Alexandroupolis – LNG Section	Greece	2020
LNG-N-82	LNG terminal Krk	Croatia	2019
LNG-N-962	Tallinn LNG	Estonia	2022
TRA-N-10	Poseidon Pipeline	Greece	2022
TRA-N-1058	LNG Evacuation Pipeline Kozarac–Slobodnica	Croatia	2023
TRA-N-1173	Poland – Denmark interconnection (Baltic Pipe) – onshore section in Poland	Poland	2022
TRA-N-12	GALSI Pipeline Project	Italy	2019
TRA-N-123	Városföld CS	Hungary	2022
TRA-N-1268	Romania–Serbia Interconnection	Romania	2020
TRA-N-1277	Upgrading GMS Isaccea 1 and GMS Negru Voda 1	Romania	2019

Code	Project name	Country	Project commissioning year First
TRA-N-1322	Development on the Romanian territory of the NTS (BG–RO–HU–AT)-Phase II	Romania	2022
TRA-N-133	Bidirectional Austrian Czech Interconnection (BACI)*	Czechia	2021
TRA-N-136	Czech-Polish Gas Interconnector (CPI)	Czechia	2022
TRA-N-161	South Transit East Pyrenees (STEP) – Enagás	Spain	2022
TRA-N-21	Bidirectional Austrian-Czech Interconnector (BACI)	Austria	2021
TRA-N-252	South Transit East Pyrenees (STEP) – Teréga	France	2022
TRA-N-256	Iberian-French corridor: Eastern Axis-Midcat Project	France	2024
TRA-N-271	Poland – Denmark interconnection (Baltic Pipe) – offshore section	Poland	2022
TRA-N-273	Poland – Czech Republic Gas Interconnection (PL section)	Poland	2022
TRA-N-291	NOWAL – Nord West Anbindungsleitung	Germany	2020
TRA-N-31	Melita TransGas Pipeline	Malta	2024
TRA-N-320	Carregado Compressor Station	Portugal	2024
TRA-N-339	Trans-Caspian	Turkmenistan	2021
TRA-N-357	NTS developments in North-East Romania	Romania	2019
TRA-N-361	GCA 2015/08: Entry/Exit Murfeld	Austria	2022
TRA-N-377	Romanian–Hungarian reverse flow Hungarian section 2nd stage	Hungary	2022
TRA-N-394	Norwegian tie-in to Danish upstream system	Denmark	2022
TRA-N-423	GCA Mosonmagyaróvár	Austria	2022
TRA-N-561	Poland–Ukraine Interconnector (Ukrainian section)	Ukraine	2020
TRA-N-592	Looping CS Valchi Dol – Line valve Novi Iskar	Bulgaria	2022
TRA-N-593	Varna–Oryahovo gas pipeline	Bulgaria	2022
TRA-N-594	Construction of a Looping CS Provadia – Rupcha village	Bulgaria	2022
TRA-N-621	Poland–Ukraine Gas Interconnection (PL section)	Poland	2020
TRA-N-63	LNG terminal in northern Greece/Alexandroupolis – Pipeline Section	Greece	2020
TRA-N-68	Ionian Adriatic Pipeline	Croatia	2022
TRA-N-70	Interconnection Croatia/Serbia (Slobdnica–Sotin–Bačko Novo Selo)	Croatia	2023
TRA-N-727	Iberian–French corridor: Eastern Axis – Midcat Project	Spain	2024
TRA-N-75	LNG evacuation pipeline Zlobin–Bosiljevo–Sisak–Kozarac	Croatia	2020
TRA-N-763	EUGAL – Europäische Gasanbindungsleitung (European Gaslink)	Germany	2019
TRA-N-780	Baltic Pipe project – onshore section in Denmark	Denmark	2022
TRA-N-90	LNG evacuation pipeline Omišalj–Zlobin (Croatia)	Croatia	2019
TRA-N-974	LARINO–RECANATI Adriatic coast backbone	Italy	2022
TRA-N-975	Sardinia Gas Transportation Network	Italy	2020
UGS-N-1229	Underground Natural Gas Storage in Dumrea Area (UGS Dumrea)	Albania	2024
UGS-N-138	UGS Chiren Expansion	Bulgaria	2024
UGS-N-233	Depomures	Romania	2020

* Implementation of BACI as a PCI will depend on the outcome of the pilot project 'Trading Regional Upgrade'

Code	Project name	Country	Project commis-sioning year First
UGS-N-294	Islandmagee Gas Storage Facility	UK	2022
UGS-N-356	Underground Gas Storage Veľké Kapušany	Slovakia	2023
UGS-N-374	Enhancement of Inčukalns UGS	Latvia	2020
TRA-N-829	PCI 5.1.1 Physical Reverse Flow at Moffat interconnection point (IE/UK)	United Kingdom	2020
TRA-N-86	Interconnection Croatia/Slovenia (Lučko–Zabok–Rogatec)	Croatia	2021
TRA-N-382	Enhancement of Latvia–Lithuania interconnection (Latvian part)	Latvia	2021
TRA-N-66	Interconnection Croatia–Bosnia and Herzegovina (Slobodnica–Bosanski Brod)	Croatia	2020
TRA-N-302	Interconnection Croatia-Bosnia and Herzegovina (South)	Croatia	2021
TRA-N-283	3rd IP between Portugal and Spain (pipeline Celorico–Spanish border)	Portugal	2024
TRA-N-628	Eastring – Slovakia	Slovakia	2023
TRA-N-325	Slovenian–Hungarian interconnector	Hungary	2022

Table 3.1: Advanced projects with direct impact in the advanced infrastructure level

Advanced projects without a direct impact in the advanced infrastructure level

Code	Project name	Country	Project commis-sioning year First
LNG-N-296	Mugardos LNG Terminal: 2nd Jetty	Spain	2020
TRA-N-1057	Compressor stations 2 and 3 at the Croatian gas tranmission system	Croatia	2022
TRA-N-1267	Upgrade Sülstorf station	Germany	2019
TRA-N-139	Interconnection of the NTS with the DTS and reverse flow at Isaccea	Romania	2019
TRA-N-362	Development on the Romanian territory of the Southern Transmission Corridor	Romania	2020
TRA-N-500	L/H Conversion Belgium	Belgium	2022
TRA-N-809	Additional East-West transport	Germany	2020
TRA-N-814	Upgrade for IP Deutschneudorf et al. for More Capacity	Germany	2019
TRA-N-950	Guitiriz–Lugo–Zamora pipeline	Spain	2024
TRA-N-964	New NTS developments for taking over gas from the Black Sea shore	Romania	2019

Table 3.2: Advanced projects without a direct impact in the advanced infrastructure level

Note: The assessment of the Advanced infrastructure level focuses on the improvement achieved by commissioning of Advanced projects and their ability to mitigate the needs identified in the Low infrastructure level. When advanced projects mitigate infrastructure needs across all scenarios, the maps presented in the report show the improvement for scenarios where the needs are the most important.

3.1 SECURITY OF SUPPLY NEEDS

This section assesses the benefits from advanced projects in improving the resilience of the EU gas system to cope with various stressful events:

- Climatic stress
- Supply route disruptions
- Infrastructure disruptions

3.1.1 CLIMATIC STRESS

Peak day

2020 and 2025:

In Croatia, the risk of demand curtailment from 2025 onwards identified in the Low infrastructure level is mitigated in the advanced infrastructure level. This improved situation results from the planned commissioning of Krk LNG terminal in Croatia and the strengthened connection to Slovenia, which itself is better connected to other markets via Austria.

However, exposure of FYROM to demand curtailment in 2025 is not improved since no advanced project is increasing the entry capacity to FYROM. The remaining flexibility during high demand situations is significantly improved in Central and South-Eastern Europe.

2030 and 2040:

Europe is not exposed to any risk of demand curtailment in any scenario. The advanced projects fully mitigate the risk of demand curtailment except for FYROM. In Sustainable Transition scenario in 2040, FYROM mitigate the risk of a demand curtailment.

Furthermore, most of the countries of Central and North-East Europe see an increment in their remaining flexibility.

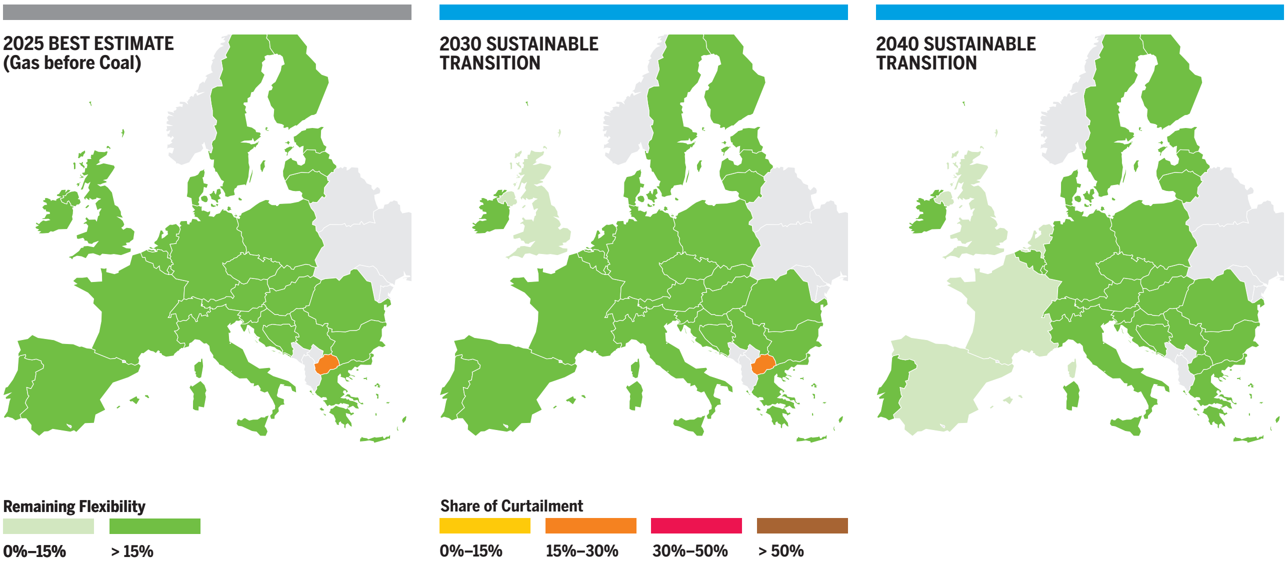

Figure 3.1: Climatic Stress for Peak Day

3.1.2 SUPPLY ROUTE DISRUPTIONS

This section investigates the impact of the advanced projects on the assessment of a supply route disruption during a high demand situation (climatic stress).

Ukraine Transit Disruption

Peak Day

Under Ukrainian transit route disruption, the Advanced projects improve the situation and fully mitigate the risk of demand curtailment in South-Eastern Europe from 2025 onwards in all scenarios, except for FYROM[9]. The new infrastructure linking South-East Europe to the Western markets and the new connections to LNG and new supply sources from the Black sea and the Caspian region have beneficial effects. Also, regarding Bulgaria, internal reinforcement and UGS Chiren expansion mitigate the demand curtailment from 2025.

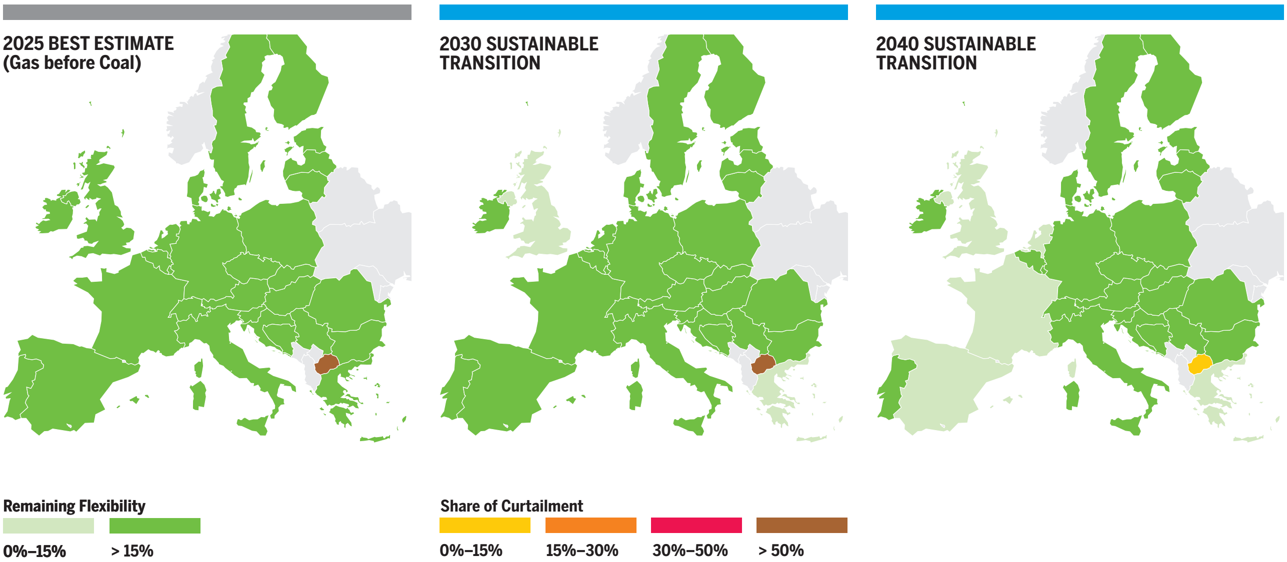

Figure 3.2:Ukraine Transit Disruption-Peak Day Belarus Transit Disruption

9) Although FYROM is exposed to demand curtailment in climatic stress conditions, it is additionally impacted by a Ukraine transit disruption.

Belarus Transit Disruption

This assessment considers the disruption of all gas imports via Belarus during climatic stress situations.

Peak day

Under Belarus disruption, the Advanced projects improve the situation and fully mitigate the risk of demand curtailment in Eastern Europe from 2025 onwards in all scenarios, except for FYROM1.

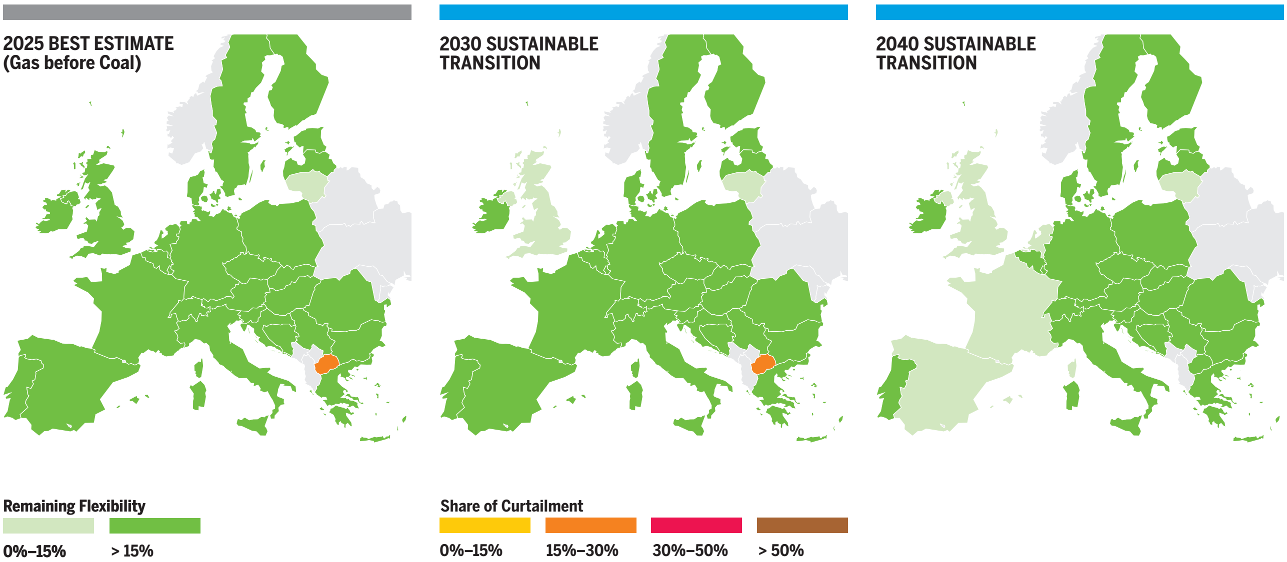

Figure 3.3: BELARUS Transit Disruption-Peak Day

Disruption of pipeline imports to the Baltic States and Finland

This assessment considers the disruption of all imports from Russia in Finland, Estonia and Latvia during climatic stress situations.

