MEDREG

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FRAMEWORK FOR THE DEVELOPMENT OF ENERGY STORAGE AND DISTRIBUTED FLEXIBILITY RESOURCES

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Environment, Renewable Energy Sources and Energy Efficiency Working Group (RES WG)

Empowering Mediterranean regulators for a common energy future

ABOUT MEDREG

MEDREG is the Association of Mediterranean Energy Regulators, uniting 28 regulators from 23 countries across the European Union (EU), the Balkans, and the MENA region. Established in 2007 and co-funded by the European Union, MEDREG serves as a platform for cooperation, knowledge sharing, and capacity building in energy regulation. It promotes coherent regulatory approaches and practices at the regional level, aiming for progressive market integration within the Euro-Mediterranean basin. To support its members, MEDREG organises training sessions, workshops, and tailored hands-on initiatives that enhance the capacity of energy regulators.

MEDREG's ultimate goal is to establish an integrated Euro-Mediterranean energy market that strengthens energy security and drives a clean energy transition. This includes integrating renewable energy sources, reinforcing cross-border infrastructure, promoting innovation, enhancing energy efficiency, and advancing renewable gases such as hydrogen. Additionally, MEDREG advocates for transparent and non-discriminatory regulation to attract infrastructure investments, modernise electricity and gas markets, and improve consumer protection.

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EXECUTIVE SUMMARY

This document examines the current state of the market as well as opportunities for energy storage (gas and electricity) and distributed flexibility resources (DFR) across the Mediterranean region. It aims to illustrate their practical applications and associated regulatory frameworks. The analysis is complemented by case studies from the region, showcasing the tangible benefits of these solutions in real-world scenarios. Finally, the document proposes actionable recommendations to strengthen regulations and promote the development of these technologies to unlock their full potential.

The report underscores the importance of advancing energy storage and DFR solutions, which are often undervalued and insufficiently supported by existing regulatory frameworks. The regulatory analysis is divided into two key areas: energy storage in electricity, and natural gas markets and DFR.

Regulatory Landscape: The regulatory landscape for energy storage in the Mediterranean region is highly diverse, reflecting different levels of renewable energy integration and energy storage adoption. Countries are categorised into three tiers based on the level of regulatory support:

1. **Advanced Frameworks**: Five countries have robust and advanced frameworks facilitating energy storage development.
2. **Supportive but Limited Frameworks**: Five countries have frameworks that provide some support but lack comprehensive measures.
3. **Minimal or Non-existent Frameworks**: The other four countries either mention energy storage in their regulatory frameworks without offering significant incentives or have no specific frameworks in place.

Technology Adoption: For electricity storage, technologies such as hydro-pumping stations and solar photovoltaics (PV) with batteries are the most widely implemented, depending on resource availability. In the natural gas sector, liquefied natural gas (LNG) storage facilities dominate across the region, particularly in countries like Algeria, Egypt, France, Greece, Spain, Portugal, and Türkiye. Additionally, France and Türkiye utilise other storage methods, such as depleted reservoirs and aquifer storage facilities.

Distributed Flexibility Resources (DFR): The deployment of DFR plays a critical role in achieving energy transition goals and zero-emission targets. Distributed flexibility resources offer numerous benefits, including economic gains, improved grid stability, enhanced energy efficiency, and increased integration of renewable energy sources. However, the level of DFR implementation varies significantly across the Mediterranean, influenced by each country's energy priorities and challenges.

- Countries like Portugal, Greece, and Türkiye are at the forefront of DFR adoption, driven by the need to integrate higher shares of renewables and decarbonise both the energy and transport sectors.
- Conversely, countries such as Albania, Algeria, and North Macedonia are focusing on diversifying their energy mix through renewable energy projects—particularly solar PV and wind—before fully committing to DFR solutions.

The report identifies key drivers for DFR adoption, types of DFR technologies in use, challenges, and best practices to guide further implementation across the region.

Hybrid Generation: The report also explores hybrid generation in the Mediterranean, including its definition, implementation, and prevalent technologies. Hybrid systems combine multiple energy sources, offering enhanced flexibility and reliability. These systems are gaining traction as countries seek innovative ways to address the challenges of renewable energy integration and grid stability.

Case Studies

Two case studies are included in the Annex:

1. **Portugal**: The Integrated Flexibility in a Market Regime (FIRMe) pilot project, which explores flexibility services in the energy market.
2. **Lebanon**: An example of distributed flexibility resource deployment in challenging regulatory and market conditions.

This comprehensive analysis provides valuable insights into the state of energy storage and DFR in the Mediterranean region. It highlights the critical need for enhanced regulatory support, targeted investments, and the adoption of best practices to address the unique challenges of each country. By leveraging these insights, policymakers and stakeholders can drive the development of sustainable and resilient energy systems across the region.

1. Report Context & Objective

The Mediterranean energy sector is at the threshold of transformation, driven by the urgent need to decarbonise and accelerate the integration of renewable energy sources. These shifts are crucial for achieving climate goals, ensuring energy security, and modernising the grid. However, this transformation comes with challenges, particularly the need for an enabling regulatory framework that supports the deployment of advanced technologies and innovative business models. The success of this transition will rely on the effective coordination of energy storage and distributed flexibility resources.

Energy storage, both in gas and electricity, as well as distributed flexibility resources like hybrid power generation, smart grids, and smart meters, will play a pivotal role in stabilising energy supply and demand. These technologies are essential for balancing intermittent renewable generation, optimising grid performance, and enhancing consumer participation in energy systems. As the region's energy landscape becomes more decentralised, flexible resources will enable a smoother transition by providing the necessary infrastructure to manage the complexities of a diversified energy mix.

Prepared by the RES WG, this report aims to deliver a comprehensive analysis of the current regulatory framework governing energy storage and distributed flexibility resources across the Mediterranean region. By focusing on energy storage technologies (e.g., batteries) as well as hybrid renewable systems (e.g., solar and wind or solar and hydro combinations), it seeks to emphasise the critical role these innovations play in enhancing grid efficiency, reliability, and consumer engagement.

Smart grids and smart meters, in particular, are highlighted as indispensable tools for developing new services and deploying DFR. These technologies not only improve grid management but also empower consumers by providing real-time information and control mechanisms. By actively managing their consumption patterns or improving energy efficiency, consumers become essential contributors to the overall stability and efficiency of the electric system.

The report also explores case studies from Portugal and Lebanon, showcasing best practices and successful implementations of energy storage and flexibility solutions. Through these examples, it offers valuable insights into how regulatory frameworks, market conditions, and technological innovations are shaping the future of energy in the Mediterranean. These case studies, available in the Annex, illustrate how storage solutions improve the controllability and efficiency of renewable energy generation and how hybrid systems optimise network utilisation.

In conclusion, this report provides actionable recommendations for enhancing regulations, fostering innovation, and accelerating the deployment of energy storage and distributed flexibility resources. By addressing these critical factors, the Mediterranean region can unlock the full potential of these technologies, supporting a more resilient, flexible, and sustainable energy system that can drive the energy transition forward.

2. Methodology & Definitions

Based on a benchmarking exercise sent to members of MEDREG's RES WG, the report encompasses three main aspects: hybrid power generation, energy storage, and DFR. In addition, it includes specific case studies from Portugal and Lebanon.

The benchmark was designed to assess the current status of these aspects in the Mediterranean region as well as the maturity of the regulatory framework. This methodology ensured that the report was informed by the experiences across the region and that the recommendations were tailored to the specific challenges and opportunities facing MEDREG members.

Figure 1. *MEDREG Members' Replies to the Benchmark*

For clarity, MEDREG's RES WG has proposed a list of definitions applied in the benchmarking and the report. They are as follows:

- **Energy Storage for Electricity**

Pumped Hydroelectric Energy Storage (PHES): Uses electricity to pump water uphill and releases it through turbines to generate electricity when needed.

Battery Storage: Employs batteries to store excess electricity and discharge it to the grid when required.

Flywheel Energy Storage (FES): Stores energy in a rotating flywheel and releases it back to the grid when necessary.

Compressed Air Energy Storage (CAES): Stores energy by compressing air into underground caverns and releases it to generate electricity when needed.

- **Distributed Flexibility Resources**

Demand-Side Response (DSR): Programmes or incentives that encourage consumers to adjust their electricity consumption patterns in response to grid conditions or price signals. For example:

- Direct Load Control: Consumers utilise control devices (e.g., thermostats) to reduce demand during peak periods.
- Demand Response Programmes (DRPs): Consumers receive incentives to reduce or shift their electricity usage during peak periods.

Distributed Energy Resources (DER): Small-scale generation, storage technologies, and demand-side flexible resources located near the point of use. Examples include:

- Solar PV: Systems that convert sunlight into electricity
- Wind Turbines: Generators that harness wind to produce electricity
- Combined Heat and Power (CHP): Systems that generate electricity and heat simultaneously
- Energy Storage: Systems that store energy for later use
- Electric Vehicles (EV)
- Heat Pumps and other Controllable End-User Technologies

Electric Vehicles: Vehicles powered by electricity, including:

- Battery Electric Vehicles (BEV): EVs that exclusively use batteries for propulsion
- Plug-in Hybrid Electric Vehicles (PHEV): EVs that can be plugged in to charge batteries and have another fuel engine (such as gasoline)

Building Energy Management Systems (BEMS): Systems that monitor and control energy consumption in buildings.

Microgrids: Localised electricity grids that can operate independently from the main grid, often incorporating DFR.

- **Role of Balancing Mechanisms and Flexibility Mechanisms in Ensuring Generation and Consumption Adequacy**

The core principle of electricity systems is that generation and consumption must be balanced at all times to maintain stable grid frequency. Traditionally, this has been achieved via two complementary mechanisms: balancing and flexibility.

The balancing mechanism provides corrective actions in real-time, centrally managing short-term mismatches between supply and demand. In contrast, flexibility mechanisms encompass various components that offer medium- to long-term adaptability through both centralised and decentralised approaches, enhancing the grid's resilience and capacity to manage variable energy sources.

- **Traditional Needs**

Historically, flexibility needs were met in a simpler energy landscape: the balance between generation and consumption was maintained by adjusting generation. In a centralised system, where a limited number of large power plants supplied electricity unidirectionally to consumers, classic infrastructure (such as one-way grids and analogue meters) was managed by integrated companies. Here, transmission operators bore primary responsibility for grid stability. In this context, hydroelectric power stations, especially those with reservoir storage, were key sources of flexibility due to their responsiveness. Thermal power stations also provided adaptability, though they required pre-heating. Meanwhile, nuclear plants, designed for constant output, offered limited flexibility by modulating downwards when necessary.

