ANALYSIS OF GAS INFRASTRUCTURE TO IMPROVE THE FLEXIBILITY AND INTEROPERABILITY OF ENERGY SYSTEMS

Empowering Mediterranean regulators for a common energy future

REF: Med21-32GA – 4.6

Gas
Working Group
(GAS WG)

Co-funded by
the European Union

AKNOWLEDGMENTS

This report is the result of a project carried out by the MEDREG Gas Working Group (GAS WG), which provided the data and comments. MEDREG wishes to thank the GAS Working Group for their contribution and efforts.

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ABOUT MEDREG

MEDREG is the association of Mediterranean energy regulators, bringing together 27 regulators from 22 countries that span the European Union (EU), the Balkans, and North Africa.

MEDREG acts as a platform for facilitating information exchange and providing assistance to its members in addition to fostering capacity development activities through webinars, training sessions, and workshops. Mediterranean regulators work together to improve the harmonization of regional energy markets and legislations, seeking a progressive market integration in the Euro-Mediterranean Basin.

Through constant cooperation and information exchange among members, MEDREG aims at fostering consumer rights, energy efficiency, infrastructure investment, and development by employing safe, secure, cost-effective, and environmentally sustainable energy systems.

The MEDREG Secretariat is located in Milan, Italy.

For more information, visit www.medreg-regulators.org

Executive Summary

The last decade saw the Mediterranean region become a center of interest and attention for the global natural gas industry. All regulators have an important role in designing the development of a functioning gas market that ensures a level playing field in the MEDREG zone.

In transitioning to the decarbonization of energy systems two aspects are crucial: flexibility and interoperability. The coordination between the electricity and gas market operators in operation planning may enhance flexibility for the management of the energy system, while the requirements regarding interoperability are enforced as part of infrastructure planning in many countries of the MEDREG zone, facilitating the commercial and operational cooperation between the countries. Moreover, interoperability and data exchange are key elements of future TSO-TSO/TSO-DSO relationships.

Speaking of energy integration, decarbonizing the power sector is perhaps the greatest challenge faced by the global energy system while having to satisfy the rapidly growing energy demand. In this regard, there are generally four major decarbonization mechanisms: optimization of energy efficiency, low carbon generation, electrification, and greenhouse gas (GHG) reduction through non-combustion techniques. The distributed generation of renewable gases will also require a greater degree of distribution/transportation interoperability, giving a central role to smarter distribution networks.

Regarding the EU Hydrogen Strategy and its impact on the MEDREG region, the priority that the European Commission under the new EU Green Deal gives to cooperation with the African Union allows several possibilities for exploring a mutually beneficial hydrogen ecosystem. Furthermore, the scenarios elaborated by the countries may lead to full decarbonization in many ways, and each country's final decision on the decarbonization path to be followed will mainly be based on economic data, which is different for each country.

TABLE OF CONTENTS

Executive Summary 3

INTRODUCTION 6

MARKET AND INFRASTRUCTURE FRAMEWORK 9

1.1 Eastern Mediterranean exploration activity 10

1.2 Gas market infrastructure investment framework 10

FLEXIBILITY AND INTEROPERABILITY 13

2.1 Definitions of the terms "flexibility" and "interoperability" 14

2.2 Flexibility and interoperability and their regulation in the Mediterranean region 15

2.3 Purposes and benefits of TSO-DSO/TSO-TSO interoperability 18

ENERGY INTEGRATION TO PROMOTE DECARBONIZATION 20

3.1 Energy decarbonization and hydrogen transportation in Europe 21

3.2 Energy decarbonization and hydrogen transportation in the MEDREG region 25

3.3 The EU Hydrogen Strategy and its impact on the MEDREG region 27

3.4 Gas and electricity networks' coordination to achieve full decarbonization 30

CONCLUSION & RECOMMENDATIONS 31

LIST OF FIGURES

Figure 1 - Overview of the responses to the GAS WG questionnaire 8
Figure 2 - Infrastructure investment process in the Mediterranean region 11
Figure 3 - The infrastructure investment plan's objectives and priorities[5] 12
Figure 4 - Definition of flexibility and interoperability 14
Figure 5 - Pie chart indicating whether there is a link between gas and electricity market operators in the member countries 15
Figure 6 - Interoperability requirements enforced as part of infrastructure planning 18
Figure 7 - Pillars of decarbonization 21
Figure 8 - Roadmap for hydrogen production in Europe 22
Figure 9 - Areas with blue or green hydrogen potential 23
Figure 10 - Investigating gas network adaptations for energy transition[17] 24
Figure 11 - Main aspects and instruments mentioned in the EU Hydrogen Strategy[20] 28
Figure 12 - Hydrogen potential across applications 29

LIST OF TABLES

Table 1. Purposes and benefits of TSO–DSO/TSO–TSO interoperability 19

INTRODUCTION

The MEDREG GAS WG prepared a report last year on how the gas market can contribute to achieving energy transition, with a focus on the Mediterranean region[1]. This year, the GAS WG will continue to analyze the potential contribution the gas market can make to energy transition by studying how the gas infrastructure can improve the flexibility and interoperability of the energy systems.

Flexibility and interoperability in energy systems have many interpretations. The two concepts might represent different understandings and interpretations when used for different purposes, so for the sake of this report, the following definitions shall be applied:

- **Interoperability**

It is mainly related to the gas quality that the gas system must realize for transporting and shipping the "blended gas." Today, this concept is very important because of the use of new more eco-friendly gases (biogas, hydrogen, etc.) with different specifications and chemical combinations.

- **Flexibility**

The gas system can increase the flexibility of the power system by utilizing its resources. In the future, power-to-gas (P2G) could offer a solution for managing excess electricity, produced by renewable and/or nuclear energy. With the massive development of renewable electricity and the strong push in favor of the electrification of certain variable uses over the year, it could constitute a flexible solution in the long term.

Since the energy infrastructure must be made more flexible, reliable, and optimized for cost-effectiveness and better performance. This report will focus on the flexibility regarding the tools of the gas system for improving the power system's flexibility by using its resources as well as on the interoperability defined mainly concerning the gas quality and the possible developments of the gas system that allow transporting and shipping the "blended gas."

The report will include four separate chapters on the market and infrastructure framework in the Mediterranean region, the flexibility and interoperability of the energy system, and the integration of energy to achieve decarbonization, and finally a conclusion that summarizes the outcome of the study.

A short questionnaire – the main method of data collection – was circulated among the members to get the necessary inputs for the report and address the following complex considerations of flexibility and interoperability within the energy systems:

- Planning future infrastructure investments should consider main objectives and priorities such as follows: Security of Supply (SOS), achieving energy transition, reducing CO_2 emission, integrating new technologies and diversifying your energy mix, and reducing state dependency to primary resource imports (coal, hydrocarbons, or natural gas).
- Infrastructure development plans include several strategies to achieve flexibility, interoperability, SOS, market liquidity, and demand-side, supply-side, and consumer needs.

[1] The report is available on MEDREG website: http://www.medreg-regulators.org/Publications/NaturalGas.aspx

- The kind of coordination, policies, regulations, rules, or practices between different energy market entities (e.g., involving electricity and gas) in terms of the development of more reliable, efficient, and secure eco-energy system.

From the 27 members, 10 replied to the questionnaire; 12 members regulate only the electricity market, don't have a regulator yet, or don't have a gas market, so this analysis is not applicable to them; and lastly, five members didn't respond to the questionnaire.

The responses were grouped and analyzed accordingly to obtain informative insights about the deployment of interoperability and flexibility in energy systems of MEDREG countries.

The following figure provides the response rate to the GAS WG questionnaire.