Peak Day

Under disruption of pipeline imports to the Baltic States and Finland, the advanced projects, mitigate the risk of demand curtailment in Estonia from 2025 onwards with the commissioning of Tallin LNG terminal. However, Finland is still exposed, but to a lesser extent, to demand curtailment as of 2020 as the interconnection capacity with Estonia faces some limitations. Furthermore, the exposure of Lithuania to a risk of demand curtailment in case of a peak day is fully mitigated with a limited risk of congestion of the interconnection Poland – Lithuania and Latvia – Lithuania in Distributed Generation scenario due to the increasing demand in Lithuania.

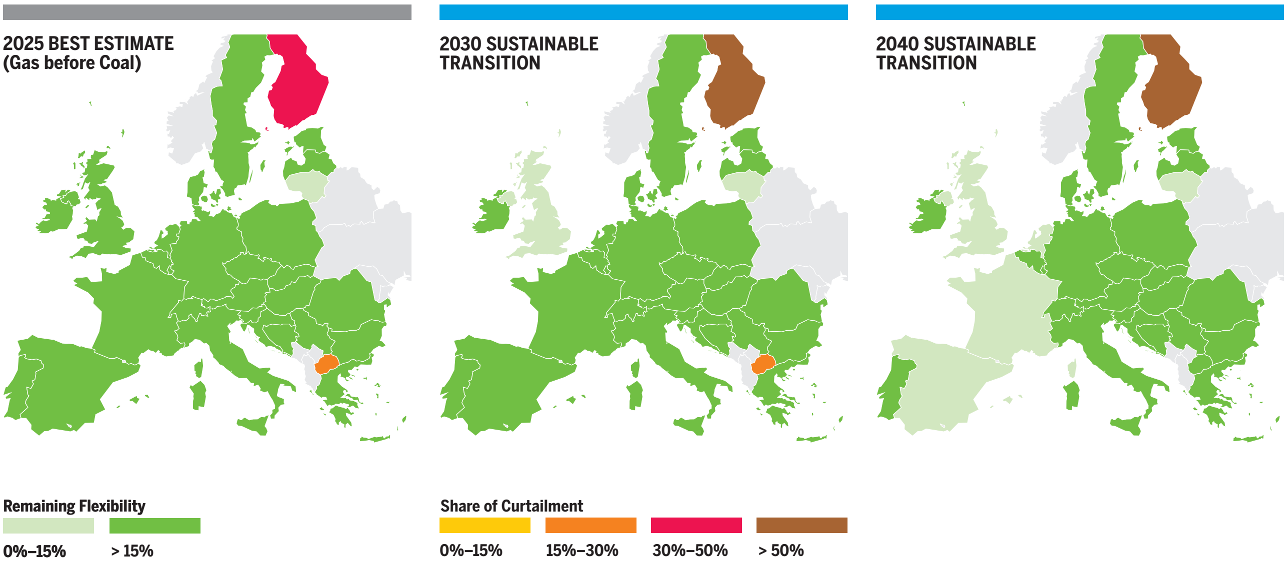

Figure 3.4: Disruption of pipeline imports to the Baltic States and Finland – Peak Day

Algerian Pipeline import routes Disruption

The simulation considers the disruption of all the imports pipelines from Algeria to the EU during climatic stress situations (peak day and 2-week cold spell). Import pipelines from Algeria:

1. MEG Pipeline
   between Algeria and Spain
2. MEDGAZ Pipeline
   between Algeria and Spain
3. TRANSMED Pipeline
   between Algeria and Italy

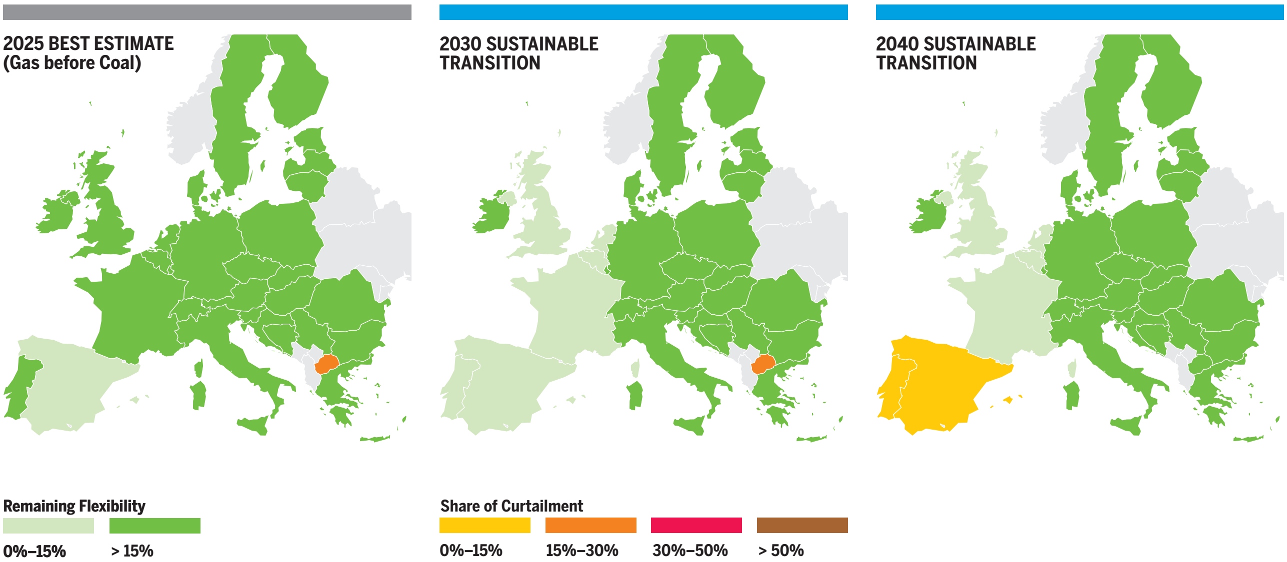

Figure 3.5: Algerian Pipeline import routes Disruption – Peak Day

Peak day

Under Algerian pipe disruption in 2030, the advanced projects mitigate the risk of the demand curtailment in Spain and Portugal.

However, in 2040 in Sustainable Transition scenario, the advanced projects cannot fully mitigate the risk of demand curtailment.

Even if the risk remains limited, the Peak Demand increase in the Iberian Peninsula (+40 % compared to 2020) combined with a locally limited level of penetration of renewable gases production, deteriorates the situation between 2030 and 2040 in case of disruption of pipeline imports from Algeria.

3.1.3 SINGLE LARGEST INFRASTRUCTURE DISRUPTION (SLID)

Advanced projects allow Europe to access to alternative supply routes and sources.

Northern Europe

The Tallin Terminal project allow Estonia to mitigate the risk of demand curtailment in Estonia from 2025 onwards (Curtailment rate = 0 %) but not in Finland because of the infrastructure limitation of the Baltic Interconnector. Finland is still exposed to a risk of demand curtailment with a curtailment rate at 40 % to 60 %.

In 2040 Sustainable Transition scenario, interconnections between Poland with neighbouring countries mitigates the risk of demand curtailment for Both Poland and Lithuania.

Sweden is no more exposed to a risk of demand curtailment with the Terminal project Gothenburg and exposure of Denmark is also mitigated with the commissioning of the Baltic Pipe reinforcement towards its National Production.

The Terminal project in Ireland partially mitigates the risk of demand curtailment and the limited exposure of UK and Ireland in case of disruption of UK Single-Largest Infrastructure is not significantly improved by the advanced projects.

Eastern Europe have a large number of projects that either mitigate the risk in the event of SLID from 2025 onwards or significantly reduce it:

- Croatia with Terminal project Krk
- Romania with National Production which nevertheless decreases from 2030 onwards and Romania is getting gas from Ukraine via Transbalkan
- Slovenia with new interconnection projects (Croatia and Austria)
- Greece and FYROM from 2025 onwards with notably the terminal project Alexandroupolis
- Serbia with new interconnection project with Croatia.
- In case of Slovakia SLID Europe is no longer exposed to Demand Curtailment.
- Bosnia does not improve its situation for all scenarios and years.

Western Europe

Advanced projects fully mitigate the risk of demand curtailment in case of SLID of Spain. Spain has still a risk of demand curtailment in 2040 in Sustainable Transition scenario. Portugal presents the same risks of demand curtailment (the projects are incomplete and do not mitigate the risks).

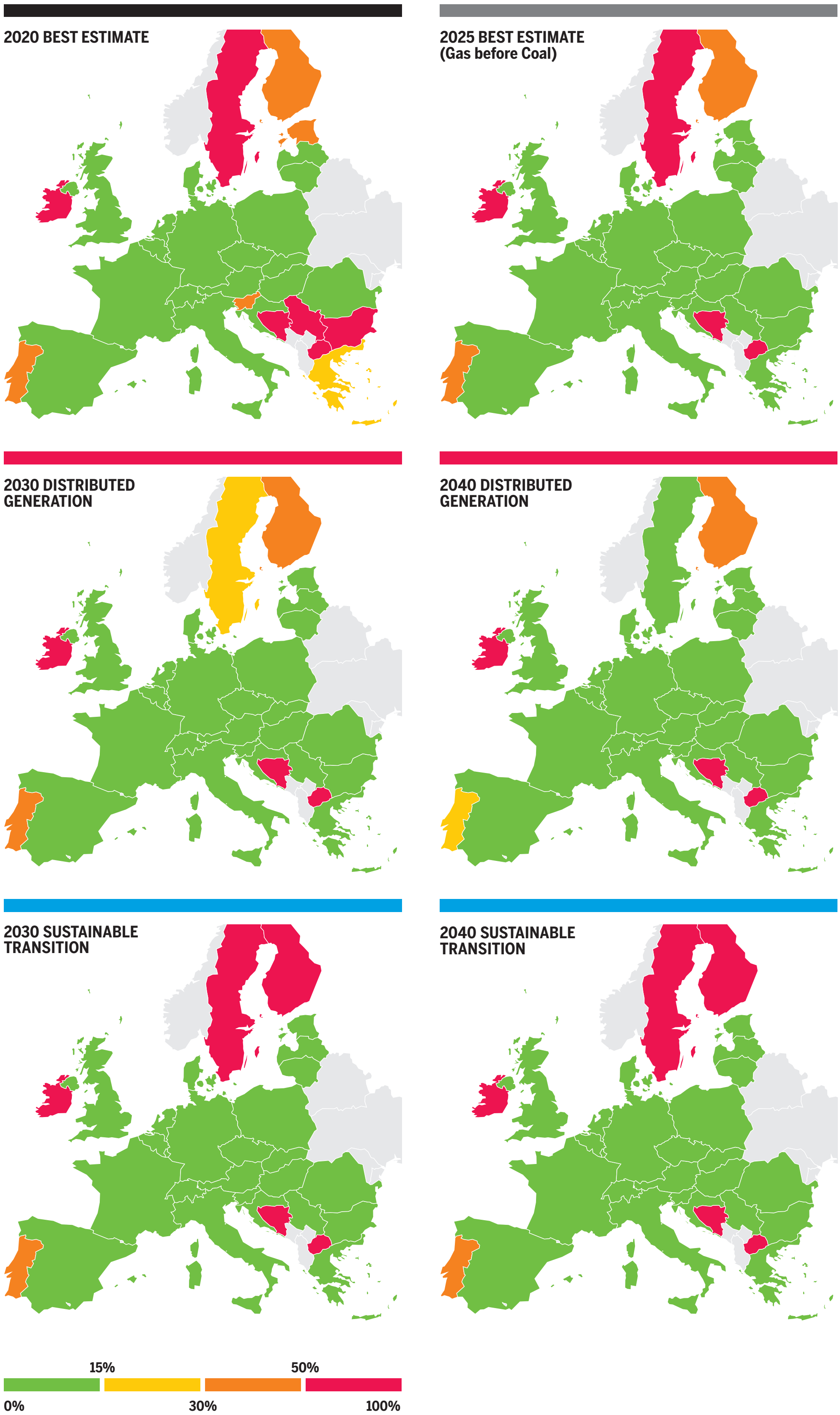

Figure 3.6: Maximum exposure to demand curtailment in case of disruption of a Single Largest Infrastructure

3.2 COMPETITION NEEDS

3.2.1 SUPPLY SOURCES ACCESS

Already from 2025, the commissioning of advanced projects (Tallin LNG terminal, Latvia-Lithuania interconnection and Inčukalns UGS) allows the Baltic States and Finland to access at least 3 supply sources from a market perspective.

2020 and 2025:

The diversification of the Iberian Peninsula is similar in the Advanced infrastructure level, with a temporary improvement in 2030 in Distributed Generation scenario and an access to 4 sources in the long term in 2040 in Global Climate Action scenario.

2030 and 2040:

In Greece, the advanced projects connect Greece to Italy and increase the capacity to Bulgaria. As a result, more European countries can physically access Azeri and Turkmen gas. However, the consequence is that, whilst more European countries can benefit from a decrease in Azeri/Turkmen price, Greece can less benefit from it and therefore the SSDi indicator for Azeri gas cannot reach the 20 % threshold in Greece in the advanced infrastructure level.

In 2030, comparing the situation of Advanced infrastructure level with Low, the situation improves especially in 2030 Sustainable Transition for France, Switzerland and marginally for Spain in 2030 (Distributed Generation) due to enhancement in the interconnection in the area that improves the access to Algerian and Norwegian supply in these countries.

Concerning Romania, the situation is improved by the increment in the interconnection between Romania and Bulgaria and between Romania and Hungary.

In the longer term in 2040, the situation is improved for most part of Europe, especially in Finland and Romania, and most countries can access 3 or more sources in all scenarios. Spain and Portugal can also benefit from the advanced projects in Global Climate Action scenario, but not in Distributed Generation and Sustainable Transition.