- **New Imperatives with the Rise of Renewable Energies**

The contemporary need for flexibility differs markedly from the traditional model, primarily due to the expansion of renewable energies like solar and wind power, which introduce significant variability into the grid. The once-centralised system has now been supplemented by a decentralised level, where numerous small- and medium-sized independent producers, or "prosumers", not only consume electricity but also inject surplus power back into the grid. This shift has transformed power flows into bidirectional exchanges, facilitated by smart grids and advanced meters that connect prosumers primarily through the distribution network.

This new paradigm necessitates robust flexibility solutions to address the intermittency of renewable energy sources, which depend on weather conditions. As a result, large-scale coordination and cooperation among a diverse array of electricity system actors have become essential.

Demand-side flexibility has emerged as a crucial tool, as discussed in the 2023 report of the RES group. Through tariff signals, consumers are incentivised to adjust their electricity use, aligning it with availability. Public awareness initiatives are also educating consumers on managing consumption effectively, which can lead to significant energy savings. Additionally, the deployment of battery storage systems and other storage technologies is expanding to help buffer supply fluctuations. Green hydrogen storage is also showing promise for seasonal storage. Hydrogen can be produced and stored, offering an adaptable form of stored energy that serves multiple sectors.

3. Overview of the Regulatory Framework for the Development of Energy Storage and Distributed Flexibility Resources (DFR)

As stated in the introduction, the need for decarbonisation, energy security, and the integration of renewable energy sources is gaining importance and urgency. However, the deployment of energy storage systems and DFR is subject to a diverse and evolving regulatory framework across Mediterranean countries. The section below provides an overview of the region's current regulatory stance on energy storage.

3.1 Countries with Advanced Regulatory Frameworks for Energy Storage

These countries have relatively mature regulatory frameworks, largely driven by the high integration of renewable energy sources and the need for flexibility to manage the intermittency of renewables.

- **Cyprus**

Cyprus faces challenges due to its isolated grid and heavy reliance on imported energy. The country's regulatory efforts are focused on integrating energy storage to ensure stability and reduce energy import dependence. The government is developing frameworks that support both grid-scale and distributed storage systems, enabling the integration of solar and wind energy, which are abundant in the region.

- **France**

France maintains a supportive regulatory stance on energy storage, with clear incentives for its development. This aligns with the country's broader energy transition and decarbonisation goals. The Pluriannual Energy Programme (PPE), enforced by Decree No. 2020-456 of April 21, 2020, targets the development of 1.5 GW of pumped storage capacity between 2030 and 2035, reflecting the function of energy storage in achieving carbon neutrality by 2050.

Additionally, the regulatory framework, such as the Tarif d'Utilisation des Réseaux Publics d'Électricité (TURPE), supports storage integration by covering part of the costs to connect storage installations. While some adjustments may still be needed to enhance the competitiveness of storage solutions, France's overall stance remains strongly favourable with robust incentives, particularly for large-scale storage projects.

- **Greece**

Greece is advancing in energy storage regulations as it adopts higher renewable energy penetration. With islands and isolated regions as a key focus, energy storage is critical to reducing renewable energy

curtailments and ensuring a stable power supply. Regulations in Greece provide incentives for energy storage deployment, particularly as the country transitions away from fossil fuels towards a cleaner energy mix. The regulatory framework is aligned with European Union directives, promoting storage to balance grid stability.

- **Italy**

The development of electricity storage systems, particularly battery energy storage systems (BESS), plays a significant role in the national strategy for the sustainability of the energy system, both from the perspective of primary legislation and regulation. Under the first aspect, it should be noted that the National Integrated Energy and Climate Plan (PNIEC) provides for the availability of an additional 80 GWh of utility-scale storage capacity by 2030, 10% of which is already contracted through the capacity market mechanism. For small-scale installations, the government has introduced important incentives in the form of tax rebates as part of the policy to increase the energy efficiency of buildings (the so-called "super bonus"). Further resources have been made available in the framework of the Recovery and Resilience Plan implementation, with a focus on research and development aimed at building and deploying sustainable BESS appliances.

From a regulatory lens, the National Regulatory Authority (NRA) is committed to substantial reforms in the overall electricity dispatching system, which would enhance flexibility and the entry of all available resources, including BESS, into the ancillary services market.

Regarding gas storage's contribution to energy security and system flexibility, Italy has a longstanding legislative and regulatory experience, stemming from the country's status as a major natural gas importer and consumer (see below, specific item). However, electricity and gas storage are mostly dealt with separately. The development of and access to gas storage facilities and markets has indeed been seen as a "structural" element in creating an interconnected and effective gas market; legislative and regulatory support for BESS has received more attention recently, as the Net Zero strategy and the rise of RES have gained pace.

- **Spain**

Spain stands as a European leader in renewable energy, driven by ambitious 2030 targets to deepen its green transition. This commitment includes substantial investments in energy storage under the updated National Integrated Energy and Climate Plan. Recent regulatory developments have focused on paving the way for the future development of the aggregator figure—a key player intended to coordinate small energy producers and consumers. These regulations open all market segments and operational services to energy storage solutions, whether as standalone systems or integrated with renewable generation.

To support its goals, energy promoters have diversified their energy storage and hybrid projects to optimise renewable energy management and enhance grid stability. These initiatives include standalone lithium-ion battery storage, thermal storage, and emerging technologies such as green

hydrogen storage. This multifaceted approach aims to support the grid, ensuring flexibility and resilience as renewable capacity expands.

Concerning the development of DFR in Spain, small-scale generation has been promoted for a long time. New legislation focused on grid interconnection enables access for storage and hybrid projects that combine multiple renewable sources on a single site. Time-of-Use (TOU) pricing is applied universally to balance peak and off-peak demand, encouraging energy consumption during off-peak hours to optimise grid efficiency. Demand Response Programmes, primarily targeting large consumers, offer incentives for shifting or reducing demand during peak periods, supporting grid stability. Spain's EV infrastructure is expanding, emphasising public charging stations with time-based tariffs to promote flexible use and align with decarbonisation targets. Finally, the net metering system provides economic compensation for energy surpluses generated within the same hour; this approach encourages immediate consumption of self-produced energy, reducing reliance on the grid as "virtual storage" and promoting efficient energy use within the self-consumption model.

3.2 Countries with Supportive Frameworks, Limited Incentives, or Unclear Regulations

These countries have supportive frameworks but are at an early stage of implementation, with varying degrees of incentives and clarity.

- **Lebanon**

Lebanon is still in the early stages of integrating energy storage as part of its renewable energy strategy. Currently, energy storage operates at a decentralised level, primarily supporting individual installations to enhance energy security and mitigate power outages. Last year, tax exemptions were introduced not only for specific types of batteries used in solar PV systems but also for solar panels and inverters, stimulating adoption across residential and commercial sectors. Additionally, feasibility studies are underway to explore Concentrated Solar Power (CSP) technologies, focused on leveraging thermal storage to support grid stability. While further regulatory clarity is necessary, these initiatives reflect Lebanon's commitment to advancing renewable energy and building a more sustainable, resilient future.

- **Morocco**

Morocco has made significant strides in promoting energy storage, especially since 2023, when Law 82.21 (auto-generation) and Law 40.19 (renewable energy development) were introduced. These laws grant private investors the right to develop energy storage systems, although specific conditions are still being defined by the executive decrees. Additionally, Morocco's National Authority for Electricity Regulation (ANRE), offers system service tariff exemptions for renewable energy projects with a stable production profile, particularly when coupled with energy storage systems. This encourages investment in storage to manage the intermittency of renewables. Morocco's experience with pumped

hydro storage (PHS) positions it as a regional leader in energy storage, but more incentives for newer storage technologies like batteries are still evolving.

- **North Macedonia**

North Macedonia is facing regulatory challenges, with no clear guidelines for energy storage deployment. The country's renewable energy targets, especially in solar and wind, are ambitious, but storage is not fully integrated into the energy planning process yet. This regulatory gap leaves the country without a clear pathway for deploying storage alongside renewable projects, hindering efforts to improve grid reliability.

- **Portugal**

Portugal's regulatory framework has some provisions for energy storage, particularly hydro-pumping, which remains the dominant storage technology. Decree-Law No. 15/2022 created a legal basis for autonomous storage facilities, but specific rules for battery storage, especially those not tied to self-consumption, are still lacking. Storage is exempt from network access tariffs when electricity is re-injected into the grid—a move aimed at promoting the integration of storage. However, the country is yet to develop clearer incentives and pricing signals for technologies beyond hydroelectric storage to address the growing need for flexibility in its increasingly renewable-heavy grid.

- **Türkiye**

Türkiye has had a regulatory framework for energy storage since 2021, which focuses on supporting renewable energy projects tied to storage. While the regulations are clear, direct incentives are limited. Licensed renewable generation paired with energy storage enjoys some indirect incentives, such as exemption from certain licensing requirements. Türkiye is also developing its natural gas storage regulations to enhance energy security, especially through underground storage facilities. However, the country is still in the early stages of widespread energy storage deployment, with regulations continuing to evolve as storage becomes more critical for grid balancing.

3.3 Countries with Neutral or Absent Frameworks for Energy Storage

In these countries, energy storage is not yet a priority, and there are no specific regulatory frameworks or incentives in place. This reflects either the early stages of renewable energy development or a focus on other energy priorities.

- **Albania**

In Albania, the regulatory framework for energy storage is underdeveloped. Amendments to the law on the power sector are still being drafted, with no clear timeline for when storage regulations will be implemented. The country is at the very early stages of considering energy storage, which is critical given Albania's reliance on hydropower and the potential for storage to support grid stability during dry seasons.

- **Algeria**

Algeria's regulatory framework does not provide for energy storage, despite the country's potential to leverage its vast renewable energy resources. The absence of storage regulations means there is little incentive for private or public investment in storage technologies, even though energy storage could play a vital role in balancing the grid as renewable energy penetration increases.

- **Egypt**

Egypt is another country where energy storage regulations are still in development. While the country has ambitious goals to integrate 7.5 GW of battery storage and 6.4 GW of pumped storage by 2040, current regulations do not provide clear guidelines for energy storage. EgyptERA has drafted a Terms of Reference (ToR) for developing storage regulations, but these are yet to be implemented. Egypt's growing reliance on renewable energy, particularly solar, highlights the urgent need for regulatory clarity to facilitate storage deployment.