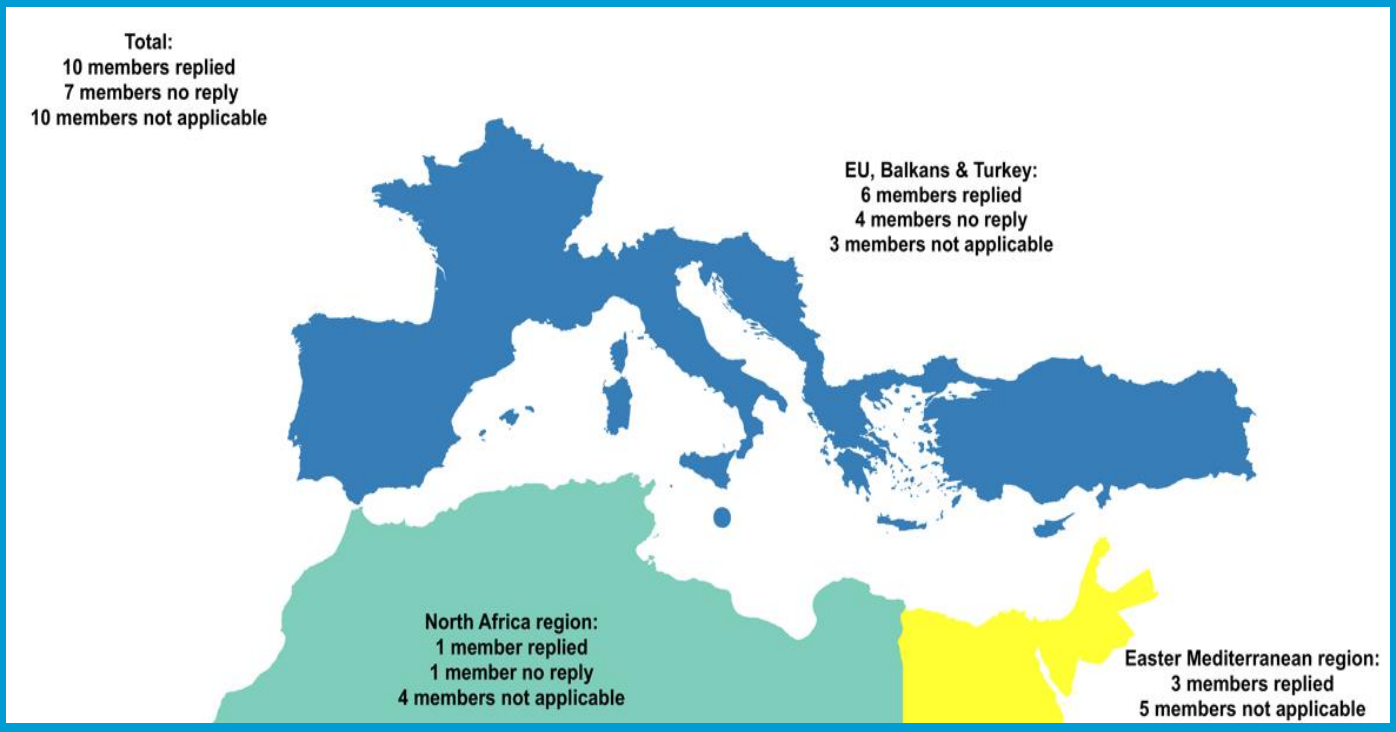

Figure 1 - Overview of the responses to the GAS WG questionnaire

1

MARKET AND INFRASTRUCTURE FRAMEWORK

1.1 Eastern Mediterranean exploration activity

The last decade saw the Mediterranean region become a center of interest and attention for the global natural gas industry with the discovery of vast gas fields in the Eastern Mediterranean, which has left us wondering and speculating about the future of the gas market and infrastructure in the region and how the global gas markets and prices will be affected by these discoveries.

The exploration activity in the Eastern Mediterranean should confirm the major discoveries[2]. This could transform the region's gas market and export diversification in the Eastern Mediterranean natural gas supply mix. Hopefully, it will also contribute to an increase in the security of supply in the region.

Further details regarding natural gas production/consumption can be found in the MEDREG report "Design mechanism for gas market able to foster energy transition."[3]

1.2 Gas market infrastructure investment framework

The development of a functioning gas market that ensures a level playing field characterized by capable and high-capacity infrastructure shall play a crucial role in the future in creating an integrated and harmonized gas market in the MEDREG zone, in addition to providing focus on understanding the particular attention to the process of planning infrastructure investments and its legal framework in the region.

All regulators serve an important role in the process, for example, approving the investments plans submitted by National Regulatory Authorities, but they are not responsible for the planning of the gas market infrastructure investment except for Israel.

The most common scheme for elaborating infrastructure investment, depending on the level of market unbundling of activities, includes the drafting of the proposal by the TSO/DSO or network owner, followed by the review by the regulator or concerned ministry (in which case the regulators provide consultancy), and finally the approval of the investment plan by the regulators or concerned ministry in the case of Italy.

In Portugal, the plan is elaborated by the TSO/DSO, reviewed by the regulators, and then approved by the ministry.

[2] Natural Gas News (NGN) Magazine, Vol.3, No. 21, by Charles Ellinas, "Eastern Mediterranean Gas – Prospects and Implications" provides an overview of the exploration activity in the Eastern Mediterranean.
[3] MEDREG report: Design mechanism for gas market to foster energy transition – February 2021

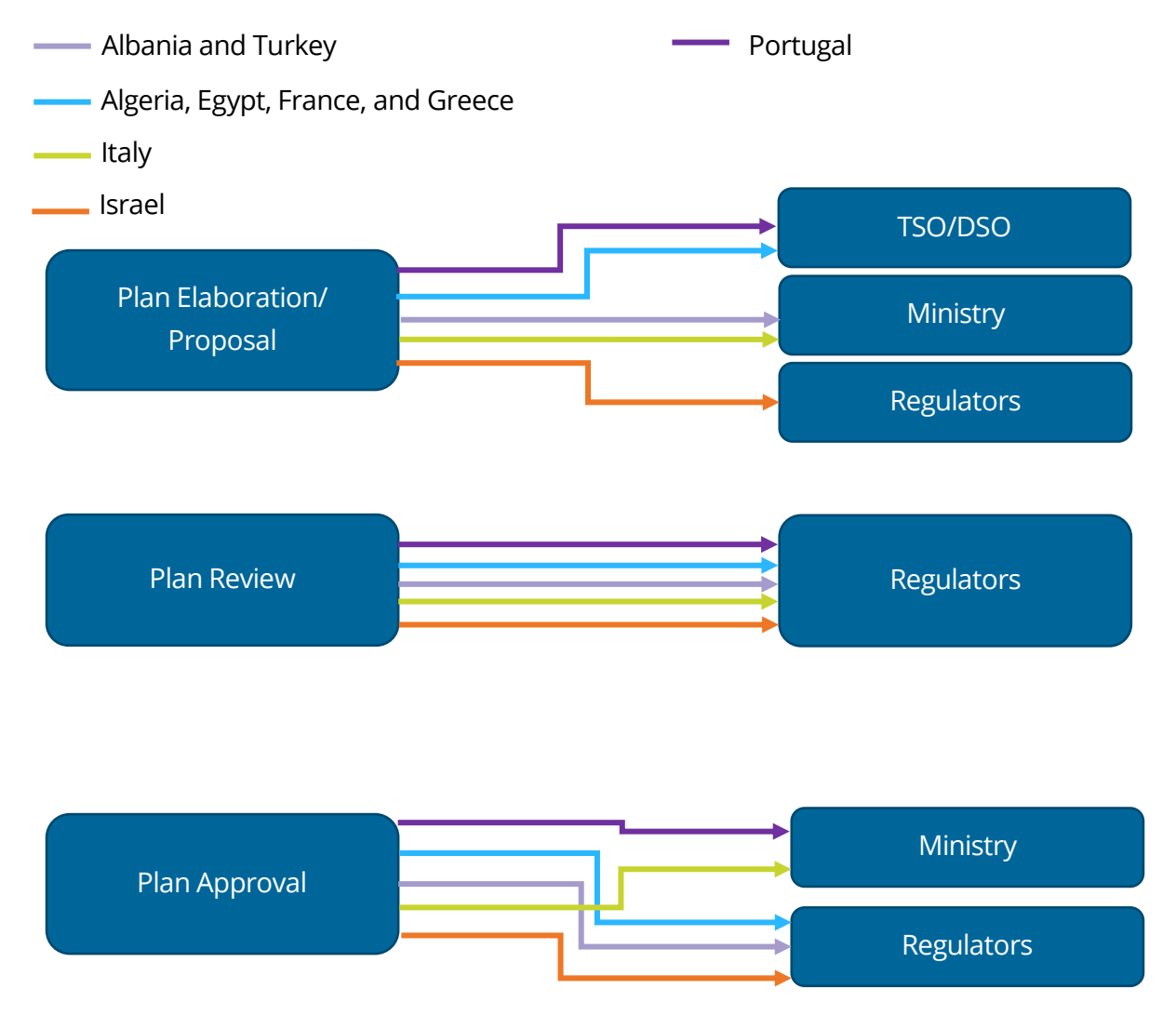

Figure 2 - Infrastructure investment process in the Mediterranean region

Studies on the development of the gas market infrastructure improved over time, and they nowadays include more requirements and market design than having just the basic needs of insuring the supply from point A to B with a good ratio price/quality.

In today's energy transition strategies, natural gas will remain an energy source for the coming decades depending on the transition pace of the energy systems and will be a key element in fuel switching, mainly from coal to natural gas, to reduce the use of polluting fuels for reducing CO_2 emissions and improving air quality.

Furthermore, the role of the functioning gas market will increase with the future development of eco-friendly gases (biogas, hydrogen, and other renewable or decarbonized gases). Moreover, the gas system

can make the electrical system more flexible with high penetration rates of renewable energy sources, using, for example, more combined-cycle gas turbine (CCGT) units.[4]

All these new parameters are included in the infrastructure investments plans, even though due to the climate change considerations in some countries (Greece and Portugal) they are not officially part of the required parameters (by law) although included.