Picture courtesy of TAP

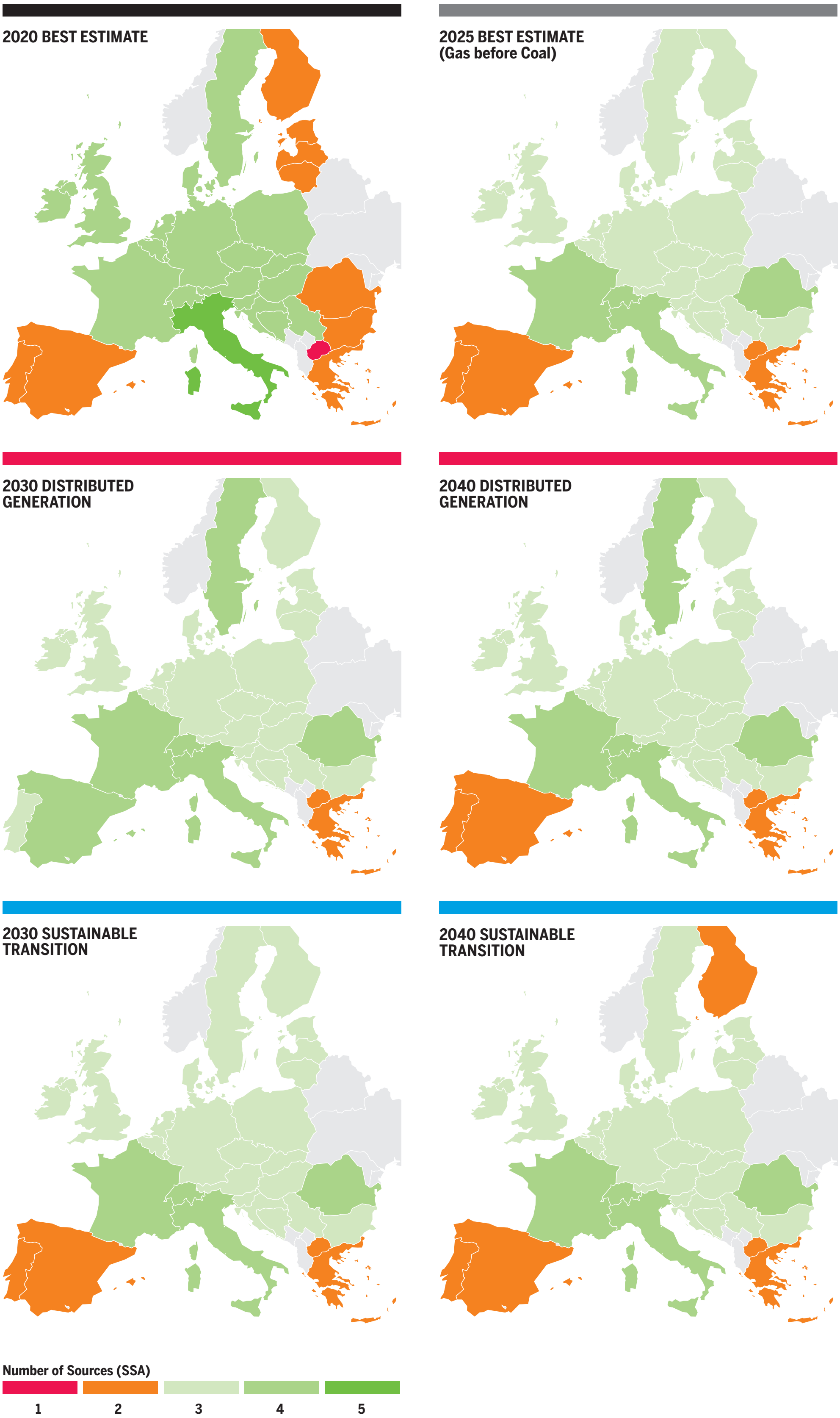

Figure 3.7: Number of supply source per country

The following graphs inform in more detail the situation across Europe for the different SSDi per country.