- **Jordan**

Although Jordan is taking initial steps towards integrating energy storage into its energy strategy, the regulatory framework is still in its infancy. The government is working on policies to support grid-scale and distributed storage systems, and there are discussions about introducing financial incentives or tax benefits for storage projects. However, more concrete regulatory actions are needed to encourage large-scale storage deployment, particularly as the country increases its share of renewable energy.

In conclusion, the regulatory landscape for energy storage in the Mediterranean region is highly diverse, reflecting varying levels of renewable energy integration and energy storage experience. However, most countries have at least one specific regulation addressing the deployment of DFR, as illustrated in the figure below:

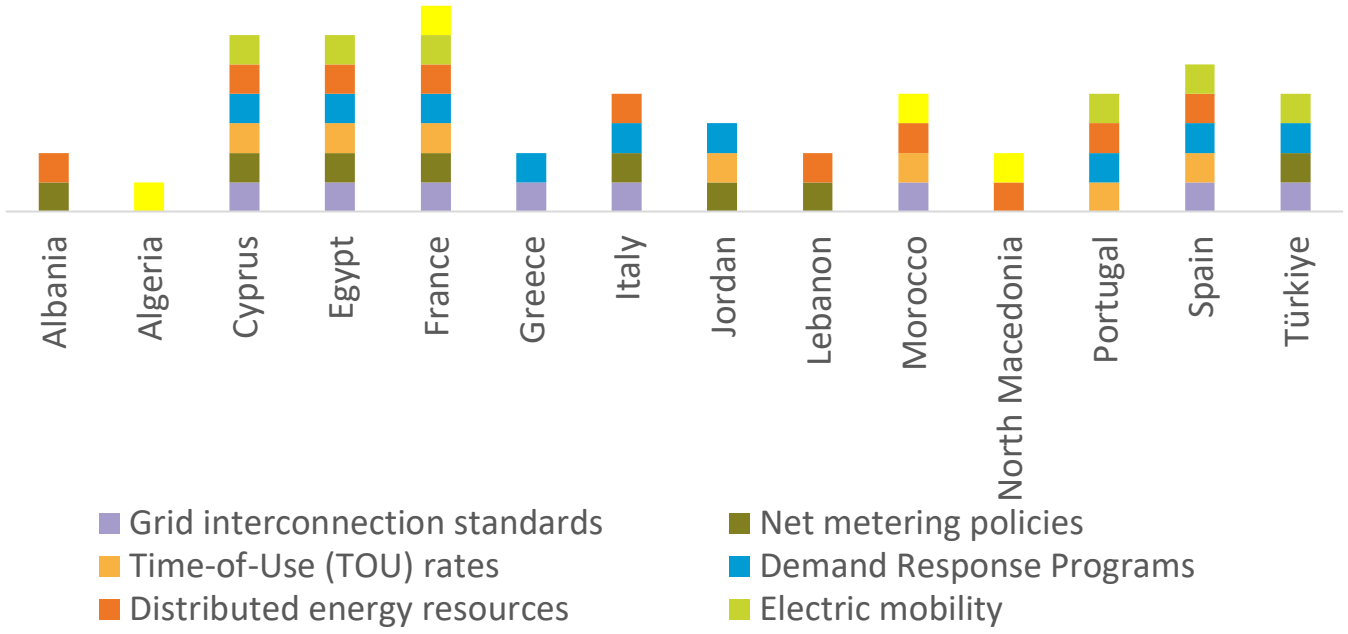

Figure 2. *Specific Regulation Addressing the Distributed Flexibility Resources*

In Jordan, TOU applies exclusively to the medium and large industrial sectors, water pumping sector, electric vehicle charging sector (residential and public stations), and communication sector.

In Algeria, there are studies relating to the flexibility measures provided by the transmission operator. On the other hand, for North Macedonia, there is currently no clear picture regarding energy storage, particularly about when to inject or withdraw electricity from the grid. Lastly, Morocco's regulatory framework permits the deployment of distributed energy resources and the development of energy storage systems. However, these laws still require the issuance of certain decrees for implementation.

Additionally, Morocco implements time-of-use rates, particularly for large consumers and professionals. There are specific tariffs for peak hours, full hours, and off-peak hours.

3.4 France's Regulatory Framework for Electric Mobility, Self-Consumption, and Smart Grids

The details regarding the regulatory framework applied in France include:

- **Grid Interconnection Standards**

According to the French Energy Code, the CRE (Commission de Régulation de l'Énergie) is responsible for ensuring efficient, transparent, and non-discriminatory interconnection systems for electricity and gas networks. The TURPE tariff framework covers costs related to the connection of storage and renewable energy production installations, promoting integration within European markets.

- **Net Metering Policies**

Although France does not have an explicit one-to-one net metering scheme, self-consumption and surplus injection into the grid are regulated under Article L. 315-1 and Article R. 314-1 of the Energy Code. This allows individuals or communities to benefit from fixed tariffs for the surplus energy they inject into the grid.

- **Time-of-Use Rates**

Articles L. 341-4 and R. 341-10 of the Energy Code regulate TOU rates, encouraging flexible energy use by allowing variable pricing across the day. This system incentivises consumers to shift usage to off-peak hours, supporting demand-side management.

- **Demand Response Programmes**

Articles L. 271-1 and L. 271-2 provide a regulatory framework for demand response, enabling consumers to adjust energy usage in response to grid needs, thereby enhancing overall system flexibility. Consumers are compensated for reducing or shifting consumption during peak periods.

- **Distributed Energy Resources**

The French regulatory framework, as outlined in Articles L. 321-1 and L. 341-4, promotes the deployment of DERs such as solar and wind, as well as small-scale storage. Regulations ensure grid access and provide mechanisms for compensation of surplus energy injected into the grid.

- **Electric Mobility**

Articles L. 353-1 and R. 353-1 govern the deployment of EV infrastructure, supporting the integration of electric mobility into the grid. The framework regulates EV charging points, energy tariffs, and vehicle-to-grid (V2G) technologies, enabling EVs to act as mobile energy storage.

3.5. Portugal's Regulatory Framework for Electric Mobility, Self-Consumption, and Smart Grids

Portugal has developed specific regulations and codes that govern electric mobility, self-consumption, and smart grid services. These regulatory measures are part of the country's efforts to enhance flexibility, improve consumer engagement, and support the integration of renewable energy sources.

- **Electric Mobility Code**

The Electric Mobility Code outlines the rules for interactions between different players in the electric mobility ecosystem, including suppliers, charging point operators, system operators, and the Electric Mobility Network Managing Entity (EGME). Consumers, known as electric vehicle users, establish contracts with electric mobility suppliers (CEME) for EV charging services. The EGME ensures the smooth data flow necessary for accurate billing, thus streamlining the commercial relations between all involved parties.

- **Self-Consumption Code**

The Self-Consumption Code governs the relationships between parties in individual and collective self-consumption setups. It has provisions for metering, data handling, energy-sharing mechanisms, and applicable regulated tariffs. The code also integrates aspects of smart grid services, which are crucial in the self-consumption regime, as well as guidelines in the "Guide for Measurement, Readings, and Data Handling" to accommodate the unique needs of this system.

- **Smart Grids and Smart Meters**

Although smart meters themselves are not considered flexible resources, they play a vital role in enabling demand response and other flexible energy services by providing consumers with real-time data and accurate metering. The Smart Grid Services Code (RSRI), approved in 2019 and revised in 2023, defines a range of services provided by distribution system operators (DSOs), such as:

- Daily remote meter reading and detailed 15-minute interval data
- Bills based on actual consumption
- Real-time local meter access
- Remote modification of contracted power
- Alerts for consumption levels and power usage

DSOs offering these smart grid services are eligible for incentives that share the costs and benefits with consumers, thus encouraging service adoption.

Decree-Law No. 15/2022 mandates the installation of smart meters in low-voltage distribution networks by the end of 2024, with integration into smart grids also set for completion by the same date.[1]

By the end of the third quarter of 2024, the smart meter rollout reached 98% of smart meters deployed and 88% integrated into a smart grid. The objective is to achieve 100% integration by the end of 2024.

- **Demand Response and Flexibility**

Demand Response Programmes are integrated into Portugal's system and flexibility services under the Manual of Procedures for the Global Management of the System (MPGGS)—a sub-regulation of the Regulation for Grid Operations (ROR). A pilot demand response project, launched in 2019, tested consumer participation in system services, mobilising 73,982 MWh of energy and generating €5.6 million in turnover. Following the pilot's success, demand participation has been incorporated into the regulatory framework, though discussions on specific tariffs for demand response services are ongoing.

[1] The Portuguese grid code defines a "distribution smart grid" as a "low voltage electric distribution network that allows to integrate the behaviour and actions of all users connected to it in an efficient way".

- **Flexible Network Connections for Generators and Batteries**

A public consultation has been launched on new rules for flexible network connections for generators and batteries, in line with Portugal's power sector national law. These rules allow transmission system operators (TSOs) and DSOs to offer both firm and extra capacity to network users, subject to restrictions communicated in advance. Users can eventually convert this capacity into firm capacity by paying additional costs once the grid is upgraded to support it.

- **Pilot Projects and Innovation**

The Code for Network Operation (ROR) includes provisions that enable regulated entities to propose pilot projects aimed at testing innovative solutions. For example, a recent assignment required medium-voltage DSOs to submit a pilot project focused on congestion management services.

- **Grid Interconnection Standards**

Portugal's grid interconnection standards are defined by both European grid codes and national regulations. The national legal framework is overseen by the Directorate-General for Energy and Geology (DGEG), which manages the licensing of the national transport and distribution networks, separate from the national regulatory authority. These standards ensure efficient integration of energy storage, flexible resources, and renewable energy into the grid.

4. Energy Storage in the Mediterranean Region

The existing conditions of energy storage projects in the Mediterranean region vary significantly among countries, with Portugal, Lebanon, and Türkiye leading the charge in growth and potential, while countries like Albania and Algeria exhibit stagnation. Emerging markets in Egypt, Cyprus, and North Macedonia show promise for future developments, albeit facing certain challenges. Overall, the region has a mixed landscape of energy storage development, highlighting the importance of supportive regulatory frameworks, financing options, and strategic investments to realise the full potential of energy storage in the energy transition.