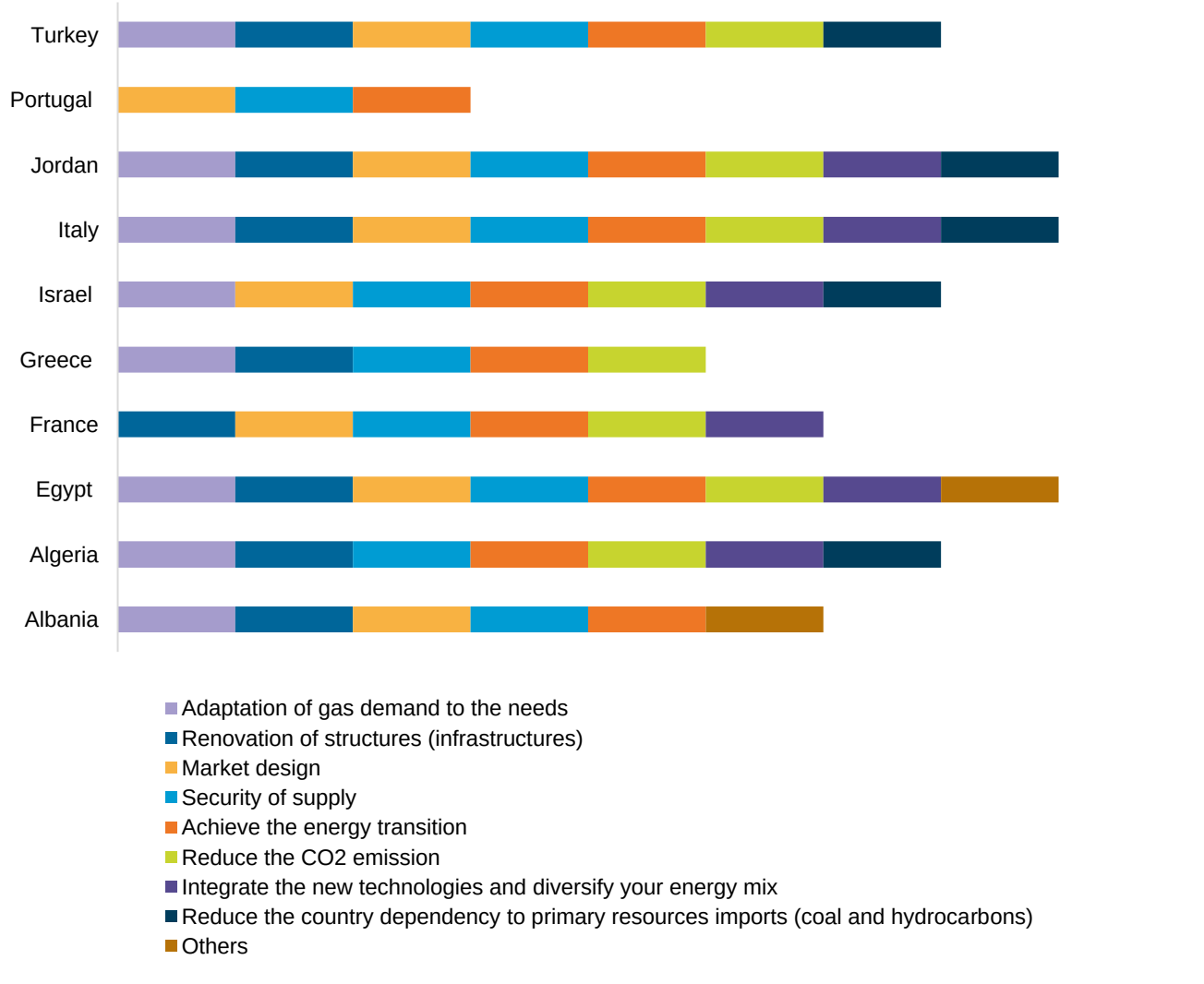

Figure 3 - The infrastructure investment plan's objectives and priorities[5]

[4] For more details on how the gas market can foster the energy transition, please read MEDREG's report on "Design mechanism for gas market to foster energy transition" - 2021

[5] The figure includes only the members who replied positively to the question

2

FLEXIBILITY AND INTEROPERABILITY

2.1 Definitions of the terms "flexibility" and "interoperability"

In addition to the different objectives and priorities of each country, two concepts are crucial to enable and achieve the decarbonization of energy systems: interoperability and flexibility. Interoperability is seen by many in the energy sector as key to unlocking flexibility services. However, both terms (flexibility and interoperability) have different interpretations in each country. Therefore, to have a standardized understanding among the members, we define **interoperability**, in short and in reference to the gas system, is mainly related to gas quality. Natural gas is a natural fossil fuel, and its calorific power as well as chemical combination depends on the field from which the natural gas is extracted.

In each country, natural gas is generally sourced from different fields across various geographies and landscapes, so the gas system must be developed for transporting and shipping the "blended gas".

Today, this concept is much more important because of the use of new, more eco-friendly gases (biogas, hydrogen, and other renewable or decarbonized gases) with different specificities and chemical combinations.

Meanwhile, the meaning of **flexibility** is based on the power system whereby it is necessary to achieve an equilibrium between power supply and power demand.

All solutions for maintaining the constant stability, keeping voltages within the predefined limits, and transferring power between supply and demand where local or regional limitations may cause bottlenecks represent flexibility tools.

Especially with the increased amount of intermittent renewable energy (solar, wind, etc.), the power system suffers further fluctuation, i.e., it becomes less stable.

The gas system can render more flexibility to the power system by using its resources, e.g., storage, Power-to-Gas (P2G) facility, and the Gas-to-Power facility, i.e., combined-cycle gas turbine (CCGT).

Figure 4 - Definition of flexibility and interoperability

The figure above provides an overview on where the given definition of the terms "flexibility" and "interoperability" fits the members' gas energy market. Most regulators confirmed that the definitions fit their respective gas market, except for **Egypt** and **Jordan.**

In **Egypt,** interoperability refers to the managing of the relations, parameters, and communication between a TSO and another TSO at interconnection, or between a TSO and a DSO at city gate, in terms of gas quality, physical and commercial balancing, communication and data exchange management, measurement station and Supervisory Control And Data Acquisition (SCADA) systems, and emergency handling.
Similarly, the definition of interoperability in **Jordan** doesn't fit with the proposed one, as it is one of the countries importing natural gas and therefore depends on its import based on prices and exporter distance (preferably from neighbouring countries) to reduce costs. Furthermore, Jordan's infrastructure is inadequate to use blended gas.

2.2 Flexibility and interoperability and their regulation in the Mediterranean region

The coordination between the electricity and gas market operators in operation planning may provide more flexibility in the management of the energy system and improve the security of supply for both electricity and gas. In normal conditions, it allows the stabilization and efficient operation of the energy system. Furthermore, in emergency cases, there being a link between the electricity and gas operators can avoid any incident that can affect the infrastructure and/or energy curtailments for consumers.

Based on the 10 replies received, only three counties don't have a link between their gas and electricity market operators regarding operation planning/procedures (both normal conditions and emergency conditions).

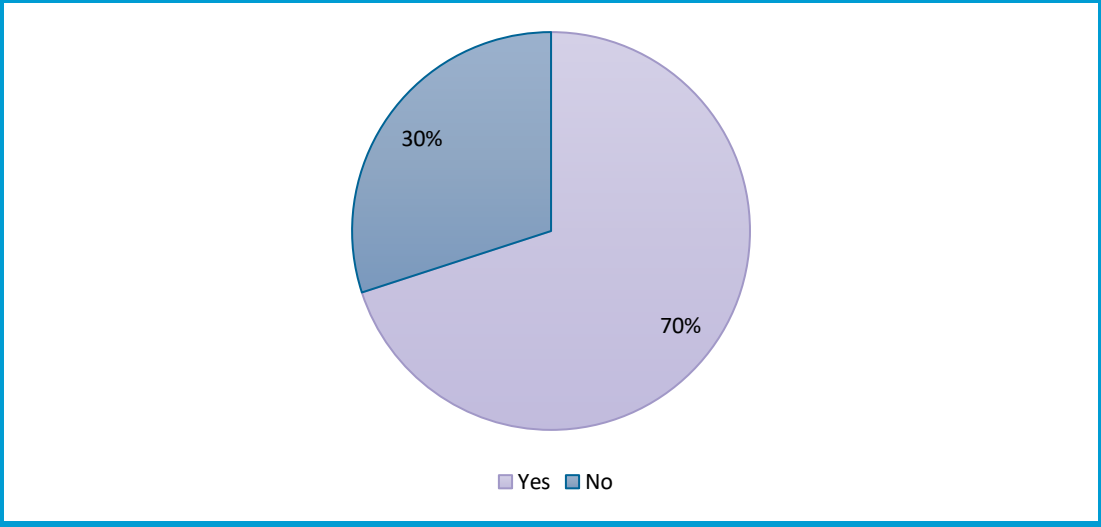

Figure 5 - Pie chart indicating whether there is a link between gas and electricity market operators in the member countries

- **Albania**

The gas transmission and distribution operators drafted the investment plan incorporating the flexibility and interoperability aspects in the energy market, and it was approved by the Albanian Energy Regulator (ERE) board in 2018.[6]

Furthermore, the rules for monitoring the natural gas market have been approved by the ERE Board in 2020.[7]

- **Algeria**

The gas transmission grid code dictates the rules for monitoring the gas transmission system in normal and emergency conditions. An emergency plan is formulated by the TSO in cooperation with network users: DSO, power producers, other network users. In case of emergency or lack of demand-offer balance, gas, and electricity, TSOs collaborate to develop a better production scheme and optimize the electricity production system.

Furthermore, the calorific value margin for natural gas is set by regulation. Gases produced by different local fields have different characteristics, which are under specification range set by regulation.

- **Egypt**

Gas and electricity TSOs coordinate in a continuous scheme on operational issues, with much attention given to emergency conditions. Such coordination occurs regarding practices and are managed on different levels: ministries, dispatching centers of the gas TSO, the electricity TSO, the gas TSO and power producers and consumers directly connected to the gas grid.

The rules and application concerning the flexibility and interoperability are defined in the network code. It foresees an update of the code to include different topics, and flexibility and interoperability will be part of such an update process. The relevant studies related to the technical development of gas market design will tackle such issues as well.