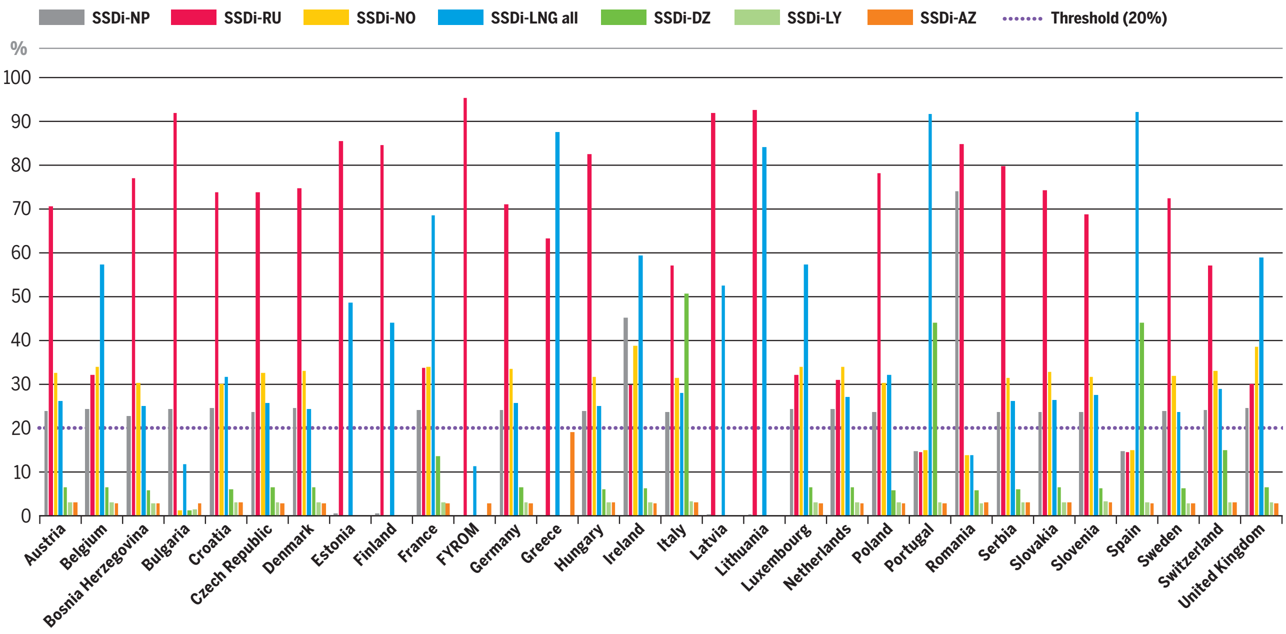

Figure 3.8: Best Estimate 2020 – SSDI indicator by country

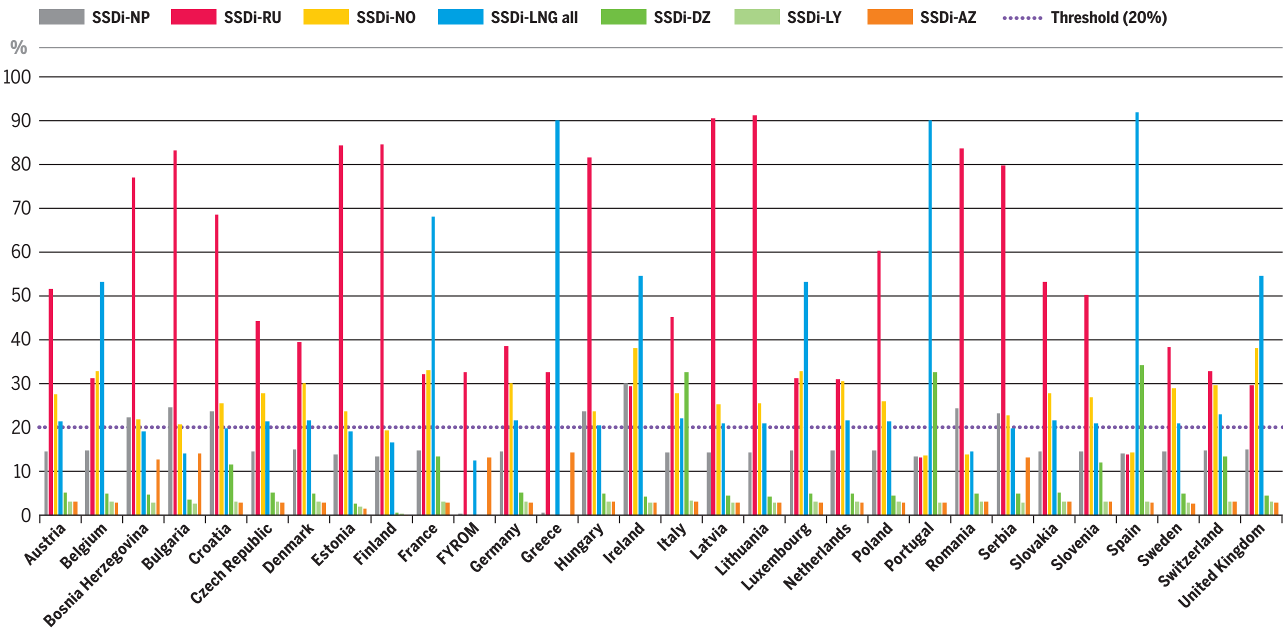

Figure 3.9: Best Estimate (Gas before Coal) 2025 – SSDI indicator by country

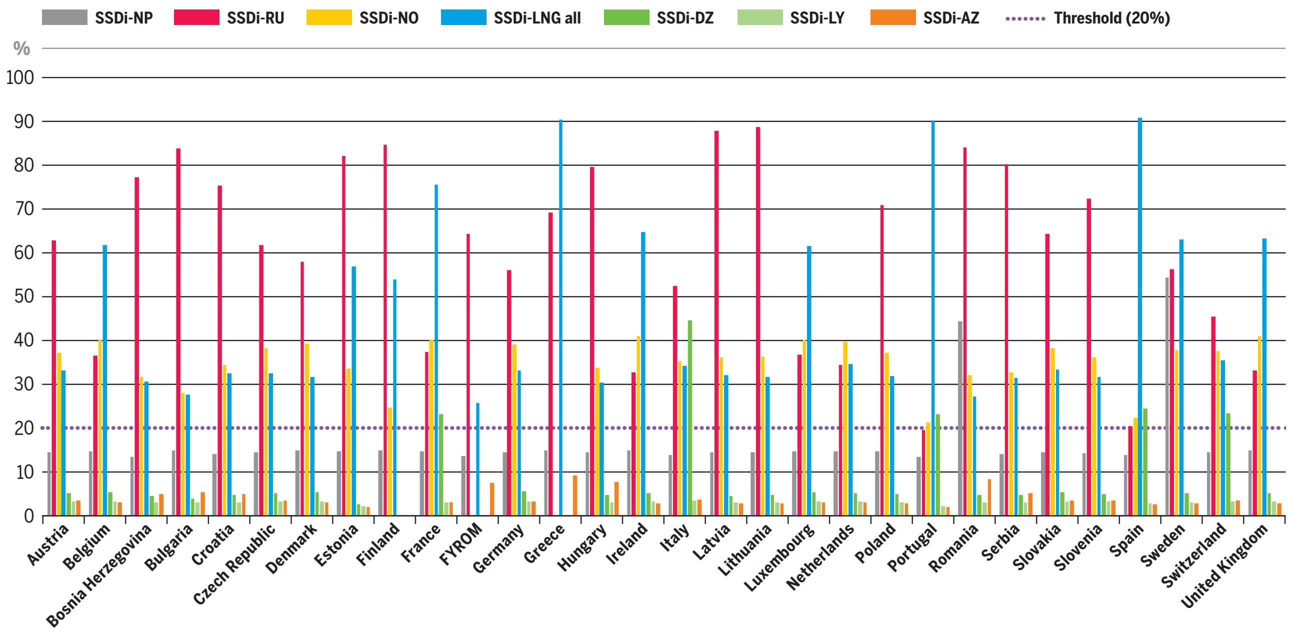

Figure 3.10: Distributed Generation 2030 - SSDI indicator by country

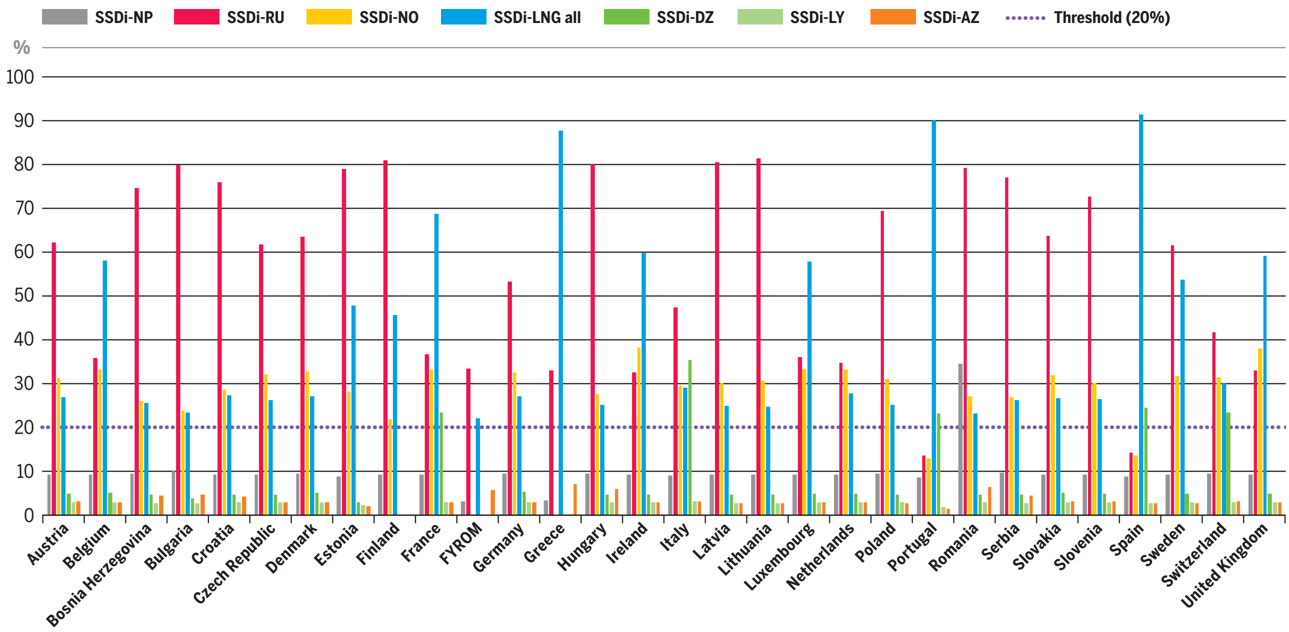

Figure 3.11: Sustainable Transition Scenario 2030 - SSDI indicator by country

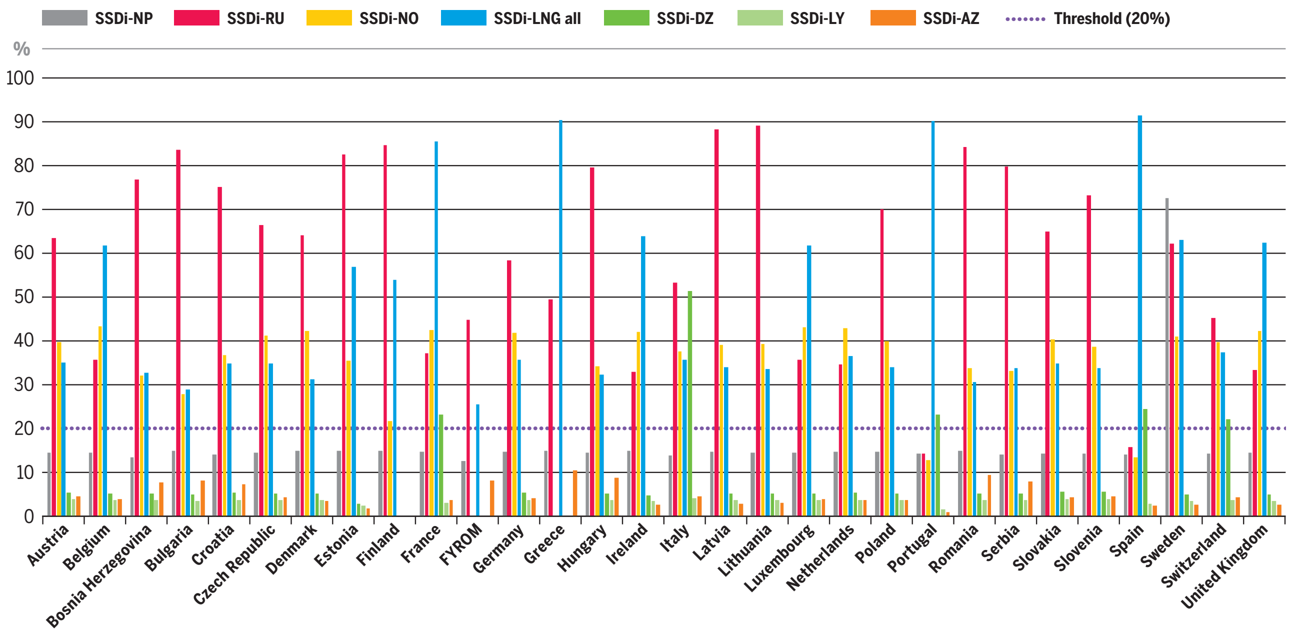

Figure 3.12: Distributed Generation 2040 – SSDI indicator by country

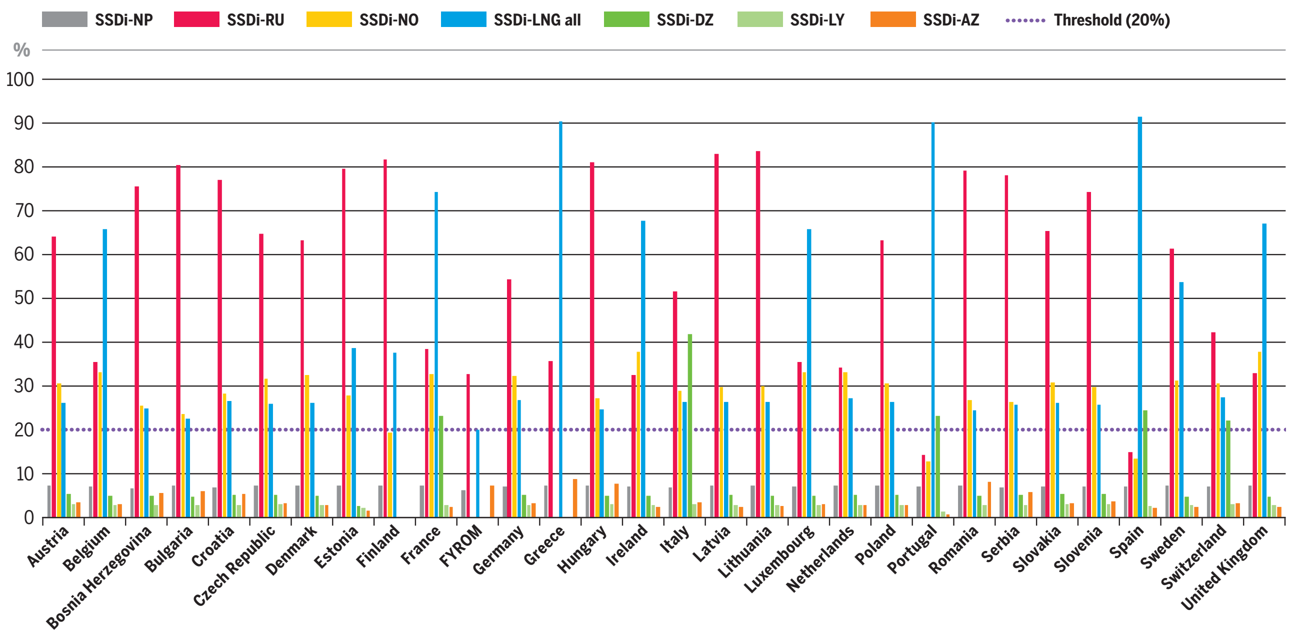

Figure 3.13: Sustainable Transition Scenario 2040 - SSDI indicator by country

3.2.2 SUPPLY SOURCE DEPENDENCE (SSD)

Russian Supply

By 2020, the advanced projects enable the countries of South-Eastern Europe to significantly reduce their dependence on Russian gas and to share the same levels of dependence as their neighbours, except for Bulgaria and FYROM, which remain with an equivalent dependence.

For most scenarios, as of 2025, all EU countries are significantly reducing their dependency (SSD < 2 % in 2030 and 0 in 2040).

It should be noted that countries of North-Eastern Europe (Finland, Estonia, Lithuania, Latvia) also show no dependence in 2040 after a significant decrease in 2030 following the commissioning of advanced projects in the region.

In Sustainable Transition scenario, the dependence decreases strongly and stabilises at most around 20 % for the most dependent countries.

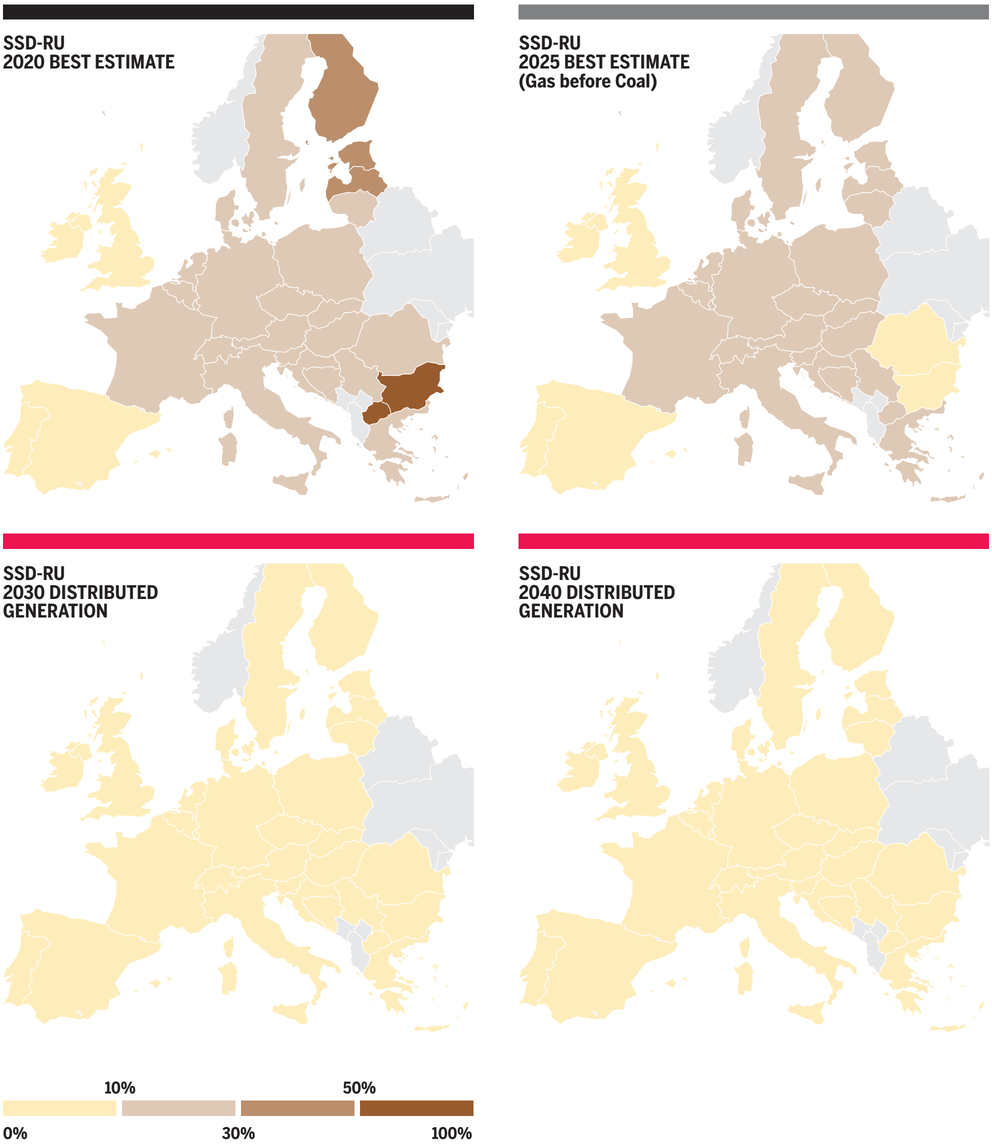

Figure 3.14: SSD RUSSIA – Scenarios and years

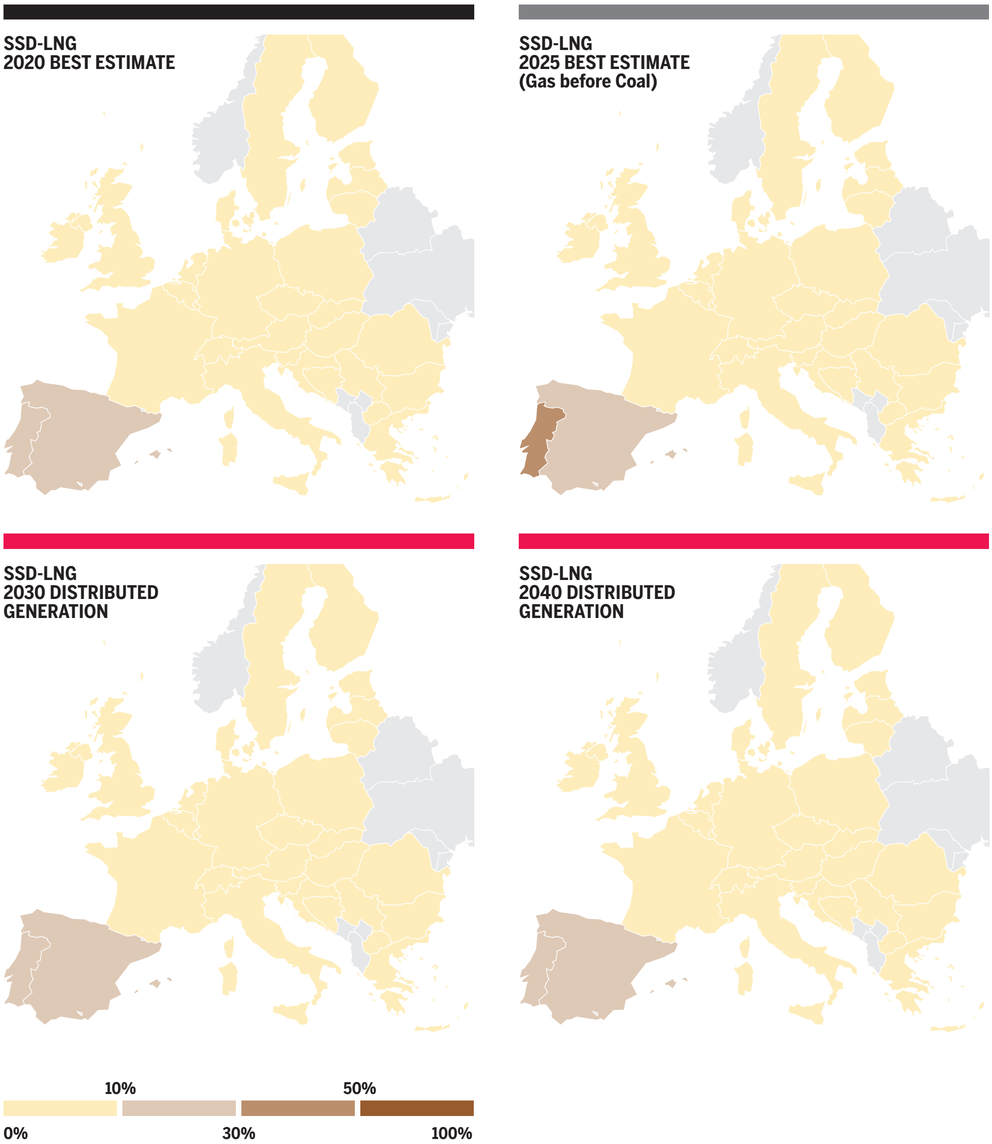

Figure 3.15: SSD LNG – All scenarios and years

Global LNG supply

In the advanced infrastructure level, results show a significant decrease of the market dependence of the Iberian Peninsula to the global LNG supply.

3.2.3 LNG AND INTERCONNECTION CAPACITY DIVERSIFICATION – LICD

The results compared to the Low infrastructure level show that most European countries are improving their diversification. The most significant developments are Bulgaria, Croatia, Czech Republic Ireland, Slovenia, Sweden and Switzerland. Nevertheless, some countries with little diversification remain stable (Bosnia, Finland, United Kingdom, Spain, Portugal).

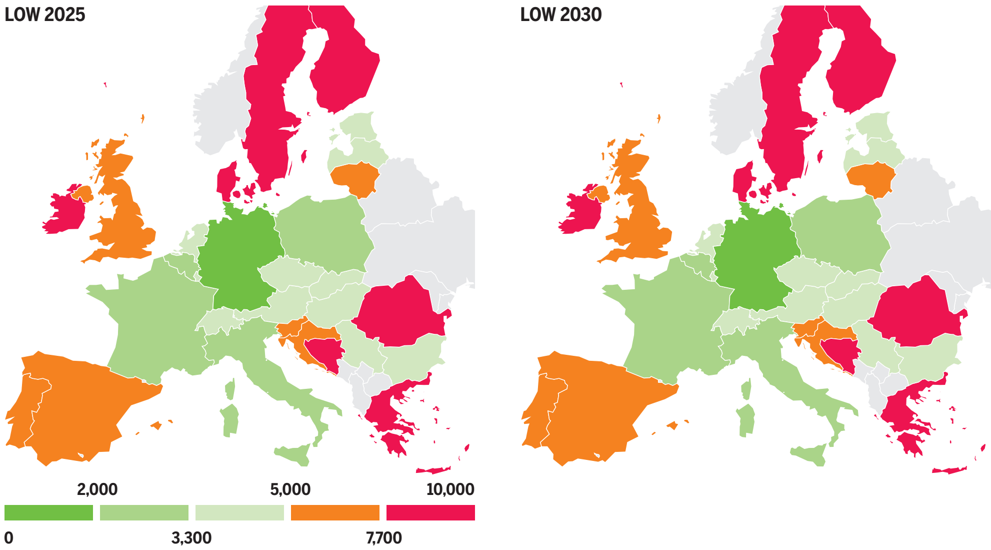

Figure 3.16: LNG and Interconnection Capacity Diversification – LOW infrastructure level

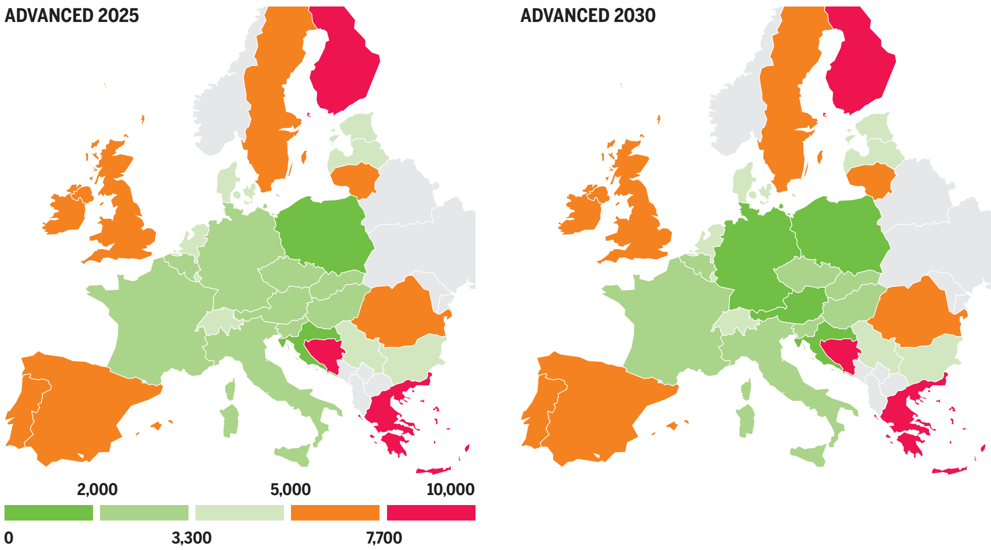

Figure 3.17: LNG and Interconnection Capacity Diversification – Advanced infrastructure level

3.3 MARKET INTEGRATION BENEFITS

3.3.1 MARGINAL PRICE

Reference case:

In Reference case, the advanced level is improving price convergence for all scenarios, especially in South-Eastern European countries (Croatia, Greece, Bulgaria, Romania) and in South-West (Italy).