4.1 Analysis of Energy Storage – Electricity

- **Albania**

The amendments to the law on the power sector are paving the way for future energy storage projects, which could be enhanced by legislative support. The focus on policy amendments indicates potential for growth.

- **Algeria**

Energy storage is not yet in place, at least for large-scale use; in terms of isolated systems, Algeria has been combining energy storage with solar PV generation in agriculture and small towns in the desert.

- **Cyprus**

The advancement of energy storage markets in Cyprus faces financial hurdles, making it less attractive compared to other energy solutions like solar PV. Without policy interventions, growth in this sector is likely to be slow.

- **Egypt**

Pending strategic approvals, Egypt shows promise in energy storage development. Once approved, the integration of storage could significantly enhance grid stability. The self-consumption scheme allows usage of batteries for storage from PV power plants.

- **France**

Energy storage in the electricity sector is emerging, with significant potential for future growth. The current regulatory framework is well-developed and will ease the implementation of future projects.

- **Italy**

The recent (October 2024) approval of the Long-Term Storage Capacity Procurement mechanism ("MACSE") has relaunched the BESS deployment process, which was seen as stagnating in the last few years due to permit issues and the rising costs of materials and facilities. While small capacity is expected to grow by 0.5 GW per year, the MACSE system should bring new utility capacity (large-scale projects) to add 9 further GW, reaching the target of around 15 GW by 2030 (this figure does not include the hydropower storage of 8 GW, which is not expected to grow).

- **Jordan**

Interest in energy storage is emerging; implementation depends on positive feasibility assessments.

- **Lebanon**

Lebanon has established a degree of maturity in energy storage with PHES, which could serve as a foundation for expanding further energy storage technologies. Moreover, the economic crisis and the removal of fuel subsidies have led to a boom in solar PV installations. Given that the shortage of electricity supply worsened in this period, a simultaneous boom in battery storage has been witnessed at the decentralised level.

- **Morocco**

Morocco's regulatory framework encourages private investment in energy storage, presenting an opportunity for significant growth in this sector as costs continue to decline.

- **Portugal**

Storage in hydroelectric power plants with pumping is considered a mature technology. Electricity storage in batteries is emerging and promising, either by harnessing the potential of EV batteries for controlled charging (intelligent load control) or deploying new grid-connected battery storage to participate in system regulation.

There are a few good examples of battery storage in the islands of the archipelagos of Madeira and Açores.

In the Madeira archipelago, there are two battery storage units on the island of Porto Santo: one with a capacity of 5.4 MVA and 3.3 MWh (operational since December 2019) and another with 12.0 MVA and 17.9 MWh (expected to commence operations in 2024). Madeira Island has two additional units: one with 23.7 MVA and 16.4 MWh (operational since September 2022) and another with 27.0 MVA and 16.1 MWh of capacity expected to be operational by December 2024 (more information can be found at https://eeminov.eem.pt/cb/).

In the Açores archipelago, a battery storage unit on the Island of Terceira began operations in March 2023, featuring a capacity of 15.0 MVA and 10.5 MWh. On the island of Graciosa, a battery energy storage system linked to a wind and a solar farm (operational since 2019), sells energy through a power purchase agreement to the local supplier (and DSO)[2].

- **Türkiye**

The regulation on energy storage has been in effect since 2021. Electricity energy storage is considered mature, particularly in the context of hydroelectric power plants.

- **Spain**

In Spain, energy storage through pumped hydroelectric plants is a well-established and widely implemented technology. Presently, Spain has 18 pumped-storage plants with a combined capacity of 6 GW. The PNIEC 2023-2030 aims to add 3.5 GW, reaching a total of 9.5 GW by 2030. This expansion will facilitate the integration of renewable energy and improve the flexibility of the electrical system. For example, the Chira-Soria project in Gran Canaria, currently under construction, is expected to have a capacity of 200 MW and 3.5 GWh. Once operational, it will play a vital role in grid stability by storing renewable energy surpluses and releasing them during peak demand periods.

Battery storage, on the other hand, is an emerging technology with significant potential across both the mainland and the islands. As part of Spain's Strategic Energy Storage Plan, efforts are being made to promote battery storage, including the integration of EVs with controlled charging systems and the installation of grid-connected batteries for system regulation. According to data managed by the system operator, in 2024, the total access capacity for stand-alone battery projects in Spain is expected to reach 17 GW, with 7.2 GW in the transmission network and 9.8 GW in the distribution network. Of this capacity, 48 MW have already been commissioned (37 MW in distribution and 11 MW in transmission). Currently, an additional 7.85 MW are under construction (4.75 MW in transmission and 3.1 MW in distribution).

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[2] *More information and images at:*

https://www.eda.pt/Mediateca/Anuncios/Paginas/Anuncio-Detalhe.aspx?item=312&lista=Notas+de+Imprensa

https://www.eda.pt/Mediateca/Publicacoes/Paginas/BateriasArmazenamentoEnergiasRenov%C3%A1veisilhaTerceira.aspx

https://www.eda.pt/Mediateca/Publicacoes/Lists/EDAINFORMA/Attachments/162/EDAINFORMA_169_OUT%202019.pdf)

The remaining projects have secured permits. Many of these initiatives are supported by the Institute for Energy Diversification and Saving (IDAE), which has launched significant calls for energy storage projects within the framework of the Recovery, Transformation, and Resilience Plan, funded by the Next Generation EU programme.

4.2 Analysis of Energy Storage – Natural Gas

While regulatory approaches vary across the Mediterranean and neighbouring countries, common themes include the alignment of national laws with EU directives (as seen in Cyprus and Portugal), a mix of public, private, and public-private ownership models, and the requirement for third-party access to ensure fair competition. Several countries, such as Greece and Lebanon, have limited or no specific natural gas storage regulations due to a lack of infrastructure or sectoral focus.

This section provides a comparative analysis of the regulatory frameworks in several countries concerning natural gas storage operations, focusing on licensing, ownership models, and capacity allocation.

- **Albania**

The Energy Regulatory Authority (ERE) has established the licensing conditions for natural gas storage operations. The methodology for calculating tariffs and determining access to storage facilities is also regulated by the ERE. These regulations ensure that storage facilities operate transparently, providing clear rules on service pricing and facility access.

- **Cyprus**

Natural gas storage in Cyprus is governed by the Gas Market Law (183(I)/2004), which aligns with the EU's Third Energy Package. This legislation provides a framework for licensing, transparency, and fair competition. The Cyprus Energy Regulatory Authority (CERA) oversees the sector, managing permits and ensuring compliance with safety, environmental, and market regulations.

Ownership models include public (via state-owned entities like DEFA), private, public-private partnerships (PPP), and third-party. However, all entities must comply with Cyprus' energy policies and security regulations. The law mandates third-party access to storage facilities under regulated conditions to prevent monopolistic practices and promote competition.

- **France**

The regulatory framework for natural gas storage in France is primarily overseen by the CRE, ensuring that storage operations are conducted in an efficient and non-discriminatory manner. The framework is detailed across key areas:

1. Main Regulations or Policies Governing Natural Gas Storage Operations

Natural gas storage in France is regulated by the French Energy Code (Articles L. 421-1 to L. 421-8) and the Law on Energy Transition for Green Growth (LTECV), passed in 2015. These regulations

outline the obligations for storage operators, safety requirements, and the framework for market participation. They also integrate European regulations such as the European Gas Directive (2009/73/EC), ensuring third-party access and competitive practices.

2. Permitting Processes

Along with environmental permits, operators must secure exploration and exploitation permits (permis d'exploiter), governed by the Energy Code, due to potential environmental impacts. These permits are granted by the Ministry of Ecological Transition; a public inquiry is mandatory to ensure community participation.

3. Ownership Models

Both public and private operators can own storage facilities, but all are regulated by the CRE. Storengy, a subsidiary of ENGIE, controls most facilities. In line with the European Gas Directive, third-party access to storage is mandatory, ensuring competition and transparency. Furthermore, ownership must be unbundled from production and supply to avoid conflicts of interest.

4. Capacity Allocation

Storage capacity is allocated via regulated auctions, overseen by the CRE. These auctions ensure fair access, with priority given to shippers who need security of supply. Suppliers are also obliged to maintain minimum storage levels to guarantee sufficient reserves, especially in winter.

5. Tariffication

Access to storage services is regulated by the CRE, which sets tariffs based on cost-reflective models, ensuring that prices promote fair competition without discrimination between users.

Currently, the underground natural gas storage capacities total 138.5 TWh in volume and 2,376 GWh/d in withdrawal rate, with filling corresponding to 45% of the useful volume.

- **Greece**

Greece does not have dedicated underground natural gas storage facilities. The existing LNG terminal at Revithoussa, with a capacity of 225,000 m^3, operates under a regulated Third-Party Access (TPA) regime. The absence of additional storage infrastructure limits regulatory focus to LNG storage facilities.

- **Italy**

The legal framework for natural gas storage is provided by a law implementing the first EU gas market directive, namely legislative Decree No. 164/2000 (commonly referred to as 'Decreto Letta'), which has been regularly updated as EU legislation advances. Natural gas storage has always been viewed as a fundamental building block of both the national and European gas markets; as such, access to scarce gas storage capacity is regulated like any other network infrastructure, with the NRA committed to establishing access and use criteria in transparent and fair conditions.

- **Jordan**

Regulations in Jordan cover licensing for various activities, including the establishment of natural gas supply stations and the handling of liquefied and compressed natural gas. There are specific instructions for obtaining permits for wholesale and retail activities, covering the entire natural gas supply chain, including storage, transportation, and sales.

- **Lebanon**

Lebanon currently lacks specific regulations for natural gas storage, with the Lebanese Petroleum Administration overseeing the upstream petroleum sector.

- **Portugal**

As in previous years, the entry capacity from the LNG terminal (regasification) was entirely booked in the annual allocation process for the gas year 2023-2024. Furthermore, the average contracting of underground storage capacity during 2023 was 100%.

LNG storage and gas storage in caverns are also considered mature given the state of development. There is an ongoing evaluation of the investment needs for two new caverns to store hydrogen.

- **Türkiye**

The total natural gas storage capacity in Türkiye reached 6.6 bcm in 2023, reflecting an increase of 0.8 bcm compared to the previous year. By 2028, it is expected to reach 10 bcm. The LNG facilities, defined as storage facilities in the Natural Gas Market Law, are also continuously increasing their capacities, with a total regasification capacity of 155 mcm/day as of 2023's end.