- **France**

There is almost no link between gas and electricity market operators. The only link is through combined-cycle gas turbines (CCGTs) since the gas system must accommodate some of the flexibility needs of the power system.

Furthermore, the gas quality standards are determined by TSOs and should be justified by suppliers. In terms of flexibility, suppliers must maintain balance daily (i.e., injections correspond to withdrawals).

- **Italy**

The network code defines the “interoperability and data exchange,” and it includes the cooperation between gas and electricity TSOs. The code harmonizes communication formats, allowing the TSO to exchange information more extensively and efficiently.

[6] ERE Board no. 18, dated 10.01.2018
[7] ERE Board no. 265, dated 28. 12 .2020

In addition, the management of the flexibility and interoperability, especially between the pivotal gas TSO (SNAM) and electricity TSO (TERNA), is described in the Scenario National Trend Italia by SNAM, in accordance with the regulation 468/2018/R/GAS as amended and supplemented as well as the regulation 539/2020/R/GAS. SNAM Rete Gas publishes the Italian National Trend Scenario report that will be used for the 2021 ten-year development plan.[8]

The document was drawn up in coordination between the major transport company and the electricity transmission system operator.

- **Israel**

The coordination between the gas and electricity TSOs is in place, regarding operation planning and procedures especially in emergency conditions. The Natural Gas Authority (NGA) and the Electricity Authority coordinate concerning those two aspects.

The regulations that define flexibility and interoperability are set by the NGA. It dictates the quality standards regarding the chemical composition of natural gas and enforces these standards strictly. Furthermore, the Ministry of Energy plans to integrate all energy sources for the big picture and plans accordingly.

- **Greece**

The nation's electricity market relies on natural gas, contributing 43% of the electricity production in 2020. Therefore, the Emergency Plan[9] describes the procedures, coordination measures, and steps taken to deal with crisis situations at national and regional levels.

Regarding the regulation that defines interoperability, the emergency plan includes the guidelines to manage it, and it's published by the Greek Energy Regulator RAE.[10]

- **Portugal**

There are general rules with regard to the cooperation between the electricity and gas sectors. The planning of infrastructure developments in each sector considers the involvement of the other sector, and, at the transmission level, the networks operators belong to the same company, hence allowing a strong cooperation at all levels. These rules are stated in the infrastructure's operation code and the quality interop of supply code.

- **Turkey**

The gas and electricity TSOs in **Turkey** are under the authority of the Ministry of Energy and Natural resources, and the cooperation between them is governed by the ministry's legal framework (in relation to operation planning and procedures). Although there are not specific documents on flexibility and interoperability, relevant procedures are detailed in the network codes of both BOTAŞ and TEİAŞ.

[8] https://www.snam.it/en/transportation/Online_Processes/Allacciamenti/information/ten-year-plan/ten_year_plan_2021_2030/scenari.html
[9] Regulation 2017/1938
[10] RAE Decision 567/2019 on the approval of the Emergency Plan

In many countries, the interoperability requirements are enforced as part of infrastructure planning, and 7 out 10 replied positively to the survey.

In 2015, the European Network of Transmission System Operators for Gas (ENTSOG) established a network code on interoperability and data exchange rules[11] to improve the degree of harmonization in technical, operational, and communication areas for overcoming barriers and challenges to reach a better flow of gas in the EU region.

This rule became applicable for the energy community and their EU neighbouring operators as well since May 2016.

Interoperability and data exchange between TSOs is a key element in facilitating commercial and operational cooperation between the member countries and including these rules in the infrastructure requirements may ease the implementation of the interoperability and data exchange rules.

Figure 6 - Interoperability requirements enforced as part of infrastructure planning

2.3 Purposes and benefits of TSO-DSO/TSO-TSO interoperability

As mentioned, interoperability and data exchange are key elements of the future TSO–TSO/TSO–DSO relationship since they ensure that the infrastructure and operation rules are harmonized to optimize the flow of gas across the networks.

Furthermore, they define the rules of communication between TSO–DOS and other parties, pertaining to the data format and the physical attributes of the gas itself (e.g., pressure, odorization, etc.).

[11] COMMISSION REGULATION (EU) 2015/703 of 30 April 2015 establishing a network code on interoperability and data exchange rules

In the MEDREG region, the members shared their purposes and benefits regarding TSO–TSO/TSO–DSO interoperability, and the security of supply, a more efficient operation of the energy systems, and avoiding any emergency are mainly the more redundant purposes and benefits in the region.

The table below lists the benefits of interoperability by country.

Country	Purposes and benefits of TSO–DSO /TSO–TSO interoperability
Albania	To establish a more integrated TSO DSO coordination.
Algeria	Continuity of supply of consumers of different DSOs, regardless of their geographical localization.
Egypt	Management of normal and emergency operational conditions/constraints and obligations. Establishing common data exchange methods. Setting predefined methods of communication.
France	Interoperability is necessary for transferring gas from one operator to another.
Greece	Security of supply. Coping with crisis situations.
Israel	Maintaining the system in good condition.
Italy	Security of supply and the use of energy market infrastructure more effectively.
Jordan	N/A
Portugal	To ensure a stable system operation and meet quality standards requirements.
Turkey	Efficient planning of the gas and electricity networks are carried out to ensure low energy costs, security of supply, and entry to the markets.

Table 1. Purposes and benefits of TSO–DSO/TSO–TSO interoperability

3
ENERGY INTEGRATION TO PROMOTE DECARBONIZATION

Large-scale electrification and natural gas decarbonization are emerging as prime topics concerning energy. Decarbonizing the power sector is perhaps the biggest challenge faced by the global energy system while having to satisfy the rapidly growing energy demand.

We are transitioning from a centralized, fossil fuel–powered, system-centric, siloed architecture to a decentralized, decarbonized, event-driven, and technology-based energy system architecture. Thus, several different technologies and fuels would likely be required, such as **hydrogen**, which can play an essential role in the energy transition plan.

3.1 Energy decarbonization and hydrogen transportation in Europe

As indicated in the following figure, there are generally four major decarbonization mechanisms: energy efficiency, low carbon generation, electrification, and greenhouse gas (GHG) reduction through non-combustion techniques. The first three pillars directly impact electric and gas utilities.

Utility and transportation decarbonization are rapidly gaining traction because of the economic advantages of renewable energy, technological acceleration, and a social mandate for a transition to clean energy.

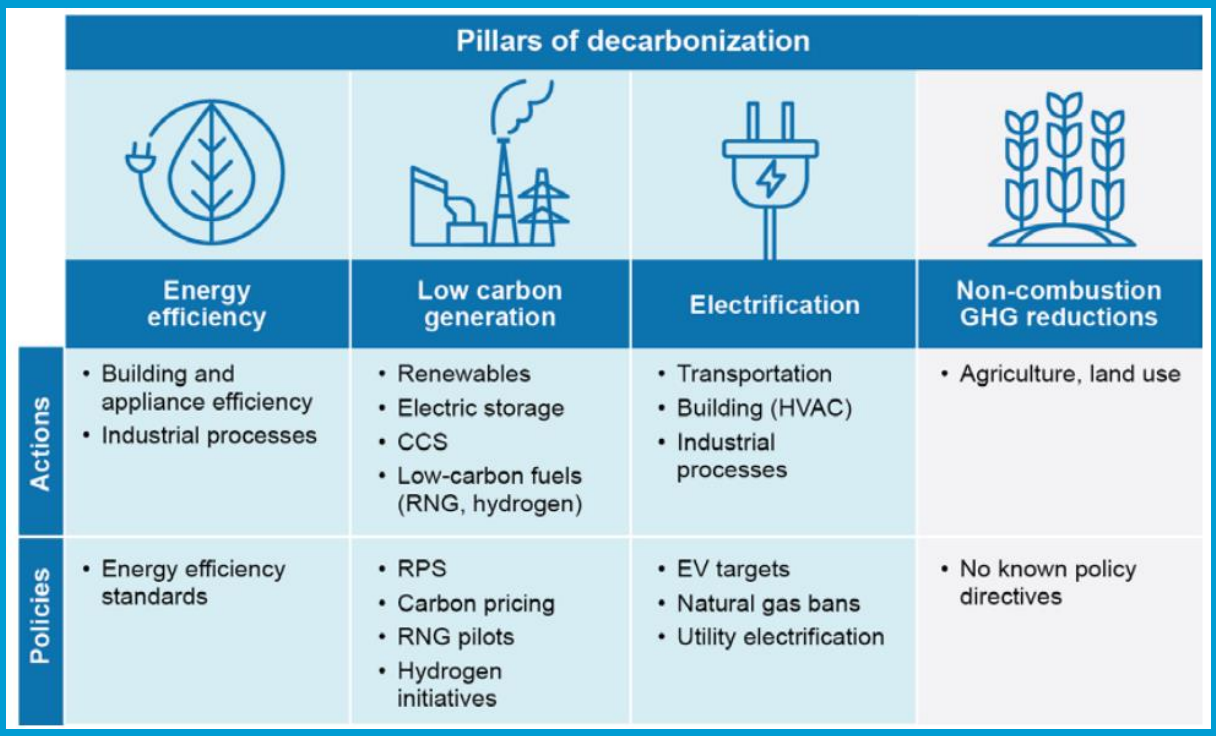

Figure 7 - Pillars of decarbonization

Source: "Utility portfolio planning for a decarbonized future" by Anant Kumar and Patrick Augustine May 2020 CRA. Charles River Associates

The present chapter discusses the continuity of the 2020 report[12] on how the gas market can improve and accelerate energy transition to achieve the decarbonization of the energy system.