Picture courtesy of FGSZ

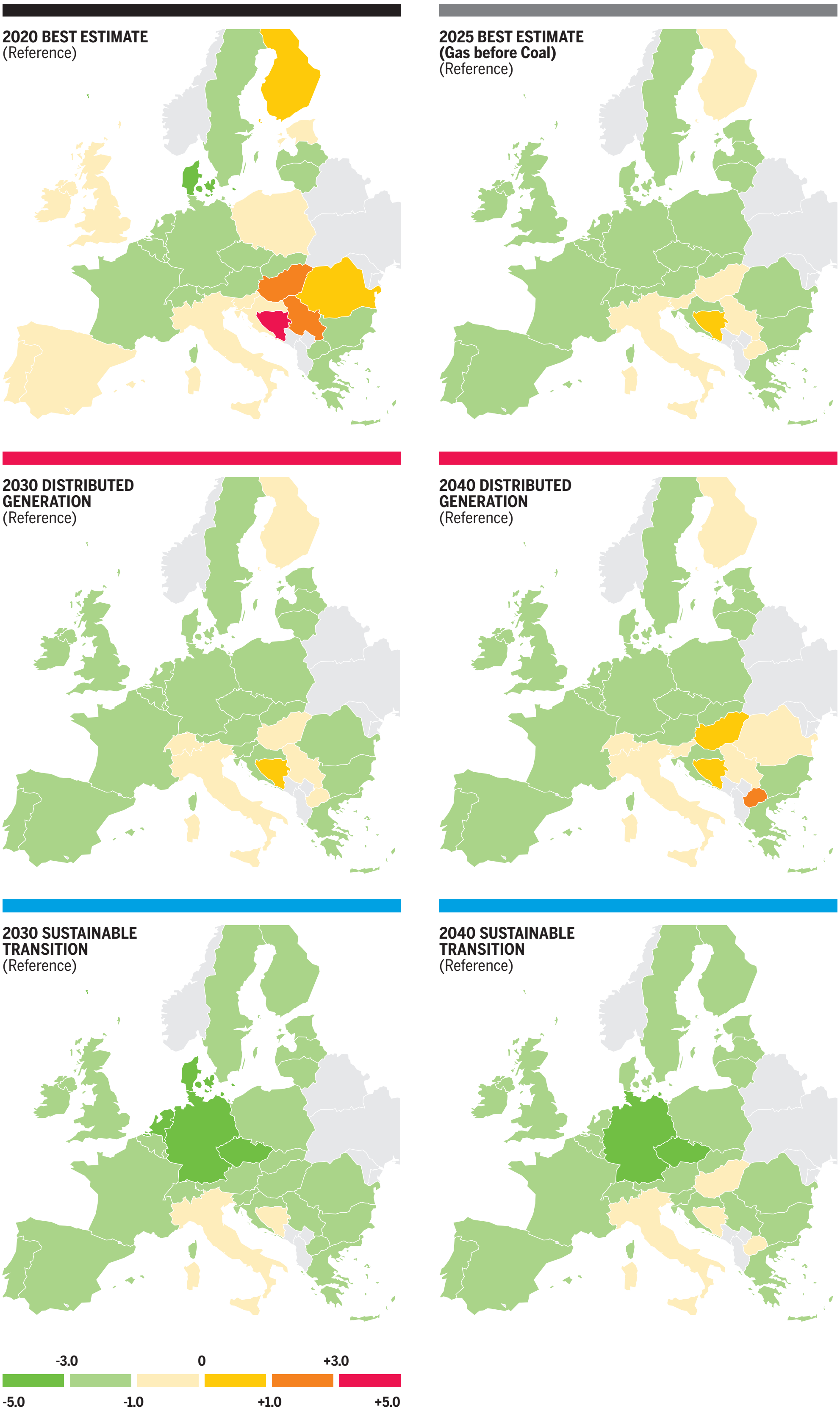

Figure 3.18: Marginal Price – Reference case – Advanced Infrastructure level

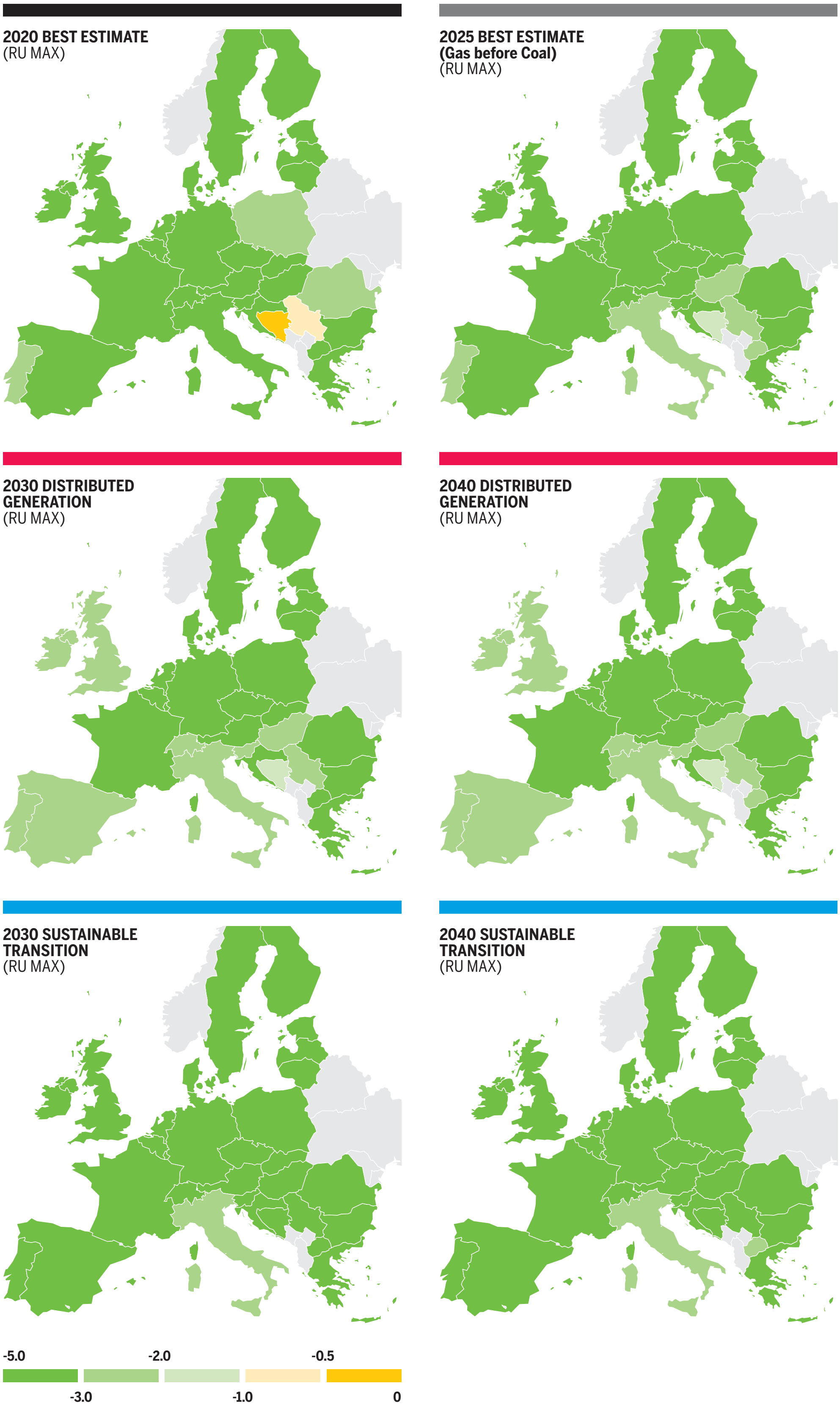

Figure 3.19: Marginal Price – Russian Maximisation – Advanced infrastructure level

Marginal prices in Price configuration "RU Max":

The advanced infrastructure level allows Western and South-Eastern countries to benefit of attractive prices on the same basis as countries directly supplied by Russia.

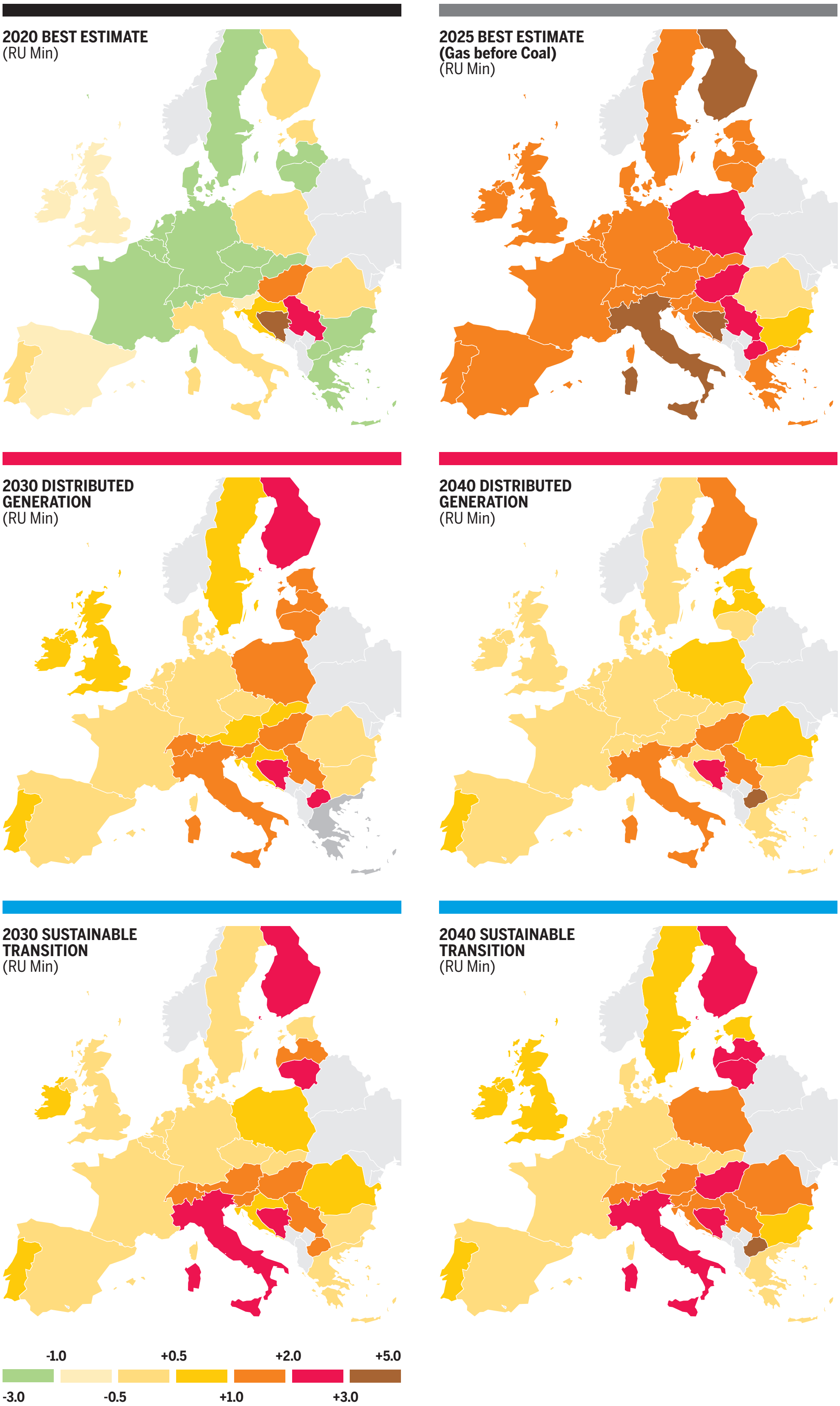

Figure 3.20: Marginal Price – Russian Minimisation – Advanced Infrastructure level

Marginal prices in Price configuration "RU Min":

Advanced projects generally increase the ability of European countries to decrease their dependence towards Russian gas. All European countries are therefore improving their situation in case of a high Russian gas price, and a better marginal price convergence is observed. However, the impact is more limited for those countries directly connected to the Russian imports.