- **Spain**

Natural gas storage in Spain is regulated by the Hydrocarbons Law, which aligns with EU standards and is supervised by the National Commission of Markets and Competition (CNMC), ensuring transparency and competition in the sector. The Technical System Operator for Gas—Enagás GTS—manages the underground storage facilities and LNG regasification plants, with a regulated access system to prevent monopolistic practices.

According to the latest data from the CNMC, in 2024, Spain's natural gas storage capacity totals around 3.4 bcm, representing about 10% of the country's annual demand. This capacity is spread across four underground storage sites. Spain also has seven LNG terminals, enabling significant import volumes and providing a flexible buffer for supply. In 2023, these storage facilities maintained high filled levels, reaching full capacity well ahead of winter, which reinforced energy security and met EU storage goals.

Additionally, the Enagás GTS has implemented a guarantee-of-origin system for renewable gases, supporting Spain's goal of carbon neutrality by 2040. The country is active in renewable gas projects, including the H2Med project—a green hydrogen corridor connecting Spain with Europe.

4.3 Types of Natural Gas Storage Facilities Used in the Mediterranean Region

LNG storage facilities are the most widely used for natural gas storage across the Mediterranean region, including in Algeria, Egypt, France, Greece, Spain, Portugal, and Türkiye. However, some countries, like France and Türkiye, also utilise other types of storage, such as depleted reservoirs and aquifer storage facilities.

In France, under the current PPE enacted by the Decree of April 21, 2020, 11 underground natural gas storage infrastructures are designated as essential for national energy security, with a total storage capacity of 138.5 TWh. This infrastructure includes eight aquifer storage facilities and three salt cavern facilities.

France's onshore LNG infrastructure includes three regulated terminals operated by Elengy: Montoir-de-Bretagne (with a regasification capacity of 10 bcm/year and 360,000 m³ of storage), Fos Tonkin (1.5 bcm/year and 80,000 m³ of storage), and Fos Cavaou (10 bcm/year and 330,000 m³ of storage). In addition, Dunkirk's LNG terminal and the Le Havre floating terminal (FSR, or Floating Storage and Regasification Unit), operated by Dunkerque LNG and TotalEnergies LNG Services France, respectively, are exempt from third-party access and tariff regulation. Dunkerque LNG has a regasification capacity of 13 bcm/year and a storage capacity of 600,000 m³, while the Le Havre FSRU is exempt from these regulations until 2028.

Power-to-Gas is currently in its demonstration phase in France. In the future, the natural gas network is expected to offer large-scale storage solutions for renewable electricity, playing a key role in energy transition efforts.

On the other hand, Italy has 13 depleted reservoir storage facilities, nine of which are owned by the national TSO (Snam), three by Edison, and one by an independent operator. The overall capacity amounts to 18.7 bcm, which is said to be close to one-third of the average winter consumption.

Spain has committed to diversifying its supply and developing a robust infrastructure for LNG regasification over decades, consolidating its position as the European country with the largest LNG storage and regasification capacity.

From the opening of its first plant in Barcelona in 1969 to the recent addition of El Musel (Gijón) in 2023, Spain currently has a storage capacity of 3,616,500 m³ and a regasification capacity of 7,662,800 Nm³/h, distributed across seven terminals along its coastlines: Barcelona, Sagunto, Cartagena, Huelva, Bilbao, Mugardos, and Gijón. These facilities ensure a flexible supply chain that reduces dependence on pipeline gas imports.

Additionally, Spain has four underground gas storage facilities: Yela, with low environmental impact and remote operation; Gaviota, one of the few offshore storage facilities in the world, which combines onshore and offshore installations in the Cantabrian Sea; Serrablo, which manages two fields

individually for greater flexibility; and Marismas in Huelva, which utilises depleted fields, providing security and stability to the energy system in the south of the country. As key infrastructures for adjusting supply to demand and managing consumption peaks, they facilitate balance in the transport network in adherence to European regulations. According to Enagás GTS, the available capacity in underground gas storages for the period of April 1, 2024, to March 31, 2025 amounts to 35,926 GWh, which is equivalent to approximately 3.39 bcm of natural gas.

4.4 Energy Storage Incentives & Regulatory Framework

The need for energy storage in the Mediterranean region is increasing. Only in recent years have some countries begun incorporating it into their energy strategies, offering incentives for storage projects. In our benchmark, we identified merely four countries with established incentive mechanisms:

- **Cyprus**

The Cyprus Energy Regulatory Authority promotes the installation of front-of-the-meter electricity storage facilities through Regulatory Decision No. 3/2019. These facilities, which are not combined with on-site electricity consumption (other than what is needed for operation), can participate in the Wholesale Electricity Market if they meet the technical requirements set by the National Transmission and Distribution. Their operation is scheduled and determined by their participation in the market, where they can both inject and store electricity from the grid. The energy absorption/injection of the storage and generation facilities is measured separately. These storage facilities can:

a. Be included in the Register of Storage Facilities according to their technical characteristics;
b. Be included in the Register of Balancing Service Providers;
c. Fully participate in all sub-markets (Forward, Day-Ahead, Ancillary Services, and Balancing Market) for both energy injection and absorption;
d. Contract with RES producers or RES aggregators to clear discrepancies either individually or through an aggregator.

Additionally, during their charging cycles, these facilities are exempt from network usage fees. The Ministry of Energy, Trade, and Industry is also working on a grant plan for hybrid energy storage systems in conjunction with renewable energy projects.

- **France**

France has introduced several significant incentives and subsidy programmes to support energy storage initiatives as part of its broader strategy to transition to renewable energy and achieve carbon neutrality by 2050. Among the key incentives are:

1. **Multi-Year Energy Plan (PPE):**

The PPE sets strategic goals for expanding energy storage capacity to support renewable energy sources like wind and solar. The government allocates funding for battery storage, pumped hydro, and hybrid storage projects to improve grid flexibility and ensure a stable energy supply.

2. **Government Subsidies for Hydrogen Storage:**

Under the National Hydrogen Strategy, France has committed €7 billion by 2030 to develop green hydrogen and storage solutions. These subsidies promote projects that store hydrogen produced from renewable energy, offering grants and financial support for electrolysis projects that convert excess renewable electricity into hydrogen.

3. **Tenders and Calls for Projects:**

The CRE regularly issues tenders targeting storage systems that enhance grid flexibility. Projects that integrate storage solutions with renewable energy generation receive long-term contracts and financial support.

- **Greece**

Contracts for differences (CfDs) are awarded through competitive tenders for battery storage, with contracts lasting for 10 years.

- **Italy**

For small-size BESS capacity, tax rebates and fiscal advantages are available for households and enterprises performing energy-efficiency measures, including the installation of batteries to smooth the production/consumption profile. Although decreasing over time, these advantages remain a significant incentive for small-size BESS deployment.

Larger electricity storage projects (mainly BESS but also pumped hydro) are supported by two main schemes: the capacity market and the recently introduced long-term storage capacity procurement scheme, relying on €17.7 billion of public funding and expected to bring new BESS capacity amounting to at least 9 GW (corresponding to 70 GWh) by 2030. The economic incentive is set to cover investment and current costs to protect investors against energy price risks.

No explicit incentives exist for the construction of new gas storage capacity; however, operators willing to invest in new gas storage capacity are allowed to consider most of this new capacity as "merchant", i.e., not subject to tariff regulation for infrastructure use.

- **Lebanon**

Customs and tax exemptions have been implemented to encourage the adoption of battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), significantly increasing the market share of electric vehicles. This growth presents an opportunity to develop energy storage programmes using these distributed flexibility resources. Since 2018, solar PV panels have been exempted from customs duties. In 2023, tax exemptions, including customs duties and VAT, were introduced not only for specific types of batteries used in solar PV systems but also for solar panels and inverters, stimulating adoption across residential and commercial sectors.

- **Portugal**

Government support programmes are in place for individual or collective self-consumption projects, allowing the installation of energy storage systems. These programmes can cover up to 85% of the investment cost (excluding VAT) under the EU-funded Recovery and Resilience Plan, with incentives available until 2026. Additional initiatives for battery energy storage are in the pipeline, including an auction launched in September 2024, representing an investment of nearly €100 million[3].

These examples highlight the region's gradual but significant shift towards integrating energy storage as a key component of energy strategies, with various financial and regulatory mechanisms being deployed.

Portugal's regulatory framework can be split into two categories: countries that already have a regulatory framework, including mandatory technical standards for energy storage projects, and countries without a regulatory framework. However, the country has identified the technical standards that will be included in their framework in the future, as shown in the figure below:

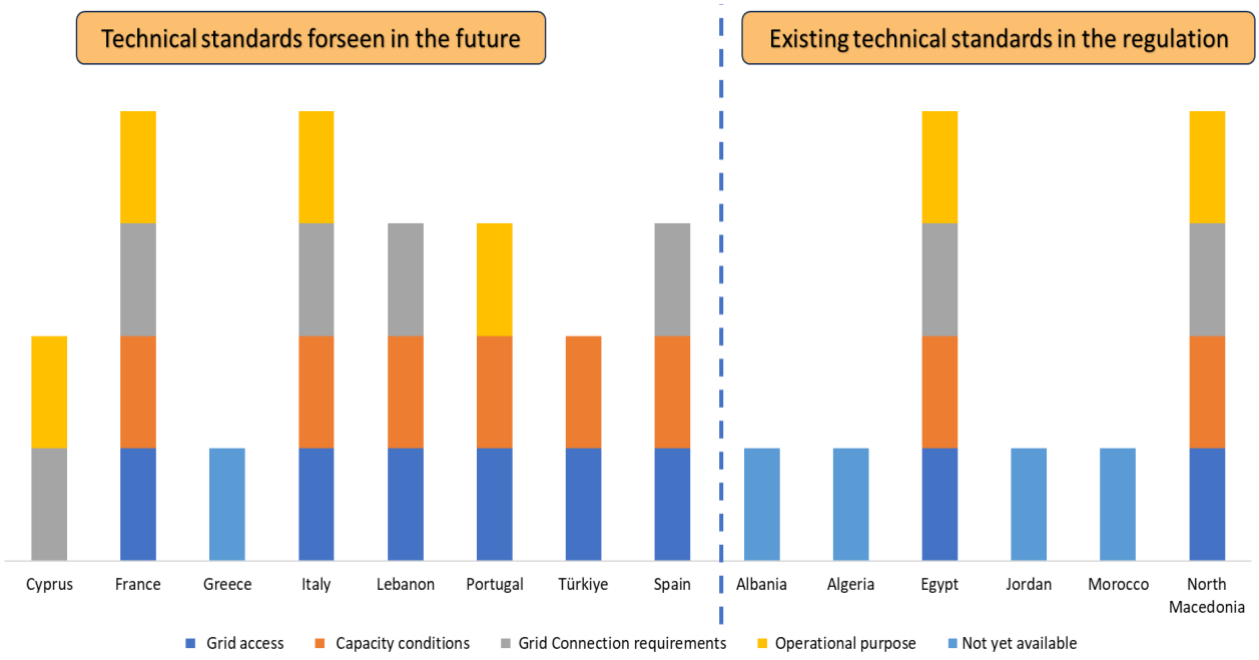

Figure 3. *Mandatory Technical Standards for Energy Storage*

[3] https://www.fundoambiental.pt/apoios-prr/c21-repowereu1/rp-c21-i08-flexibilidade-de-rede-e-armazenamento.aspx
Ordinance No. 176-B/2024, of July 30, regulated the investment program. The main conditions were:
- Installing at least 500 MW of battery-based storage, associated to renewable power plants;
- Minimum 1 MVA of installed capacity, charge and discharge at maximum power during 2 hours minimum;
- Storage connected in generation facilities behind-the-meter, using the same network connection;
- Storage absorbs at least 75% of its energy from the generator facility where it is connected;
- Financial support covers up to 20% of eligible costs;
- Projects must be operational by December 31, 2025.

In **France**, the technical standards for energy storage are specified in the energy code as follows:

- **Grid Access**

Article L. 332-1 of the Energy Code establishes the framework for grid access, detailing the rights and obligations of energy storage operators. Storage systems must meet technical compatibility standards to ensure seamless integration with the national grid.

- **Capacity Conditions**

Articles R. 314-1 and R. 314-2 outline the capacity conditions that storage systems must meet. These conditions ensure that systems have the capacity to contribute effectively to grid demand management and stability.

- **Grid Connection Requirements**

Articles L. 342-1 and R. 342-1 of the Energy Code specify the technical requirements for connecting energy storage systems to the grid. These requirements include performance testing and compliance with safety and reliability standards.

- **Operational Purpose**

Articles L. 311-1 and L. 311-2 define the operational purposes of storage systems, which include frequency regulation, demand management, and the integration of renewable energy sources into the grid.

In **Italy**, the standards are mandatory for building and managing any energy storage system; criteria, rules, and procedures are established by the Regulatory Authority for Energy, Networks and the Environment (ARERA), the Ministry of the Environment and the Energy Security (MASE), and the Energy Services Manager company (Gestore dei Servizi Energetici, GSE) according to their own powers and responsibilities. Moreover, the capacity to balance the network and supply the energy for solving bottlenecks is required for operators participating in the public procurement system and relying on incentives[4].

In **Portugal**, access to the electricity network requires obtaining a Capacity Reserve Title (Título de Reserva de Capacidade, TRC) for both generation and storage, as outlined in the legal framework. Once the TRC is secured, the licensing process follows. For behind-the-meter storage units, only the licensing procedure is required.

The production and operation licences specify the grid access requirements and operational objectives of storage systems, including compliance with obligations to participate in system services, energy arbitrage, storage of excess generation, operating reserves, and maximum injection capacity (with or without restrictions). These licences also detail other conditions for the development of storage activities.

[4] See "MACSE" mechanism for BESS.

The grid connection requirements are not regulated by the energy authority but are subject to EU regulations as well as national transmission and distribution network codes. Technical conditions, including grid compliance, are enforced through these codes.

Portugal's Quality of Service Code (Regulamento da Qualidade de Serviço, RQS) establishes standards, including NP EN 50160, which defines voltage characteristics of electricity supplied by public networks. It also mandates that infrastructure operators monitor the characteristics of gas, setting limits on parameters such as the Wobbe index, relative density, dew point, hydrogen sulphide, and total sulphur content. Additionally, the RQS enforces European standards such as EN 16726 and EN 16723-1, which specify biomethane quality for injection into the natural gas network, and EN 14687, which outlines minimum quality requirements for hydrogen.

In **Türkiye**, the design, installation, connection, acceptance, and operation of electrical storage units and facilities must comply with the country's regulation on energy storage, as well as relevant technical legislation, standards, and criteria. Gas storage regulations also ensure that gas quality standards are met during the storage and withdrawal of natural gas.

In **Morocco**, Law 82.21 on auto-generation and Law 40.19, which amends Law 13.09 on renewable energy development, allow private investors to develop and use energy storage systems under certain conditions to be defined by a forthcoming decree. However, this decree has not yet been published; thus, the technical standards for energy storage remain undetermined. The National Authority for Electricity Regulation (ANRE) issued a transmission network grid code in early 2022, which is currently under review to integrate new technological advancements and legal updates, including technical standards for energy storage systems.

In **Spain**, integrating energy generation and storage facilities into the grid requires an access permit under national regulations, particularly Royal Decree No. 1183/2020, followed by administrative authorisation for construction and operation.

To promote energy storage, recent measures were introduced by Royal Decree-Law No. 8/2023, prioritising renewable energy storage over conventional power generation in hydro plants. The CNMC is also advancing specific guidelines for storage facility connections to distribution and transmission networks, optimising the integration of large-scale battery technology.

In September 2024, Circular 1/2024 of the CNMC set out comprehensive guidelines for access and connection of energy demand (consumption), complementing a former Circular focused on generation. This aims to promote flexibility, efficiency, and transparency across energy infrastructure, particularly for storage systems, data centres, and EV charging stations, with specific objectives being as follows:

1. Flexible Access: A "flexible capacity" mechanism allows certain demand facilities to choose non-guaranteed access, supporting grid sustainability.

2. Transparency: Grid operators must publish network capacity details, facilitating informed decisions for projects related to self-consumption and EV charging.

3. Energy Storage Support: Defined criteria for access and connection enable greater integration of behind-the-meter storage solutions, addressing potential connectivity challenges.

Circular 1/2024 also builds on a previous resolution standardising capacity assessment across network operators to ensure consistent grid evaluation. This regulation emphasises integrating renewables and storage, recognises storage's dual role in generation and consumption, and gradually introduces "grid-forming" capabilities that allow generators to stabilise the network by acting as voltage sources. Additionally, a recent public consultation reviewed a draft resolution on storage operating patterns, proposing designated time blocks for injecting or absorbing energy from the grid. This proposal includes monitoring devices to support regulatory compliance and facilitate storage connections, even when systems do not require full capacity access continuously.

5. Distributed Flexibility Resources in the Mediterranean Region

5.1 DFR Implementation Status in the Mediterranean Region

The implementation of DFR across the Mediterranean region varies significantly between countries, reflecting differing levels of maturity in energy policies, market structures, and technology adoption. Below is a figure illustrating the current state of DFR implementation in selected countries:

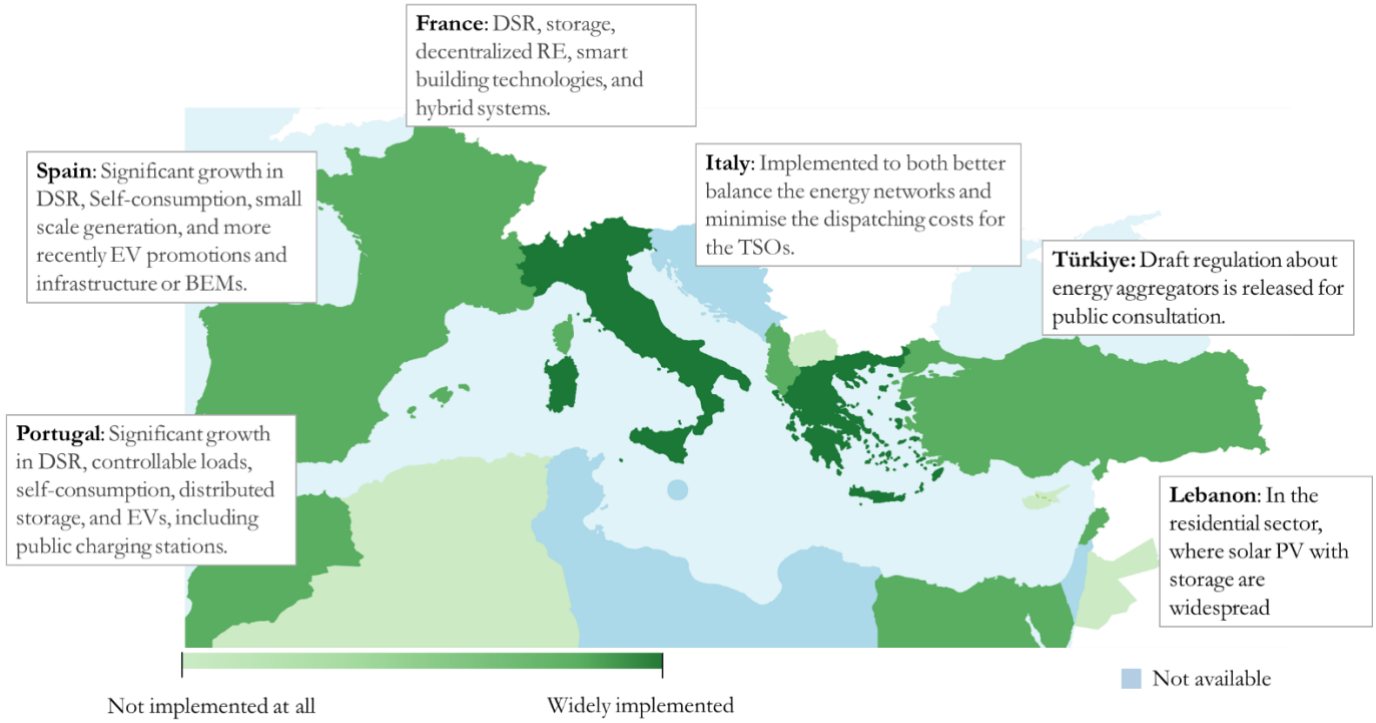

Figure 4. *DFR Implementation Status in the Mediterranean Region*

Leading examples, such as France, Portugal, Greece, Spain, and Türkiye, demonstrate that a combination of regulatory support, technological innovation, and consumer engagement can drive the widespread adoption of DFR technologies.