Based on the responses to the circulated questionnaire, a better vision may now be provided on the climate change objectives of various Mediterranean countries and on whether the existing infrastructures are developed enough to support the use of new technologies and alternatives gases, mainly hydrogen.

The beginning of the energy transition – except for the faster development of Renewable Energy Sources (RES) – brought natural gas to the spotlight as a "bridge," being cleaner than the other fossil fuels. To increase the current share of renewables from 20% out of the total energy consumption to an ideal 100% after 2050, natural gas is still needed for several years[13]. According to the Inception Impact Assessment published by the EC, "biogas, biomethane, renewable, and decarbonised hydrogen as well as synthetic methane would represent some 2/3 of the gaseous fuels in the 2050 energy mix, with fossil gas with CCS/U representing the remainder."

For example, steel is still made from coal; thus, switching to natural gas would reduce emissions. The most radical and definitive solution would be to switch to hydrogen, but today hydrogen is made from gas (blue hydrogen) and the technologies to commercially produce green hydrogen are still uneconomical.

Achieving carbon neutrality cannot rely on renewable energy resources and electrification alone and will need the widespread development of hydrogen as a vector of decarbonization. Developing countries in the Mediterranean region with good renewable energy resources could produce green hydrogen locally, generating economic opportunities, increasing energy security, and reducing exposure to oil price volatility and fuel supply disruptions.

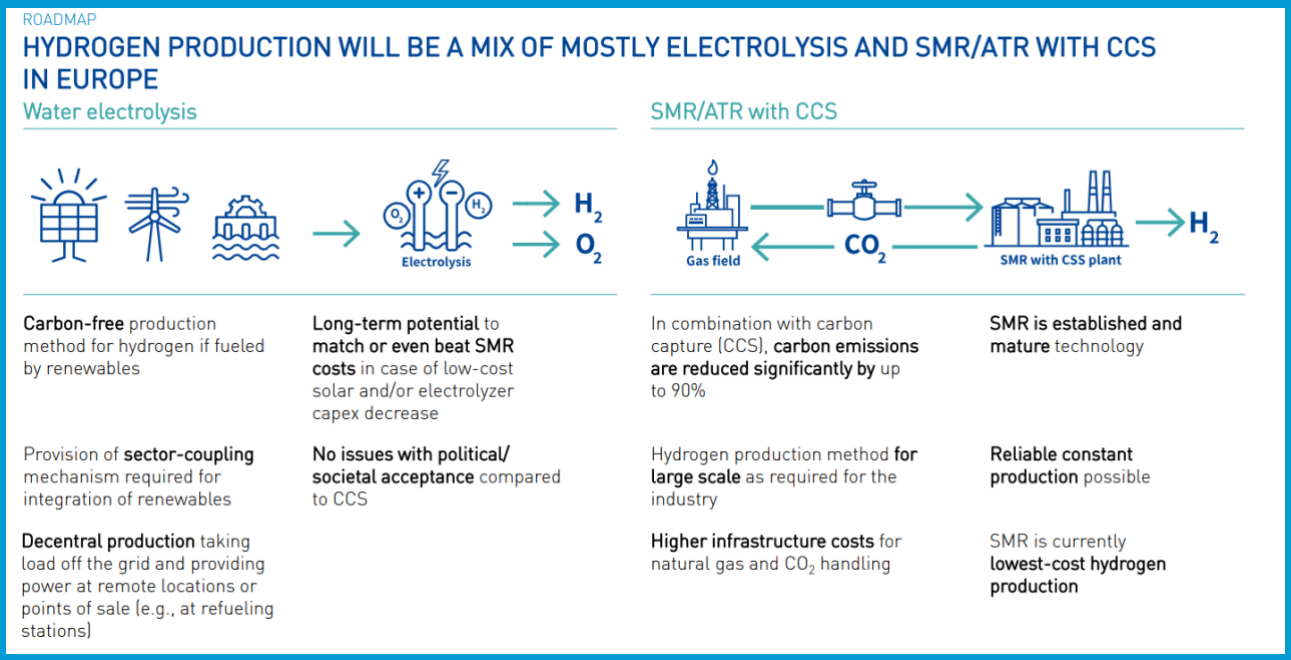

Figure 8 - Roadmap for hydrogen production in Europe

[12] "Design mechanism for gas market to foster energy transition" – MEDREG report – 2020

[13] Pippo Ranci, La Repubblica, 31 March 2021

[14] Source : https://www.fch.europa.eu/sites/default/files/20190206_Hydrogen%20Roadmap%20Europe_Keynote_Final.pdf

According to international energy expert Pippo Ranci (see footnote no. 13), "it will be possible to produce -green hydrogen- only starting from electricity, and it should be all from renewables, a reality that does not exist today. Floating platforms are proposed and work well those of the North Sea, but in the Mediterranean, the wind is less strong and regular. The costs would be very high, and even solar energy on the platforms is still an expensive solution."

As presented in the following graph, across the Mediterranean region, the value for green and blue hydrogen potential varies. This dictates a different strategy for energy transition.

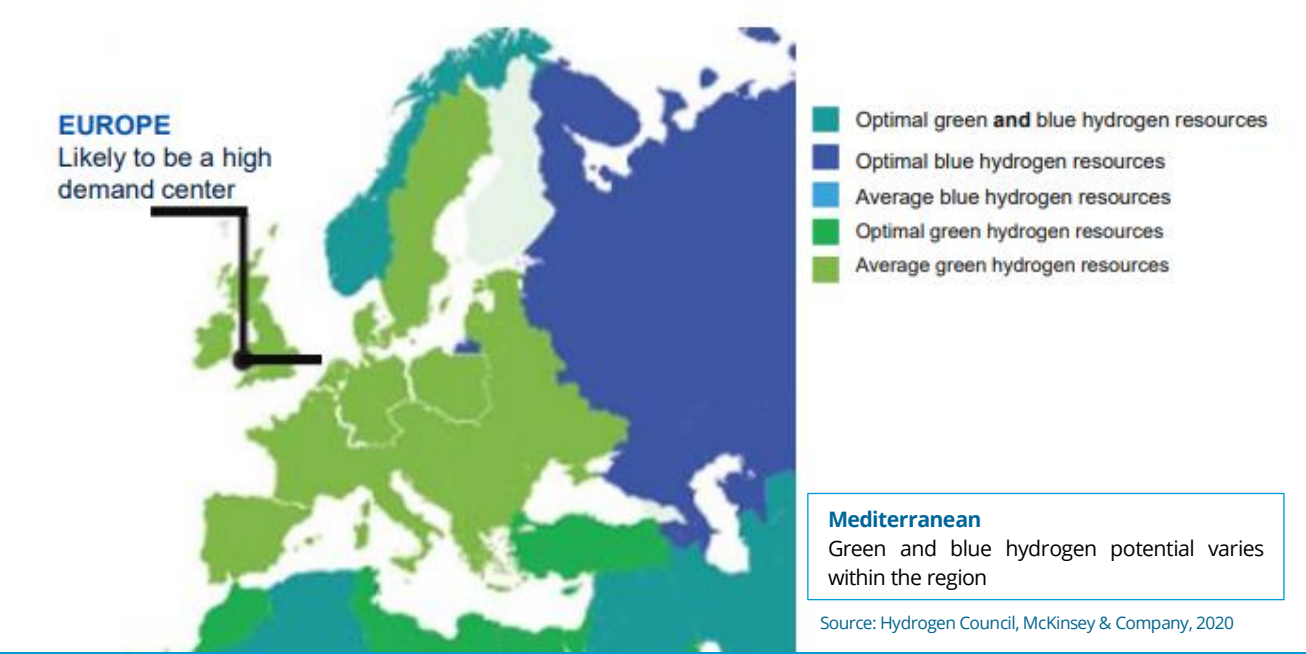

Figure 9 - Areas with blue or green hydrogen potential

Similarly, the best H_2 transport mode varies based on distance, terrain, and end use. Besides its transport via pipelines, hydrogen can be transported via marine terminals (including adapted Liquified Natural Gas (LNG) terminals), by ship in gaseous or liquid form, via liquid or gaseous hydrogen carriers, or via truck or rail. Different technologies are being examined for the transportation and storage of hydrogen in liquefied or pressurized state or in the form of ammonia or methanol.

However, according to the Spanish experience, transporting and storing liquid H_2 can be challenging; due to the current technology constraints, LNG tanks are not designed with the purpose of transporting and storing liquid H2 at -252 ºC, and their refitting wouldn't be financially viable.

Regarding pipelines, there are three pathways for the integration of hydrogen into the gas system: the injection of hydrogen and its blending with natural gas in the existing gas infrastructure, the development of a dedicated hydrogen network by converting the existing gas infrastructure or via the construction of new hydrogen infrastructure, and finally via methanation, which involves capturing CO_2, and combining it with hydrogen to produce e-methane, injected in the gas network.

Pipelines carrying pure hydrogen gas are technically feasible and have been in operation for decades in various countries including the US, Germany, the Netherlands, France, and Belgium. However, the extent of such pipeline systems is limited, and they do not provide an extensive basis for the rapid upscaling of hydrogen deployment[15].