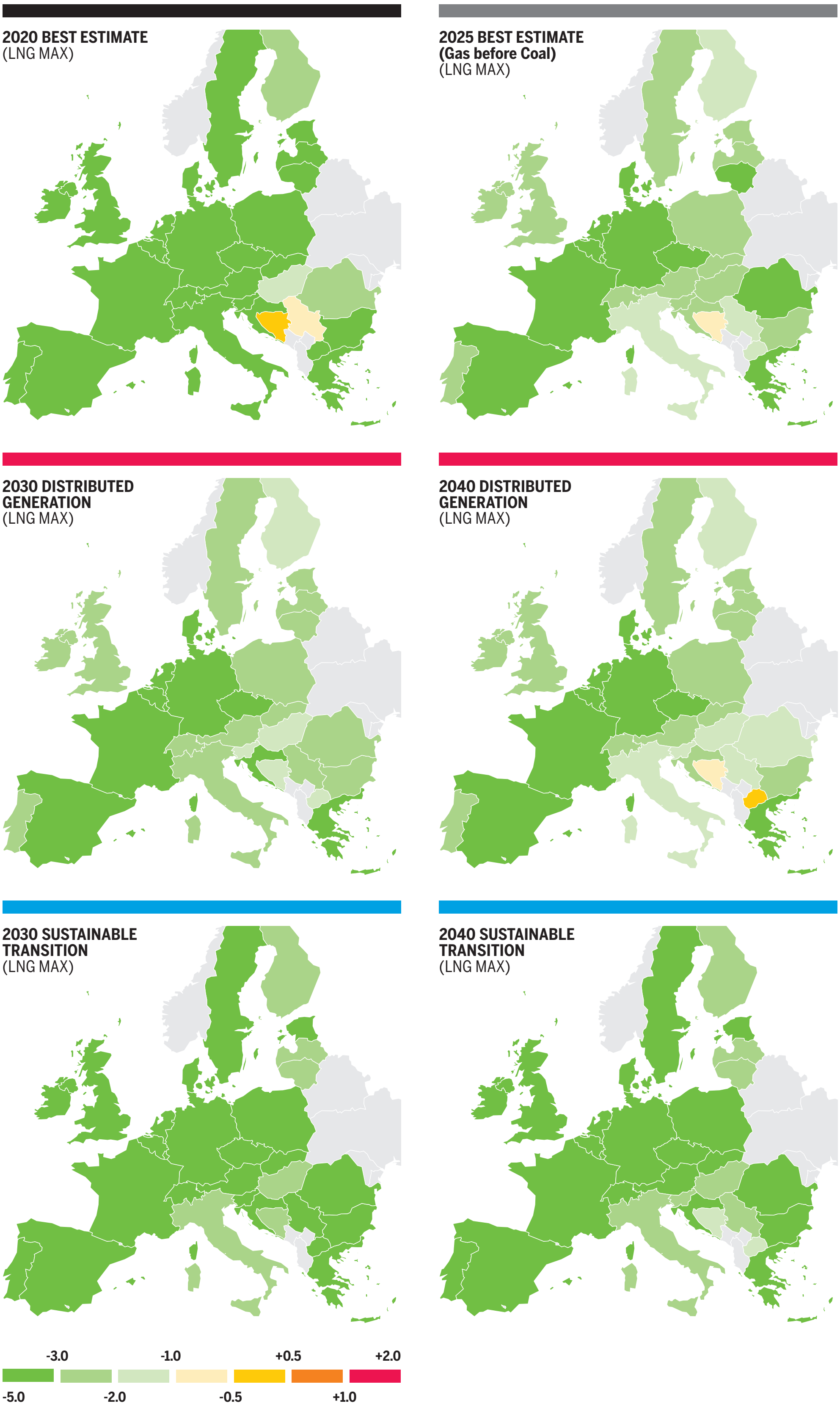

Figure 3.21: Marginal Price – LNG Maximisation – Advanced Infrastructure level

Marginal prices in Price configuration "LNG Max":

With the consideration of Advanced LNG terminal projects, many countries and neighbouring countries directly benefit from attractive LNG prices (South-East, Baltics and North-East countries). Price convergence is observed for all scenarios.

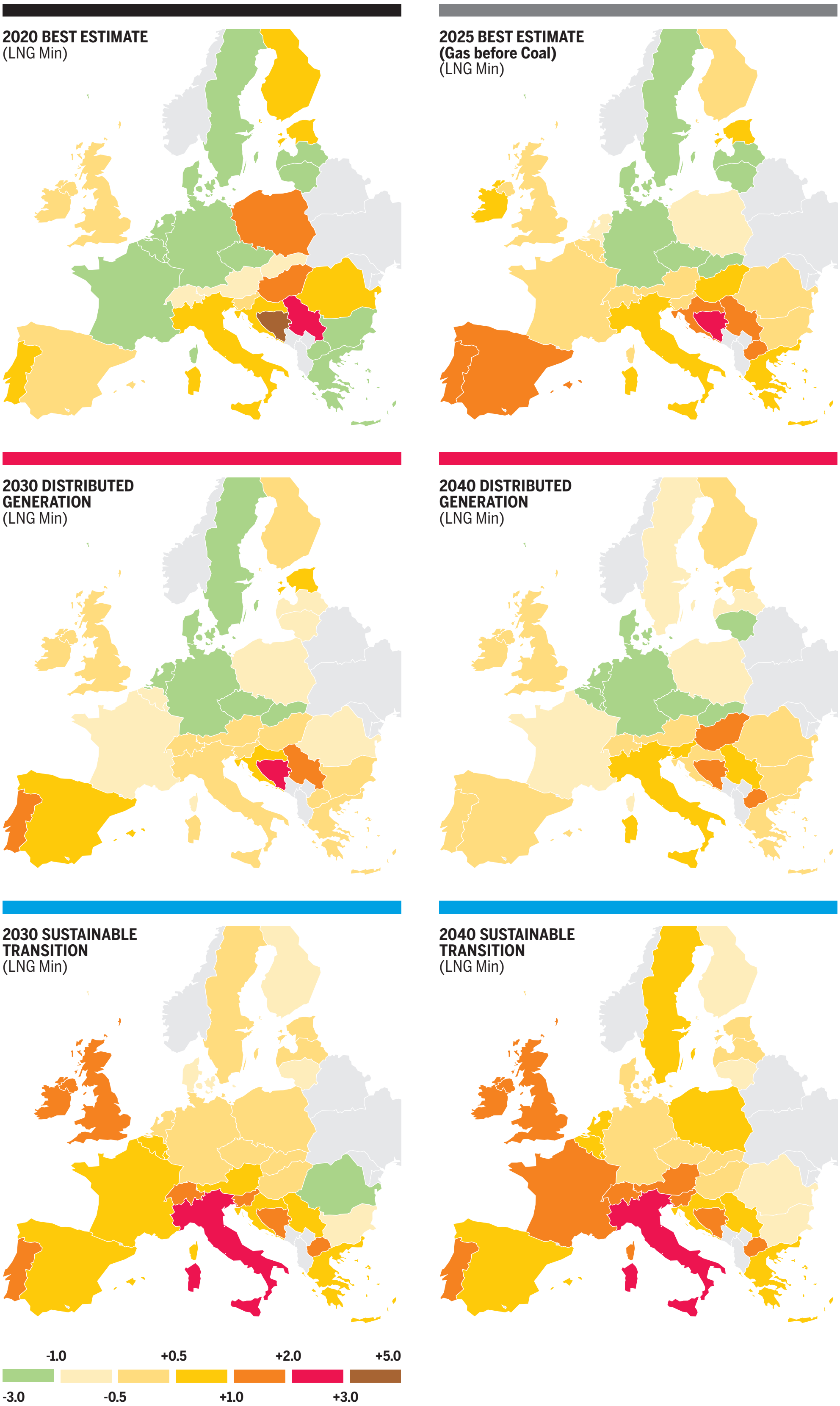

Figure 3.22: Marginal Price – LNG Minimisation– Advanced Infrastructure level

Marginal prices in Price configuration "LNG Min":

A high LNG price can influence the marginal price in most of Europe with a more limited impact than in the low infrastructure level due to the advanced infrastructure projects which facilitate the North-South and East-West flows.

3.4 CONCLUSION ON THE ASSESSMENT ADVANCED PROJECTS

The advanced projects prove efficient in terms of improving security of supply, diversification and competition.

In terms of security of supply advanced projects provide the following benefits:

- Croatia is no longer exposed to demand curtailment in case of peak demand, including on the long-run.
- Bulgaria and Romania are totally protected
- The Baltic States and Poland improve their resilience in case of short-term route disruptions.
- South-Eastern countries fully mitigate the risk of demand curtailment from 2025 onwards, except for FYROM, in case of short-term Ukrainian route disruption.
- Many countries reduce or mitigate their exposure to a risk of demand curtailment in case of disruption of their single largest infrastructure.

The advanced projects additionally deliver in terms of improving competition, by increasing route and supply diversification and consequently lifting local high dependence to specific supply sources. In particular, the Baltic States and Finland are connected to the main EU gas grid and can access three supply sources, decreasing their dependence to Russian gas.

Finally, the advanced projects, by improving competition and market integration, prevent a large number of Eastern European countries to be subject to monopolistic supply behaviour.

The overall investment costs for all advanced projects represent 27 Bn€. The actual costs of achieving the above listed benefits would certainly be much lower as some advanced projects potentially compete in terms of delivering security of supply, competition and market integration to the areas in need.

Even with the materialisation of advanced projects, some needs would still not be covered:

- In FYROM, Bosnia and Herzegovina the SLID remains close 100 % on the long run.
- Finland, Lithuania, Ireland, Portugal, Romania, Serbia and Sweden improve their situation but not totally (Security Of Supply, Market).


Picture courtesy of Fluxys Belgium | David Samyn

4 IMPACT OF THE PROJECTS ON **THE THIRD PCI LIST**

This section focuses on the benefits of 3rd PCI list projects without a FID status yet, independently from their advancement status. The identification of infrastructure gaps in the Low infrastructure level (section 6.3) forms the basis for this impact assessment.

The relevant projects for this infrastructure level can be found in Annex A, the relevant capacities in Annex C.

As a general result, the implementation of all projects in the 3rd PCI list would be a significant contribution in strengthening the European gas infrastructure.

These results cannot be directly compared to those of the advanced infrastructure level as on one hand a number of advanced projects are not part of the 3rd PCI list, and on the other hand a number of 3rd PCI list projects do not have an advanced status.

4.1 SECURITY OF SUPPLY NEEDS

4.1.1 CLIMATIC STRESS

The climatic stress without disruption shows a risk of demand curtailment only for FY-ROM in some scenarios: in 2025 for Best Estimate (coal before Coal) and in 2030 for Sustainable Transition.

4.1.2 SUPPLY ROUTE DISRUPTIONS

This section investigates the additional impact of a supply route disruption during a high demand situation (climatic stress) and the benefits that PCI projects provide in that situations.

Ukraine Transit Disruption

Peak Day

For the Ukrainian transit route disruption, PCI projects fully mitigated the risk of demand curtailment for Europe from 2025 onwards except for FYROM[10].

The new infrastructure linking South-East Europe to the Western markets and the new connections to LNG in that region have beneficial effects. Also, regarding to Bulgaria, the commissioning of the Bulgarian projects and Interconnection Greece Bulgaria projects, that increment the entry capacity and mitigate the demand curtailment from 2025 awards.

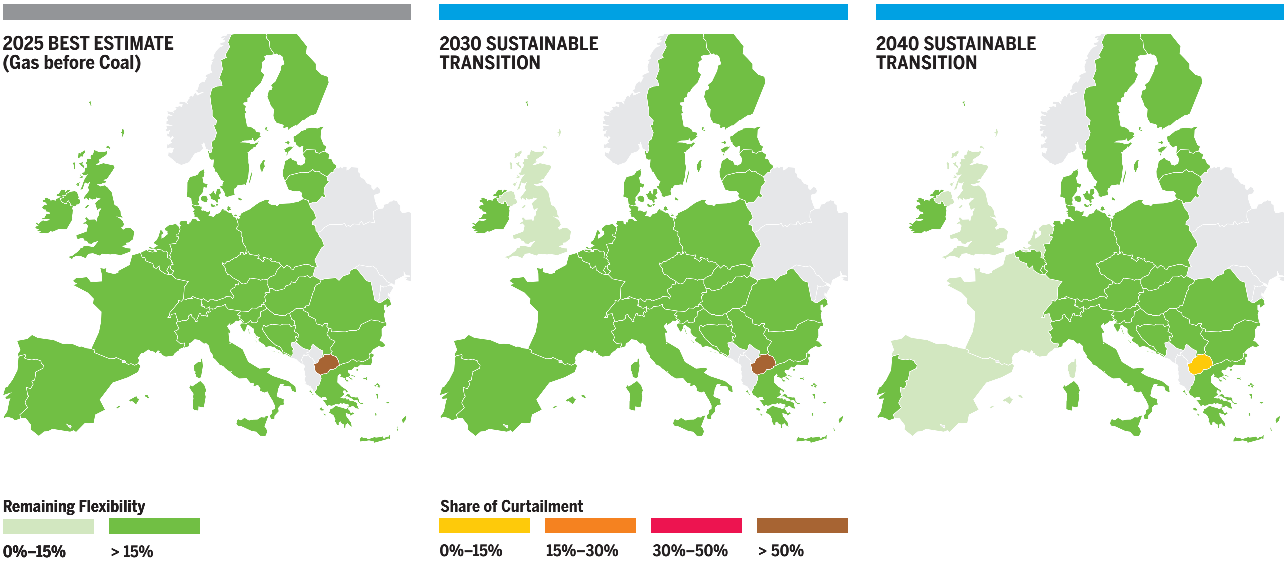

Figure 4.1: Ukraine Transit Disruption-Peak Day

10) Although FYROM are exposed to demand curtailment in climatic stress conditions, it is additionally impacted by a Ukraine transit disruption, specially in 2040 Global Climate Change and Sustainable Transition because without disruption FYROM don't show any curtailment.

Belarus Transit Disruption

Peak Day

Under a Belarus transit disruption, the PCI projects, fully mitigate the risk of demand curtailment for Poland and Lithuania in 2030 and 2040. However, in 2040, Northern Europe countries show a low remaining flexibility due to the cooperation between countries like in the low infrastructure level.

Concerning Lithuania, the demand curtailment is completely mitigated in all scenarios except in 2040 Sustainable Transition due to the commissioning of the enhancement of Latvia-Lithuania interconnection. Therefore, the situation improves from low infrastructure level.

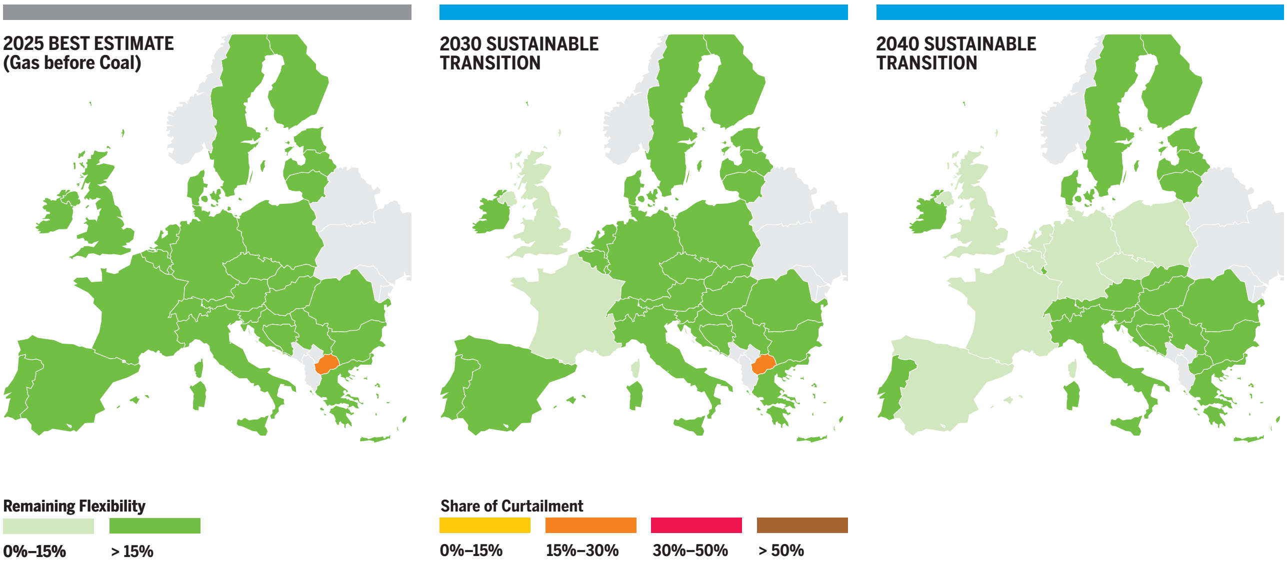

Figure 4.2: BELARUS Transit Disruption-Peak Day

Disruption of pipeline imports to the Baltic States and Finland

Peak Day

Under disruption of all imports to the Baltic States and Finland, results show that, in the PCI infrastructure level, Finland and Estonia continue to be exposed to a high risk of demand curtailment (CR > 50 %) from 2020 onwards.

However, from 2025 onwards, PCI projects improve the situation in Lithuania for all scenarios.