Countries in the earlier stages of DFR deployment, like Albania, Algeria, and North Macedonia, can benefit from observing the experiences of their Mediterranean neighbours, particularly in creating incentives and regulatory structures to support flexibility.

Overall, the potential for DFR in the region is vast, especially as countries transition to more decentralised and renewable-based energy systems. By embracing best practices such as regulatory

reform, technological innovation, public-private partnerships, and grid modernisation, Mediterranean countries can unlock the full potential of distributed flexibility, contributing to a more resilient, efficient, and sustainable energy future.

In terms of the most widely adopted DFR mechanisms, solar PV—with or without battery storage—stands out as the most common. This is largely due to the maturity of the technology, which does not require significant infrastructure upgrades or high investment costs. For example, Lebanon has successfully deployed solar PV systems across all sectors, specifically residential.

Electric vehicles are also gaining traction, particularly in countries like Portugal, Spain, Türkiye, and Greece, where EV adoption is growing rapidly. Other nations, such as Morocco, are actively updating their regulatory frameworks to support the integration of EVs into their energy systems.

Meanwhile, the progress of DRPs and combined heat and power (CHP) systems has been slow across much of the region. Spain is a notable exception, where CHP is already a well-established technology in numerous industrial sectors, and is further adapting to support the nation's decarbonisation goals. This shift involves modernising regulations and incorporating renewable energy sources to reduce carbon emissions and increase efficiency. An upcoming 1,200 MW cogeneration auction aims to support this transformation, targeting facilities that can blend natural gas with renewable gases like hydrogen—a move expected to attract new investments and strengthen both economic and environmental sustainability in the sector.

Along with a shift in consumer behaviour, these mechanisms demand more substantial investments in infrastructure, including smart meters. As a result, their implementation, though essential for enhancing grid flexibility in the long term, is more complex and gradual.

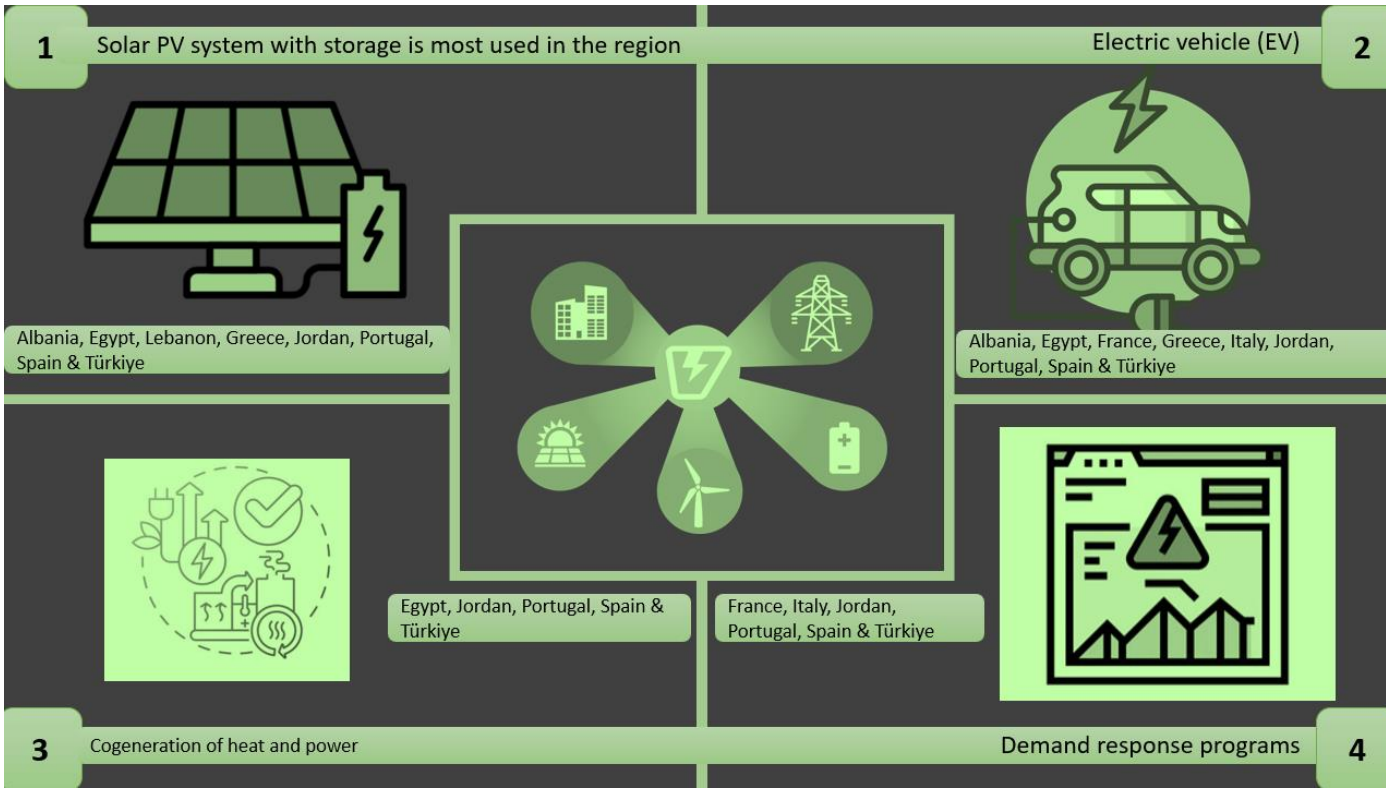

Figure 5. *Types of DFR Used in the Mediterranean Region*

5.2 DFR Drivers & Barriers

The implementation of DFR is a critical factor in achieving energy transition goals and zero-emission scenarios. Distributed flexibility offers numerous benefits, ranging from economic gains to social advantages, including improved grid stability, enhanced energy efficiency, and increased integration of renewable energy sources.

As observed, the level of DFR deployment varies significantly across the Mediterranean region, largely influenced by the urgency and specific energy challenges of each country. For instance, countries like France, Greece, Portugal, Spain, and Türkiye are more proactive in adopting DFR solutions. These nations face the challenge of further integrating renewables into their grids and decarbonising both the energy and transport sectors. Conversely, countries like Albania, Algeria, and North Macedonia are prioritising the diversification of their energy mix by focusing on renewable energy projects, especially solar PV and wind, before fully committing to DFR solutions.

The figure below highlights the key drivers for DFR implementation in different Mediterranean countries.

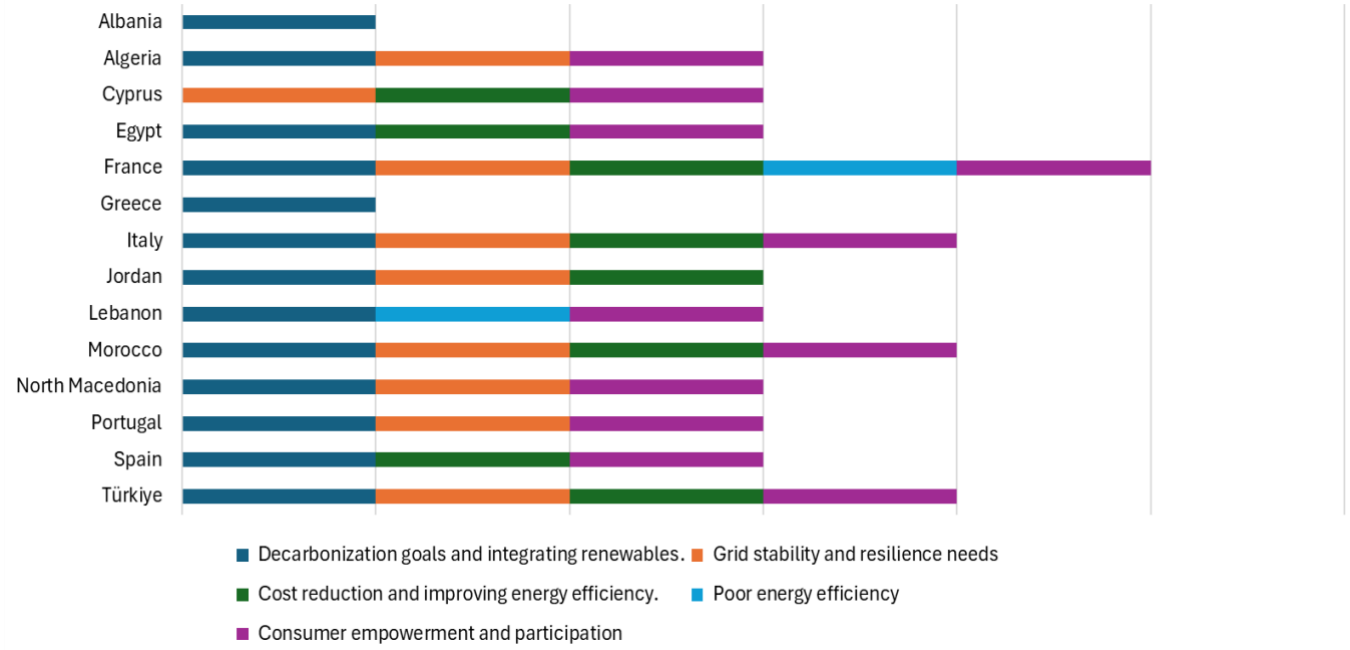

Figure 6. *Drivers for DFR Implementation in the Mediterranean Region*

5.3 DFR in the Natural Gas System

- **Portugal**

In the context of natural gas systems, Portugal is currently one of the few Mediterranean countries that has allowed the injection of renewable gases into its network. According to Decree-Law No. 62/2020, combined-cycle natural gas (CCNG) power plants are subject to curtailment rules. Suppliers are required to maintain security supply reserves, but this obligation can be waived if alternative fuel supplies are contractually guaranteed and authorised by the DGEG. Portugal has also established a legal framework for renewable gas injection into the national grid, making it a reality.

In 2024, Portugal approved the Biomethane Action Plan 2024-2040 (PAB). This plan outlines a comprehensive and sustainable strategy to develop the biomethane market, positioning it as a key solution for reducing greenhouse gas emissions, decarbonising the economy, and decreasing natural gas imports in both the industrial and domestic sectors. Biomethane is also considered an important player in the future of mobility, leveraging domestic resources across various sectors.