Using the existing gas pipeline infrastructure across the Mediterranean region can enable low-cost transportation, first by blending hydrogen in gas transmission infrastructure, then by repurposing the pipeline, and finally by developing new dedicated hydrogen pipelines. However, this infrastructure is far from being completed. The flexibility of the current gas networks (pipelines and compressors) to transport hydrogen, as well as the storage facilities, is still under study[16] and shall be investigated for potential uses and re-purposing, as depicted in the following figure:

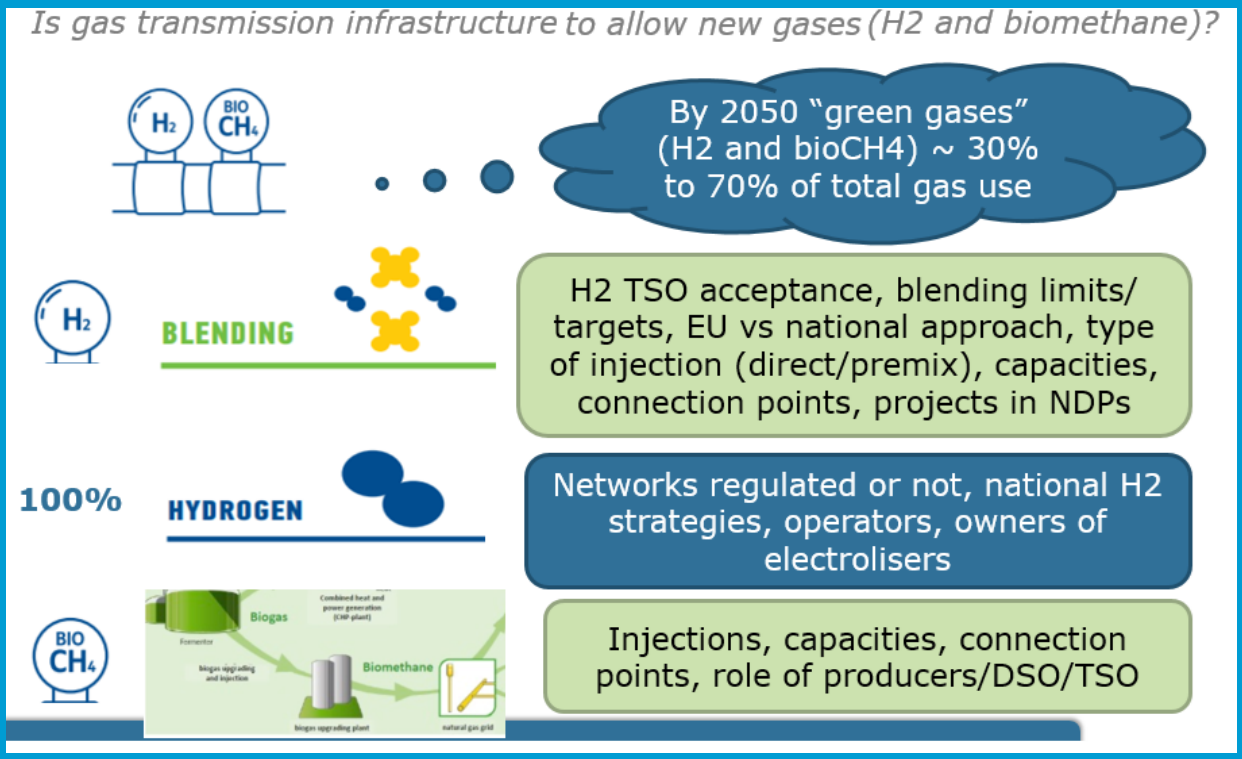

Figure 10 - Investigating gas network adaptations for energy transition[17]

[15] International Renewable Energy Agency (IRENA), HYDROGEN: A RENEWABLE ENERGY PERSPECTIVE, *September 2019*
[16] See the ACER study, "Transporting Pure Hydrogen by Repurposing Existing Gas Infrastructure: Overview of existing studies and reflections on the conditions for repurposing", 16 July 2021.
[17] Source : https://documents.acer.europa.eu/nl/Gas/Paginas/Low-carbon-gasses.aspx

3.2 Energy decarbonization and hydrogen transportation in the MEDREG region

The distributed generation of renewable gases will require a greater degree of distribution/transportation interoperability, thus giving a central role to smarter distribution networks.

The regulators of gas markets in Albania, Algeria, Egypt, France, Greece, Israel, Italy, Jordan, Portugal, and Turkey responded to the part of the questionnaire relevant to this chapter.

Six countries, namely France, Israel, Italy, Jordan, Portugal, and Turkey, responded positively to the question of whether the existing infrastructure of the energy system in each Mediterranean country can support the transition to natural gas and the integration of renewables and alternative fuels (hydrogen, biogases, and low carbon gases). More details are provided below:

- **France**

The existing infrastructure of the energy system supports the integration of renewable fuels, more precisely biomethane.

The framework for the integration of biomethane adopted by France includes, on the one hand, a guaranteed purchase price up to over 15 years for producers and a system of guarantees of origin designed to ensure traceability, and, on the other hand, a right to injection, the implementation of which has been entrusted to the French Energy Regulator CRE. The latter aims to convey the right signals to project developers to optimize the costs of connection to the networks via a zoning system that considers the characteristics of the existing networks (grid, reception capacity, etc.) and production potential. Although the entry-exit system is limited to the perimeter of the main network operated by the TSOs, biomethane production has access to the virtual marketplace (and benefits from the system of obliged buyers as a last resort). The French framework demonstrates that it is possible to develop and integrate biogas production by maintaining the infrastructure/design of the gas system.

- **Israel**

At the moment, the Ministry of Energy plans the connection of renewable energies to the electric transportation system, but it still in its early stage and requires great coordination and planning between different entities inside the ministry.

- **Italy**

The current infrastructure of the energy system can support the transition to natural gas and the integration of renewables and alternatives fuels to a certain level. For achieving a higher level of integration, the gas and electricity TSOs (SNAM and TERNA) conducted studies under different scenarios.

- **Portugal**

Recent national legislation assures support of the existing energy infrastructures to the transition and the integration of renewables and alternative fuels (hydrogen, biogases, and low carbon gases).

- **Turkey**

The existing infrastructure in Turkey mostly supports the transition to natural gas and the integration of renewables and alternative fuels. In recent years, in all 81 provinces of Turkey, have access to natural gas because of the extensive improvements of the transmission system and the regulations allowing smaller distribution systems to be gasified by LNG or CNG.

On the utilization of hydrogen in natural gas networks, projects are currently underway via the R&D funds granted by EMRA as a component of DSO tariffs. During the ongoing project, an injection comprising up to 20% hydrogen mixtures was performed in the pilot distribution zones, and the compatibility of household devices as well as that of the distribution network was tested.

In contrast, three countries, namely Algeria, Egypt and Greece, report that the existing infrastructure is only designed to supply natural gas and does not meet the requirements for the transportation of renewable gases or hydrogen.

- **Algeria**

The existing infrastructure is designed to supply natural gas. The renewable energy development plan states that alternative fuels such as biogases are directly used for producing electricity.

- **Egypt**

The existing infrastructure is mainly designed for natural gas. The country is in the phase of updating its energy mix strategy and is going to develop a hydrogen strategy that includes all strategic aspects of using hydrogen as part of achieving energy transition.

- **Greece**

The current transmission infrastructure cannot support the use of alternative gases, but plans have made to check the readiness of the distribution infrastructure.

Greece is at the planning stage of development, with several pilot projects underway, especially in areas where lignite fields used to be. Moreover, infrastructure built from now on shall not be approved by the regulator unless it is hydrogen-ready.

Notwithstanding the various levels of infrastructure readiness, as depicted by the replies of the members, the changes that are expected due to an increasing displacement of conventional forms of electricity generation at the transmission and distribution network levels with renewable energy sources (RES) and the effect on the utilization of gas infrastructure are significant.

3.3 The EU Hydrogen Strategy and its impact on the MEDREG region

The repercussions on the global economic and political equilibrium due to the transformation of the European Union's production and consumption model are still under evaluation. In the MEDREG region, according to the study conducted by the Florence School of Regulation[18], the Paris Agreement on climate change and the UN Sustainable Development Goals (SDGs) in 2015 triggered the world towards rapidly achieving the sustainability goals. By 2050, the global energy landscape will look completely different compared with todays. The EU is keen to achieve its 2050 decarbonization goals, with an estimated 24% of hydrogen (~ 2,250 TWh) covering the total energy demand. However, the entire EU's hydrogen demand cannot be met locally and therefore energy partnerships with regions abundant in renewable energy (RE) would be needed to procure green hydrogen to meet the EU's decarbonization goals. Given the priority that the European Commission under the new EU Green Deal gives to cooperation with the African Union, the two continents are poised to explore a mutually beneficial hydrogen ecosystem. This is also described in the EU Hydrogen Strategy, which highlights the African Union as a partner to cooperate with on research and innovation to regulatory policy, physical interconnections, and technological development[19].

The EU Hydrogen Strategy incorporated its main aspects, as indicated in the following figure, to tackle issues related to supply – infrastructure readiness and opportunities for re-purposing, potential demand and end uses of hydrogen, required and expected horizon of investments, and research and innovations that will accelerate economical hydrogen systems' development as well as the importance of the international dimension including potential markets, alliances with producing countries, importing, exporting, transportation, and any relevant challenges.