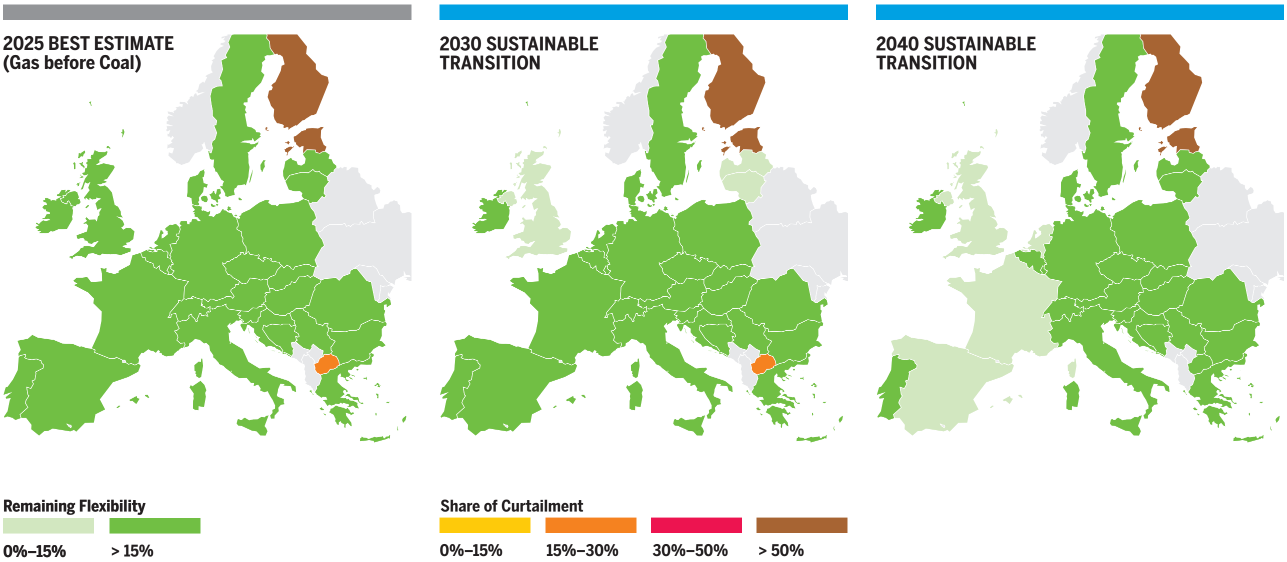

Figure 4.3: Disruption of pipeline imports to the Baltic States and Finland -Peak Day

Algerian Pipeline import routes Disruption

The situation is improving in all the years and scenarios for the Iberian Peninsula with a low risk of demand curtailment in 2025 and 2030 (below 5 %). In Sustainable Transition scenario in 2040, with an increasing peak demand in Spain (+40 % compared to 2020), the risk is partially mitigated down to 15 % compared to 20 % in the low infrastructure level. For Portugal the situation is also partially mitigated with a risk of demand curtailment down to 15 % compared to 20 % in the low infrastructure level.

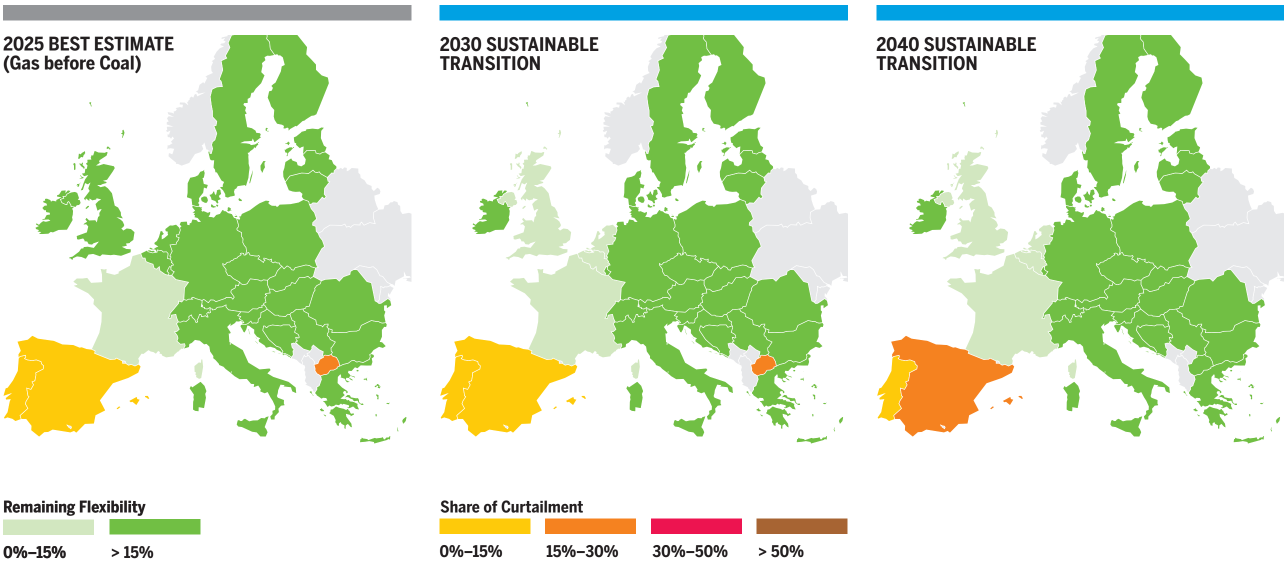

Figure 4.4: Algerian Pipeline import routes Disruption – Peak Day

4.1.3 SINGLE LARGEST INFRASTRUCTURE DISRUPTION (SLID)

Northern Europe

In 2040 Sustainable Transition scenario, interconnections between Poland and Czech Republic mitigates the risk of demand curtailment for Both Poland and Lithuania.

Sweden is no more exposed to a risk of demand curtailment with the commissioning of the LNG terminal project Gothenburg and for Denmark the risk is mitigated with the commissioning of the Baltic Pipe reinforcement towards its National Production.

SLID impact on Finland and Estonia is not improved in the PCI infrastructure level.

The LNG terminal project in Ireland partially mitigates the risk of demand curtailment and the situation is unchanged in UK.

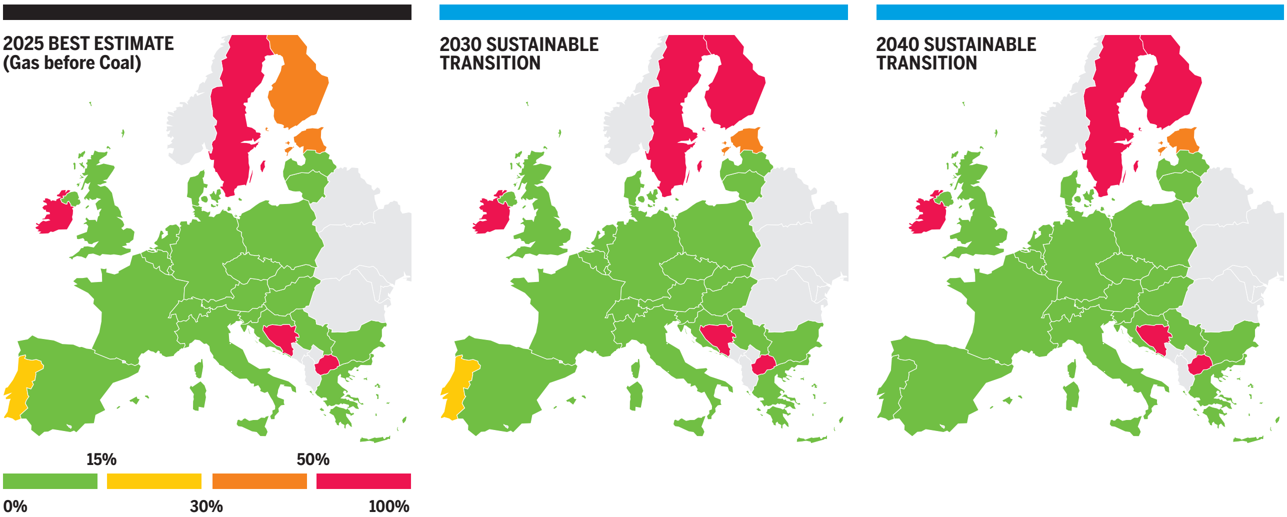

Figure 4.5: Maximum exposure to demand curtailment in case of disruption of a Single Largest Infrastructure

South-Eastern Europe

Projects from the 3rd PCI list either mitigate the risk in the event of SLI from 2025 onwards or significantly reduce it:

- Croatia with Terminal project Krk
- Serbia with new interconnection project with Croatia.
- Romania with interconnections projects with neighbour countries and the National Production which nevertheless decreases from 2030 onwards
- Slovenia with new interconnexions projects
- Greece and FYROM from 2025 onwards with the terminal project Alexandroupolis
- In case of Slovakia SLID Europe is no longer exposed to Demand Curtailment.

All those projects are also part of the Advanced infrastructure level.

Western Europe

PCI projects fully mitigate the risk of demand curtailment in case of SLID in the Iberian Peninsula in all scenarios specially for Portugal from 45 % in 2020 to 20 % in 2025, to 25 % in 2030 and to less than 10 % in 2040. Spain has only a risk of demand curtailment in 2040 in Sustainable Transition scenario.

4.2 COMPETITION NEEDS

4.2.1 SUPPLY SOURCES ACCESS

Already from 2020 the access to supply sources in the PCI infrastructure level is improved in South-Eastern Europe for all years and in all scenarios.

On the longer run, the situation in Finland continues showing an infrastructure limitation and only count with one source.

The 3rd PCI list projects improve temporarily the access of the Iberian Peninsula to additional supplies in 2030 in Distributed Generation scenario, but the effect is not visible in 2040.

Figures 4.7 to 4.9 inform in more detail the situation across Europe for the different SSDi per country.

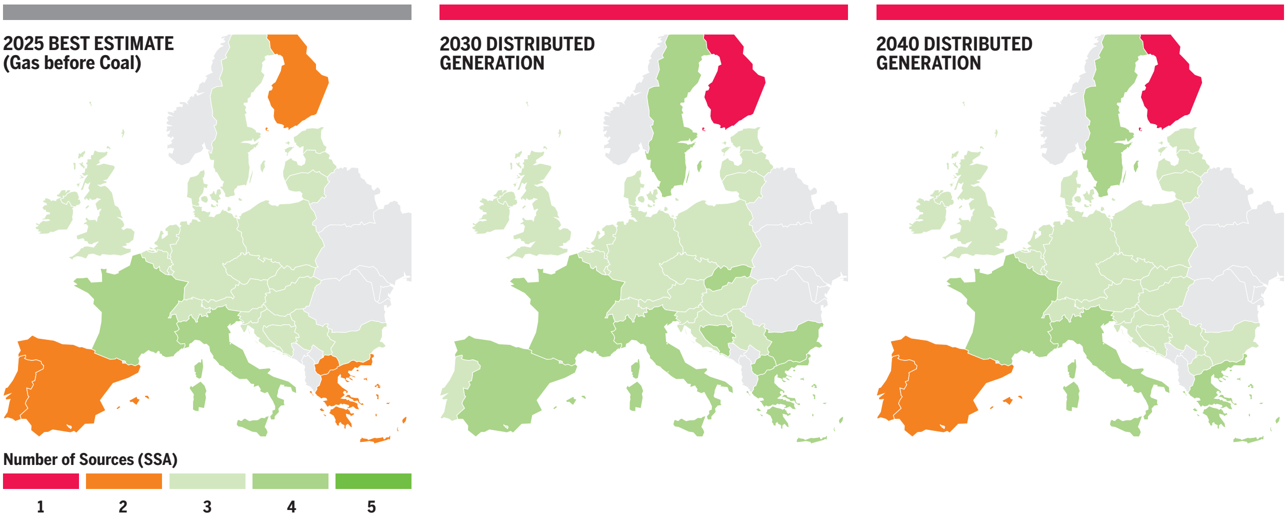

Figure 4.6: Number of supply source per country

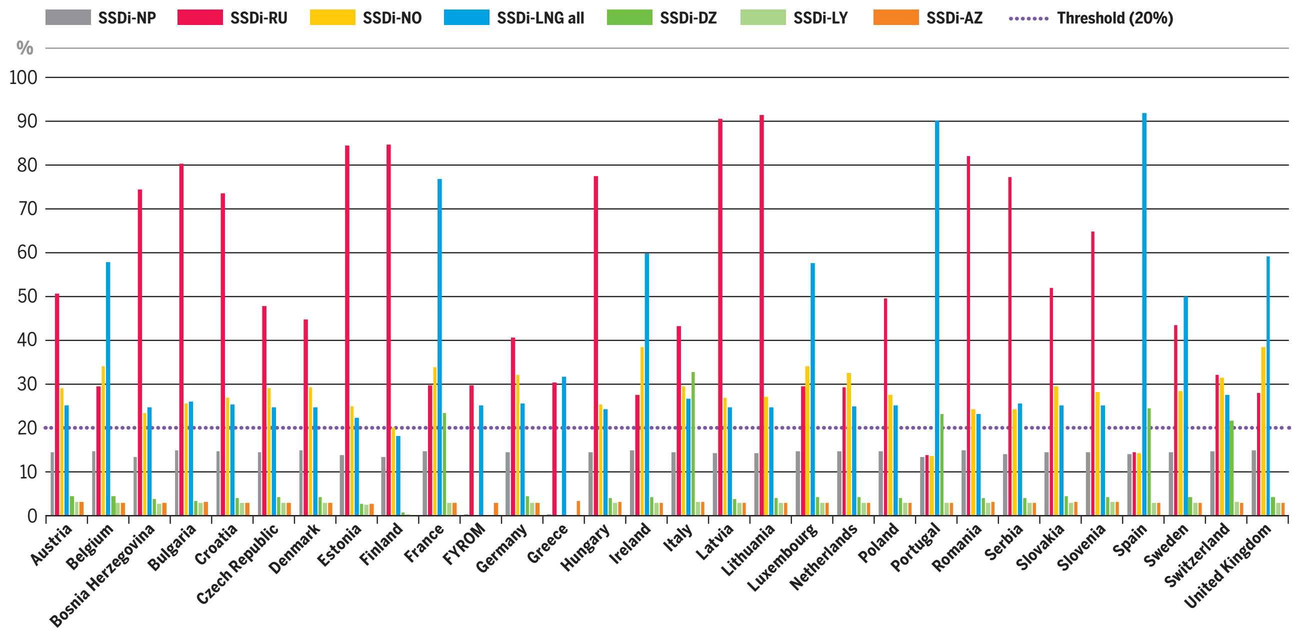

Figure 4.7: Best Estimate (Gas before Coal) 2025 - SSDI indicator by country

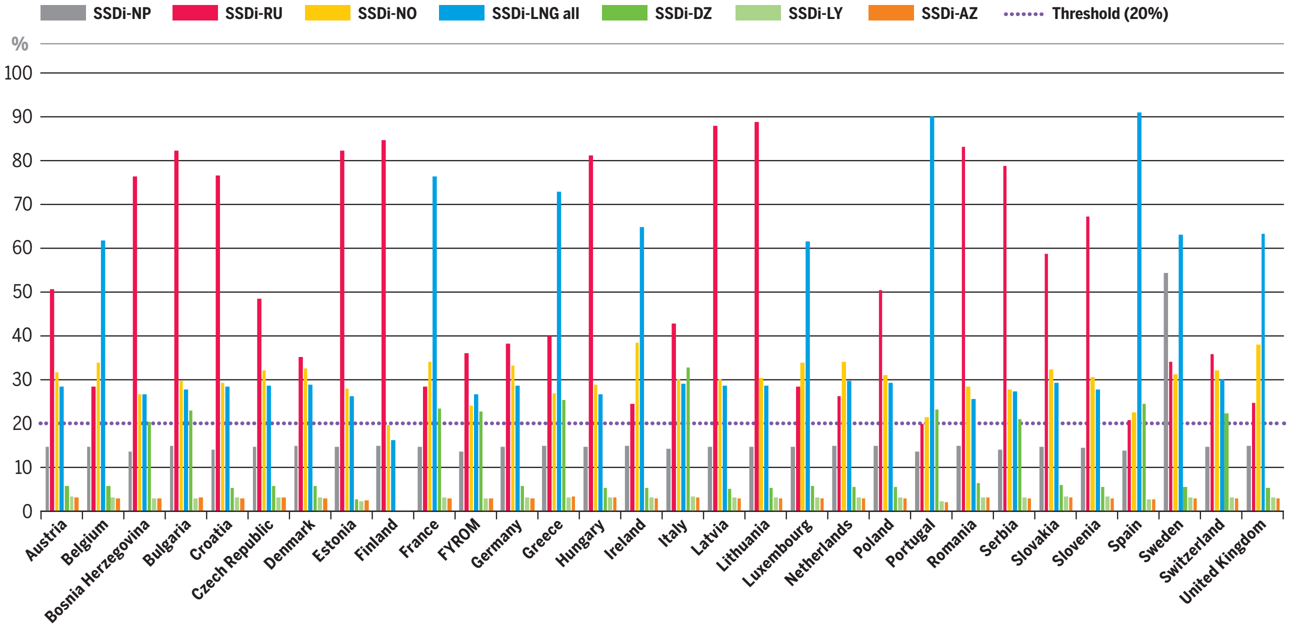

Figure 4.8: Distributed Generation 2030 – SSDI indicator by country

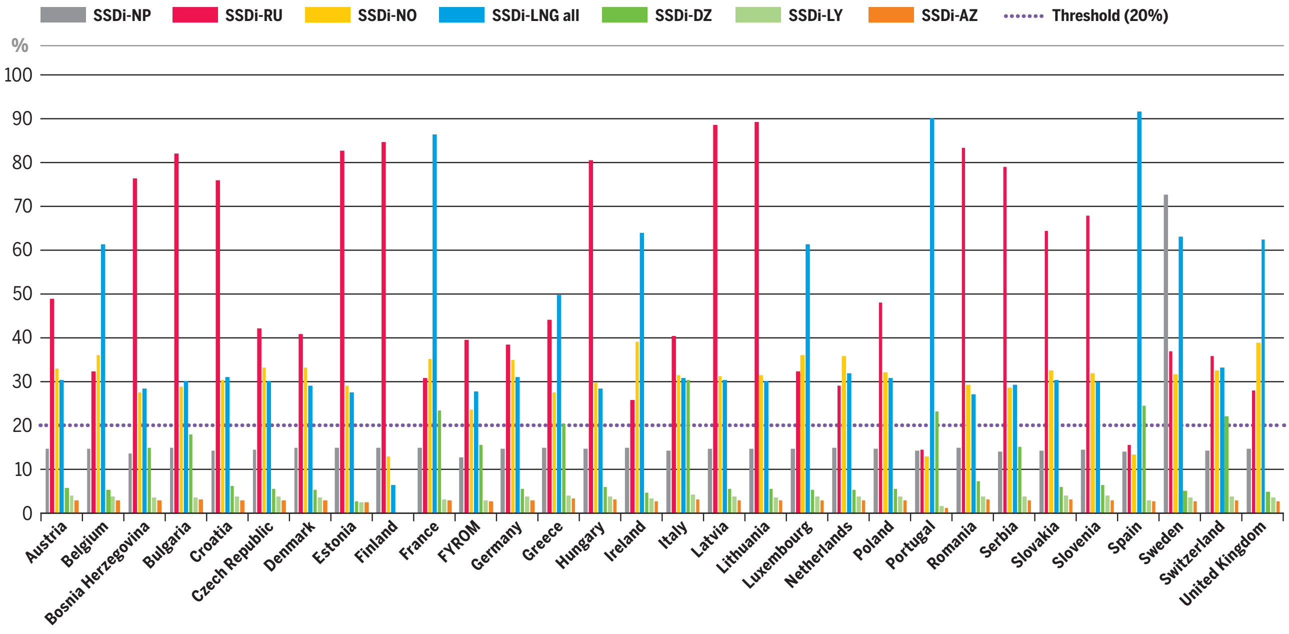

Figure 4.9: Distributed Generation 2040– SSDI indicator by country

4.2.2 SUPPLY SOURCE DEPENDENCE (SSD)

Russian Supply

PCI projects generally allow all EU countries to share their dependence and therefore to significantly reduce it in Eastern Europe. However, dependence on Russian gas remains significant for the Baltic States and Finland.

LNG supply

PCI projects reduce the dependence of European countries close to 0 % as of 2030 for all scenarios. However, the impact for Spain and Portugal remains very limited.

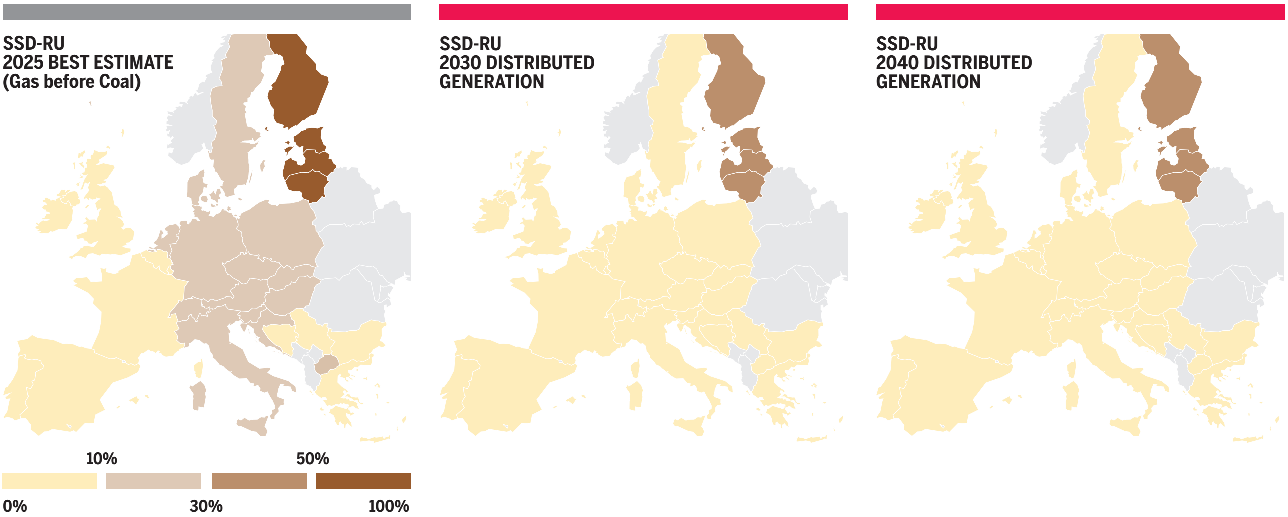

Figure 4.10: SSD RUSSIA – Scenarios and years – Maps results

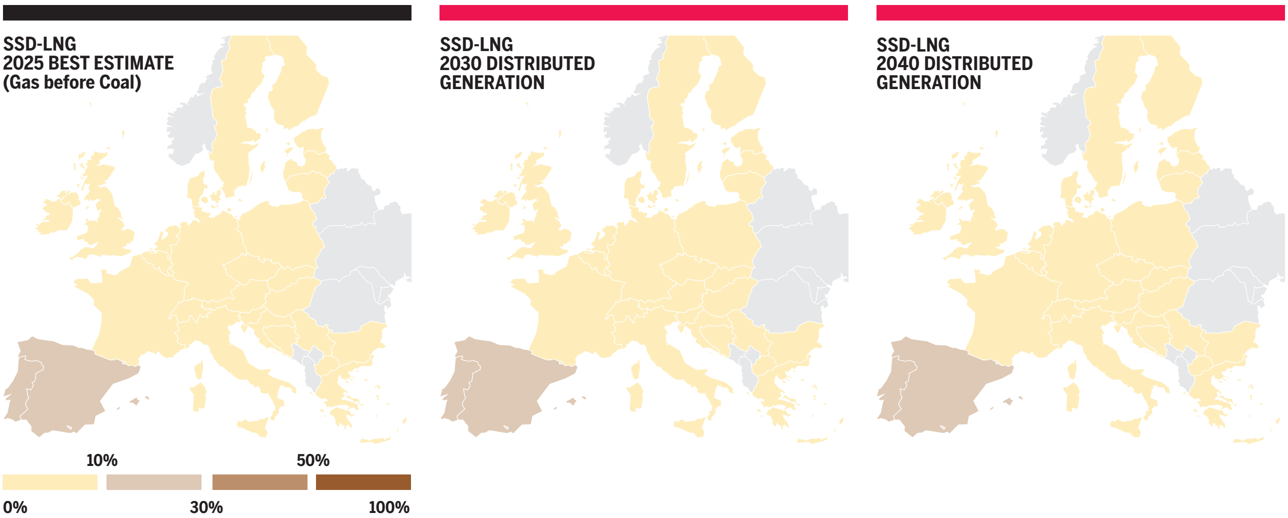

Figure 4.11: SD LNG – All scenarios and years – Maps results

4.2.3 LNG AND INTERCONNECTION CAPACITY DIVERSIFICATION – LICD

The results show that most European countries are improving their diversification compared to the Low Infrastructure level. The most significant developments are in Romania, Bulgaria, Serbia, Denmark, Ireland and Sweden. To a lesser extent, the following countries are improving their situation without reaching a sufficient level of diversification: Czech Republic, Greece, Hungary, Poland, Slovakia, Slovenia and Spain. Nevertheless, some countries with low diversification remain stable (Estonia, Bosnia and Herzegovina, Finland, United Kingdom, Latvia, Lithuania and Portugal).

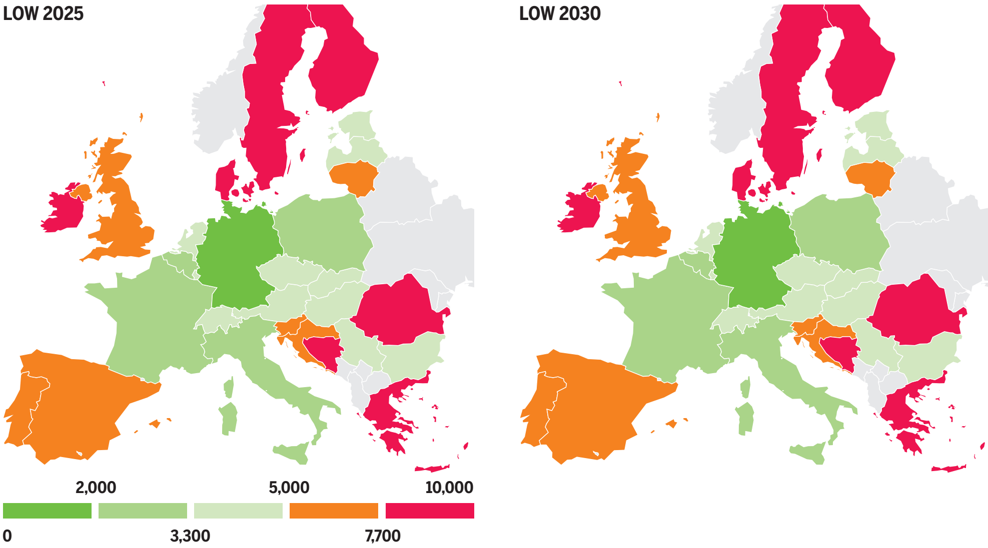

Figure 4.12: LNG and Interconnection Capacity Diversification – LOW Infrastructure Level

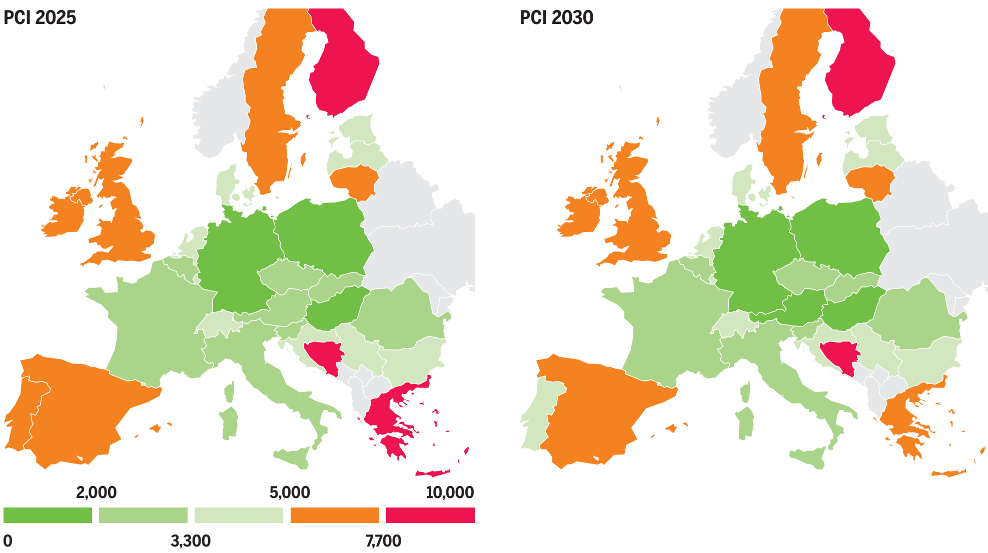

Figure 4.13: LNG and Interconnection Capacity Diversification – PCI Infrastructure Level

4.3 CONCLUSION

3rd PCI list projects mitigate some needs identified in the Low infrastructure level:

Security of Supply

- Croatia is no longer exposed to demand curtailment in case of peak demand, including on the long-run.
- Overall Europe and especially South Eastern countries results protected from demand curtailment or remaining flexibility limitation in case of short-term Ukrainian route disruption including on the long-run.
- The Baltic States and Poland improve their resilience in case of short-term route disruptions.
- Many countries reduce or mitigate their exposure to a risk of demand curtailment in case of disruption of their single largest infrastructure.
- Compared to the Advanced infrastructure level, exposure of Finland and Estonia to demand curtailment in case of supply disruption or infrastructure disruption (SLID) is not mitigated.

Competition

The access to supply sources is improved to the point where all European countries have access to a minimum of 3 different supply sources (2030). In the long term, Finland and the Iberian Peninsula have access to 2 sources.

The 3rd PCI list projects additionally deliver in terms of improving competition, by increasing route and supply diversification and consequently lifting local high dependence to specific supply sources. Dependence on Russian supply is mitigated in all parts of Europe but in the Baltic States and Finland where dependence remains relatively significant. The Iberian Peninsula dependence on LNG is also significantly mitigated.

Regarding the LICD indicator, 3rd PCI list projects improve the situation and almost all European countries show an index below 5,000.

Picture courtesy of Teréga

COUNTRY CODES (ISO)

AL	Albania
AT	Austria
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BE	Belgium
BG	Bulgaria
BY	Belarus
CH	Switzerland
CY	Cyprus
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