[18] Green Hydrogen – Bridging the energy transition in Africa and Europe (October 2020):
[19] See also Tudor Constatinescu – DG ENER – 1ST MEDREG WORKSHOP ON HYDROGEN, 3 November 2021

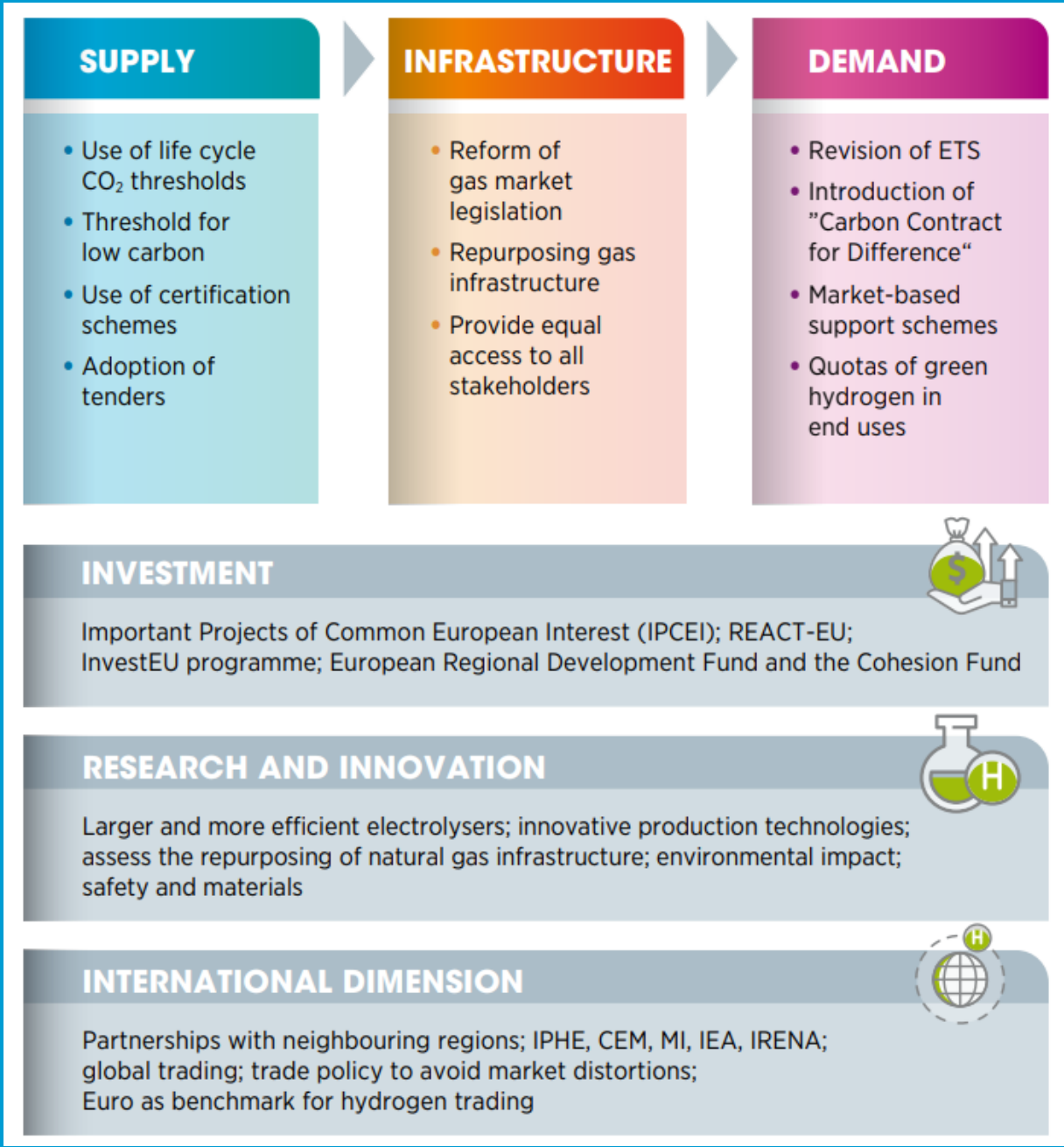

Figure 11 - Main aspects and instruments mentioned in the EU Hydrogen Strategy[20]

At the industrial level, several studies and analysis were conducted to first assess the potential of hydrogen and the extent to which hydrogen will play a role in the decarbonization of the energy sector.

Similarly, in the first years of renewable energies (solar photovoltaics and wind), the hydrogen potential is promising. However, technical barriers including the maturity of technologies and the necessary

[20] Source : https://now.solar/2021/04/30/green-hydrogen-a-guide-to-policy-making/

infrastructure, plus the costs incurred for the massive deployment of the system decreased its attractiveness among some investors.

Nevertheless, with the active cooperation between the private and public sectors and a regulatory framework that incentivizes and encourages the development of the technology, hydrogen will soon gain in popularity and attract more investors, and its deployment will thus experience a boom like in the case of renewable energies.

It was highlighted that many industrials started work on several pilot projects in different sectors to better understand the technology uses and limits.

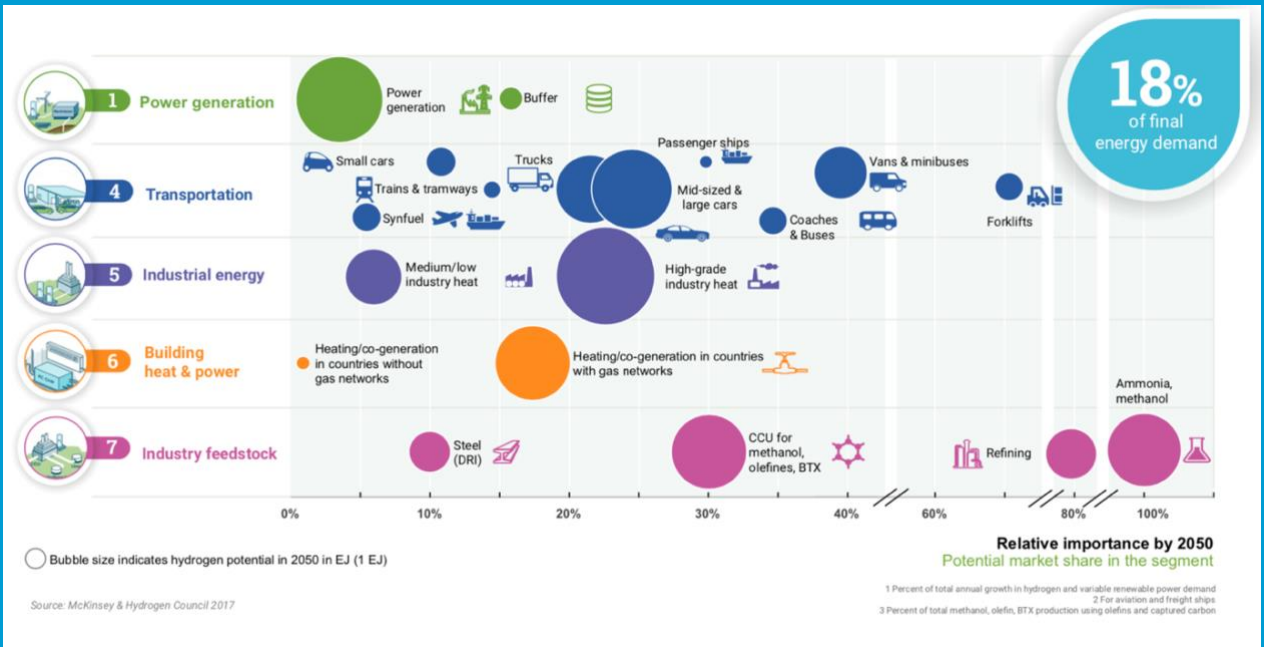

Figure 12 - Hydrogen potential across applications

In terms of R&D, industrials are making efforts to improve technologies while reducing the costs of producing hydrogen, with the most recent research reaching a rate of blending of 15% without any constraints. Furthermore, some studies are exploring the use of wastewater instead of fresh water.

Moreover, incentives may be a temporary solution to foster the development of the hydrogen market, for example, by using hydrogen guarantee certificates and providing funds to support the R&D. This is the case in Turkey, where the national regulatory authority (EMRA) support industrials in the R&D.

Given the above, it becomes evident that the Mediterranean Basin can and will be at the center of the coming evolution. It is hence of utmost importance that all Mediterranean countries be prepared and plan on how the development of electricity and – more importantly for this study – the development of gas network should progress under different possible scenarios.

Relevantly, the regulators were asked if there are any energy scenarios to manage substantial changes due to the increasing displacement of conventional forms of electricity generation at the transmission and

distribution network level with the use of renewable energy sources (RES) and its effect on gas infrastructure utilization. Five countries replied positively, with the following comments:

- **Egypt**

The main responsibility in this regard is part of MOP and MOE's high level strategy making, and the relevant regulators of gas and electricity shall develop the necessary regulations or procedures/rules for all involved parties responsible for infrastructure development.

- **Turkey**

In particular, the scenarios regarding increasing the share of renewable sources are extensively studied by both the ministry and EMRA.

- **Israel**

There are different demand forecast scenarios to check the need of conventional energies. As a result, for example, it was decided to shut down or convert coal-fired power plants' activity.

- **Italy**

The scenarios are developed through a collaboration between the gas and electricity TSOs (SNAM and TERNA).

- **Portugal**

The National Energy and Climate Plan for 2030 and the National Carbon Neutrality Roadmap for 2050 present these scenarios.

It is obvious that the above scenarios must involve policies pertaining to the gas and electricity sectors simultaneously, for example, to decide whether – and to what extent – research and investments aimed at improving batteries to directly store the intermittent RES electricity will lead investments to electrolyze and store hydrogen for future use. Apparently, an optimal compromise will lie somewhere in the middle, which each country will have to evaluate. Therefore, planning for a decarbonized future implies developing a coherent plan for both electricity and gas networks.

3.4 Gas and electricity networks' coordination to achieve full decarbonization

Members have been asked how far their gas and electricity networks rely on each other to achieve full decarbonization, and moreover, if there are any common and binding policies, regulations, or rules in place. The NRAs' replies were the following:

- **Algeria**

At present, there are no binding policies or regulations set for the purpose. The national renewable energy program is based mainly on energy production from solar photovoltaics and aims at achieving the decarbonization of electricity production by reducing the use of fuel and natural gas.

- **Egypt**

The dependency is full as natural gas is the main source for power generation. RES is about 9% of the installed capacity, although it is planned to be almost 22% by 2022 and further rise to 45% or more by 2035. There is an energy strategy binding on the level of higher strategy makers of relevant ministries; such coordination and planning is managed through the energy mix strategy and its relevant functional plans.

- **Turkey**

The Ministry of Energy and Natural Resources coordinate the collaboration between natural gas and electricity system operators.

- **Jordan**

The dependence of the gas and electricity networks on each other still needs development.

- **France**

The multi-annual energy program is the steering tool for/for energy policy (non-binding)'. It dictates the measures and actions that will enable France to decarbonize energy-related sectors and achieve carbon neutrality by 2050.

- **Greece**

There are no such regulations/rules in place.

- **Israel**

The NGA and the Electricity Authority's plans are coordinated, and both set regulations to promote those goals.

- **Italy**

To achieve full decarbonization, TSOs of both the gas and electricity sectors (SNAM and TERNA) collaborate to develop the necessary infrastructures according to the policy of the Ministry of Ecological Transition.

- **Portugal**

Having adopted the strategic documents the National Energy and Climate Plan for 2030 and the National Carbon Neutrality Roadmap for 2050, all subsequent national regulations are now being defined for ensuring full decarbonization.

As a final note on the issue, the scenarios elaborated by the countries may lead to full decarbonization in many ways. Each country's final decision on their decarbonization roadmap will mainly be based on economic data, different for each country. The important question here is how much the complete energy transition will cost and who should/will pay for it. When comparing costs to benefits, an often-non-monetized benefit is a cleaner environment. However, consumers are very reluctant to pay more than the already increased price for energy.

4
CONCLUSION & RECOMMENDATIONS

The current improvement of flexibility and interoperability of energy systems is generally achieved by energy transition strategies.

In this regard, natural gas will remain an energy source in the coming decades depending on the transition pace of the energy systems and will be a key element in fuel switching. At the same time, the role of the functioning gas market will increase with the future development of eco-friendly gases as the gas system will be called for providing a flexibility to the electrical system with high penetration rates of renewable energy sources, by using, for example, more combined-cycle gas turbine (CCGT) units.[21]

To improve flexibility, the ability to manage the intermittency of non-dispatchable power, such as wind and solar power for achieving an equilibrium between supply and demand, is crucial to integrate significant levels of clean power. There are different ways to ensure the real-time matching of supply and demand. For example, gas and coal plants can adjust production up or down to smooth out fluctuations in the output of wind and solar power.

Two facilities are pivotal in this regard: well-designed incentives for encouraging users to modify their consumption via demand-side management programs and battery storage capability to act on the power system as both a generator when discharging and a consumption point (or "load") when charging.

Unfortunately, demand-side management programs are currently not prevalent among different MEDREG members, and battery storage is not adequately "strong" for assuring the management, maintenance, and development of a national high-voltage electricity grid and for dispatching – an activity that involves managing the flow of electricity on the grid at any moment.

Furthermore, few utilities or governments have yet compiled a detailed, quantitative pathway to decarbonize the power sector substantially, and some principles apply widely, depending on the desired level of decarbonization.

National regulatory agencies (NRAs), which have the responsibility to ensure the completion of energy transition in a competitive environment that guarantees the protection of consumer rights, may work along a pathway for the implementation of incentives for demand-side management programs and battery storage. To succeed in that role, NRAs must be built around the following principals: transparency, gradual time horizon, and investor/consumer protection.

Keeping in mind that the process may take a long time to achieve a good framework, it's crucial to have a good and clear relationship between the government and the regulator to attain a well-functioning regulatory framework.

Regarding interoperability (mainly related to gas quality was considered and explained in chapter 2), natural gas pipelines carrying alternative, more eco-friendly fuels (biogas, hydrogen, and other renewable or decarbonized gases) are technically feasible and have been employed in various locations, as described in chapter 3. Unfortunately, the laying of such pipelines is very costly, and the duration for reshuffling the existing infrastructures is not so short.

[21] For more details on how the gas market can foster energy transition, please read the MEDREG report on "Design mechanism for gas market to foster energy transition" – 2021

The transmission lines for balancing production across geographies with different interoperability standards and different certificates of guarantee for the use of alternatives gases may hinder a regional market integration. An appropriate and consistent regulatory system should be shared between neighbouring countries to facilitate gas transport that finally creates a fully functioning and interconnected Mediterranean gas market.

Pertaining to the energy scenario, on the one hand, the European Green Deal constitutes a plan to decarbonize the EU economy by 2050, revolutionize the EU's energy system, profoundly transform the economy, and inspire efforts to combat climate change[22], but, on the other hand, the European Union must reckon the differences arising from imperfect governance that emphasizes the differences between the Member States[23].

The European Union imported more than 320 billion euros of "energy" in 2019, and over 60% of its imports from Russia constitutes gas and oil. Europe is the second largest net importer of crude oil and consumes about 20% of world supplies. Ceasing the use of fossil fuels, with the goal of reaching climate neutrality by 2050, will have an impact on world markets: it will lower prices and reduce the income of the main exporters.

According to projections by the European Commission, fossil fuels will continue to provide around half of the energy the EU requires up to 2030. By then, the use of coal will be significantly limited. Actions will be taken reducing the use of oil and natural gas above all between 2030 and 2050: regarding oil, the aim is to gradually eliminate its use, while methane would remain at about 10% of the pie chart indicating energy consumption. According to Mark Leonard, Jean Pisani-Ferry, Jeremy Shapiro, Simone Tagliapietra, and Guntram Wolff[24] the energy transition that should reduce oil and gas bills is estimated at 296 billion euros in 2018. At the same time, dependence to China and other countries rich in minerals and metals will increase and will be necessary to produce solar panels, wind turbines, lithium-ion batteries, fuel cells, and electric vehicles. Waiting for the energy transition that will eliminate dependence on Russia as well as reduce oil and gas bills, today oil prices is soaring, and Europe is out of gas[25].

The energy markets are driven by demand and offer, and today, it is the demand that dominates, as well as production. In fact, demand is strongly driven by Chinese and Asian needs.

Surely the price signals also direct investments and make renewables even more competitive. Investments in grids should grow rapidly, but let's not forget that electricity grids are decisive for the dispatching of renewable sources that cannot produce power throughout the day but require basic energy, which is inevitably still produced from coal, nuclear, or gas. Before that, Europe will undergo a transition that is likely to last at least twenty years (see footnote no. 22)

[22] European Commission (2020) 'Stepping up Europe's 2030 climate ambition: investing in a climate neutral future for the benefit of our people', SWD/2020/176, available at https://eur-lex.europa.eu/resource.html?uri=cellar:749e04bb-f8c5-11ea-991b01aa75ed71a1.0001.02/DOC_1&format=PDF. European Commission (2020a) 'A hydrogen strategy for a climate-neutral Europe', COM(2020)

[23] Valeria Termini, Energia la grande trasformazione, Laterza, 2020

[24] Mark Leonard, Jean Pisani-Ferry, Jeremy Shapiro, Simone Tagliapietra e Guntram Wolff,
The geopolitics of the European Green Deal, Policy Contribution, European Council on Foreign Relations (Ecfr) and Bruegel Institut, February 2021

[25] Stefano Saglia, Member of the Italian Regulatory Authority for Energy, Networks and the Environment. https://formiche.net/2021/09/petrolio-gas-saglia/

Considering the energy integration process to achieve decarbonization, it is uncertain how it will evolve in practice. It could be suggested that a gradual and flexible regulatory approach based on the peculiar development of the energy market and infrastructure of each country will help this process. As a first step of the NRAs, it is important to define the general regulatory principles, in addition to periodically monitoring the new energy sectors to identify whether more regulation is needed.

The regulators should also highlight the importance of developing new assets based on the needs of the energy system and choosing the most cost-efficient solutions in consideration of the different decarbonization scenarios. Infrastructure costs should be allocated in a transparent way to those who will benefit from them, thus avoiding cross-subsidization among consumers in different sectors.

In that regard, if the network shows characteristics of natural monopoly and can be considered an essential facility, there is a structural risk of an abuse of market power that would need to be addressed by defining general regulatory principles with minimum requirements.

Co-funded by
the European Union

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