The action plan is structured in two phases with distinct time horizons, emphasising the creation and consolidation of a biomethane market while ensuring social and environmental sustainability. By 2030, the plan aims to implement 2.72 TWh of biomethane capacity, potentially reducing natural gas consumption by 9.1%. By 2040, this figure is expected to reach 5.57 TWh, leading to an 18.6% reduction in natural gas use.

- **France**

Several resources are implemented as Distributed Flexibility Resources for natural gas systems, such as:

1. **Curtailment of Industrial Gas Loads**

Curtailment involves reducing natural gas consumption in industrial sectors during peak periods or when there are supply constraints. This approach helps manage demand and ensures stability in the supply of gas. France's energy regulations encourage the curtailment of industrial gas loads during times of peak demand or emergencies.

2. **Residential Demand Response Programmes for Water or Space Heating**

These DRPs allow households to adjust their natural gas consumption for heating water or spaces based on grid signals. This form of demand response incentivises consumers to reduce or shift their gas usage during peak periods, contributing to overall system flexibility. While more common for electricity, similar concepts are being explored for natural gas in the country.

3. **Injection of Biogas or Biomethane into the Natural Gas Grid**

The injection of renewable gases, such as biogas or biomethane, into the natural gas grid enhances the sustainability of gas supply and contributes to flexibility strategies. France actively promotes injecting biomethane as part of its decarbonisation efforts, with government targets for increasing the share of renewable gas in the grid.

- **Italy**

Like France, Italy also employs the curtailment of industrial gas loads.

- **Spain**

The injection of renewable gases, such as biomethane and green hydrogen, into the natural gas grid is established by recent legislation. Royal Decree No. 376/2022 sets sustainability criteria and establishes a certification system for renewable gases, including biogas, biomethane, and hydrogen. Additionally, Royal Decree-Law No. 14/2022 provides guidelines for the direct connection of renewable gas facilities, such as hydrogen, to the gas network, recognising these connections as public utilities, thereby encouraging investment in renewable gas infrastructure. Natural gas transmission operators have been designated as provisional network operators for hydrogen to facilitate its deployment. Furthermore, the CNMC Resolution (April 2024) establishes procedures for connecting biomethane plants to the natural gas network, addressing logistical and operational requirements to support seamless integration amid a growing number of biomethane projects.

In the updated PNIEC for 2023-2030, Spain has outlined ambitious objectives for renewable gases. Key targets include producing up to 1.72 billion m^3 of biogas annually by 2030, which would help decrease reliance on fossil gas within the national energy framework. The plan also aims to achieve

12 GW of electrolyser capacity for green hydrogen production and 22.5 GW of energy storage capacity, supporting the smooth integration of variable renewable energy sources into the grid.

5.4 Challenges & Barriers to Develop DFR

While the benefits of DFR are substantial, several challenges and barriers can hinder their widespread adoption. In our survey of MEDREG members, we identified the most significant obstacles countries face in developing DFR solutions. These challenges include:

1. **Infrastructure Limitations**

Many countries need to upgrade their grid infrastructure to accommodate DFR technologies such as demand-side response and smart metering.

2. **Investment Hurdles**

The high initial costs of deploying DFR technologies, particularly in less developed markets, can be a major barrier.

3. **Regulatory and Policy Gaps**

Clear and supportive regulatory frameworks are often lacking, making it difficult for countries to integrate DFR effectively.

4. **Consumer Awareness and Engagement**

Successful DFR deployment requires a shift in consumer behaviour, which can be slow to change without proper incentives or education.

The figure below presents a detailed breakdown of these barriers based on the experiences of Mediterranean countries.

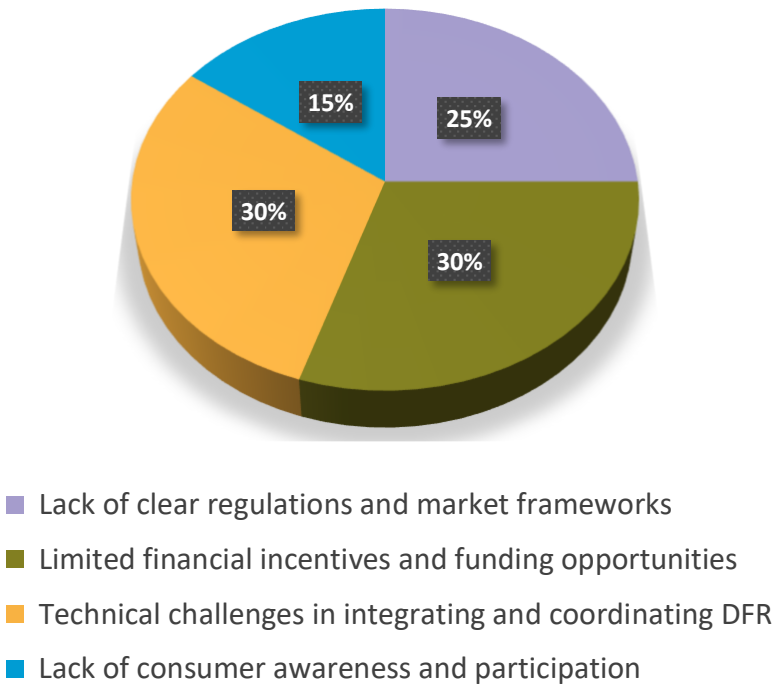

Figure 7. *Barriers for DFR Implementation in the Mediterranean Region*

By understanding and addressing these challenges, countries can anticipate and overcome them while learning from the experiences of neighbouring nations to accelerate the deployment of DFR.

5.5 Role of Energy Regulators in the Development of DFR

Energy regulators play a critical role in transforming energy systems, especially the development and deployment of DFR. As global energy systems shift towards decarbonisation, decentralisation, and increased reliance on renewable energy, the ability to manage and optimise energy supply and demand at a more localised level becomes essential. DFR solutions, such as distributed generation, energy storage, DRPs, and smart grid technologies, offer new avenues for balancing the grid, improving energy efficiency, and integrating higher shares of renewables.

National Regulatory Authorities are the key to shaping regulatory frameworks, market mechanisms, and technical standards that enable the effective implementation of DFR. Their role is multifaceted, covering aspects such as tariff structures, licensing, grid access, consumer protection, and the facilitation of new business models. By fostering a conducive environment for innovation and flexibility, regulators ensure that energy systems are more resilient, efficient, and capable of supporting the transition to low-carbon energy.

The involvement of NRAs in DFR deployment varies across countries, depending on their unique energy landscapes, policy priorities, and levels of regulatory maturity. In this context, the following

sections offer a snapshot of the role played by NRAs in several Mediterranean countries, highlighting their efforts to support DFR and overcome associated challenges.

- **Albania**

The regulatory authority plays a critical role in the development of DFR by approving network tariffs and setting purchase prices for electricity generated by small-scale solar and wind power plants. This supports the integration of renewable energy sources into the grid and encourages small producers to contribute to energy flexibility.

- **Cyprus**

The Cyprus Energy Regulatory Authority has taken key regulatory steps to foster distributed flexibility in the electricity market. It has created a supportive framework for integrating DERs and allowing aggregators to pool resources from multiple small-scale producers and consumers to participate in the energy market. In line with EU directives, CERA has also introduced regulations enabling demand response aggregation, where consumers can participate in energy markets alongside generators. These efforts promote flexibility, increase grid efficiency, and ensure that DSOs can procure services like demand response or energy storage to manage grid congestion cost-effectively.

- **Egypt**

The Egyptian Electric Utility & Consumer Protection Regulatory Agency (EgyptERA) has issued several regulations to promote distributed generation, including net metering and self-consumption schemes. The limit for PV power plants across the country has been upgraded to 1000 MW instead of 300 MW. The Private-to-Private scheme shall apply only to energy production from renewable energy. The Certificate of Origin regulations, though approved by EgyptERA's Board of Directors, are still in the phase of contracting a registry to trade such certificates. Additionally, consumers who want to prove that their production is from renewable energy can purchase electricity through direct contracting with the New and Renewable Authority.

- **France**

France's national energy regulatory authority plays a crucial role in the development of DFR. Its functions can be summarised as follows:

1. **Regulatory Framework Development**

The CRE establishes the regulations and legal frameworks that govern the use of distributed energy resources. This includes defining access conditions and technical standards that enable the integration of flexibility technologies into the energy market, creating a conducive environment for innovation.

2. **Market Design and Integration**

The authority works on designing markets for flexibility services, ensuring that distributed resources can be compensated fairly for providing services like demand response and generation control. This involves creating mechanisms that allow for effective market participation.

3. **Supervision and Compliance**

The CRE supervises DFR operations to ensure they meet safety and performance standards. This includes evaluating applications for connections and authorisations for DFR installations, maintaining oversight of their integration into the grid.

4. **Promotion of Competition**

By ensuring open access to DFR for all market participants, the CRE fosters a competitive environment. This promotes innovation and enhances the quality of services available to consumers, ultimately benefitting the overall energy system.

5. **Incentives and Funding Mechanisms**

The regulatory authority regulates financial incentive mechanisms to encourage the adoption of DFR. This can include subsidies, tariff incentives, and funding opportunities that support flexibility solutions contributing to grid balance.

6. **Coordination with Stakeholders**

The CRE collaborates with various stakeholders, including government agencies and industry players, to ensure that DFR are integrated into national renewable energy strategies and energy transition policies.

- **Greece**

The Regulatory Authority for Energy, Waste, and Water (RAAEY) plays a key role in promoting DFR by establishing market mechanisms and technical standards that facilitate the participation of DERs. These include renewable energy sources, energy storage, and demand response systems. RAAEY supports flexibility services through dynamic pricing, time-of-use tariffs, and by encouraging innovation in the form of pilot projects and regulatory sandboxes. This approach ensures the reliable and efficient operation of flexible resources while supporting Greece's energy transition goals.

- **Italy**

The Italian energy regulator ARERA is responsible for establishing the rules, technical criteria, and economic principles intended to support the deployment of energy storage, primarily BESS. Although targets and incentive schemes are proposed by the Government as part of the efforts to implement EU objectives, the NRA is often tasked with detailing the functioning of these schemes and instructing other institutional actors such as GSE and GME (the Energy Services Manager and the Energy Market Manager, respectively). For example, in 2023, the NRA issued a decision establishing criteria and conditions for participating in the long-term storage capacity procurement mechanism, thereby setting the preconditions for the allocation season initiated by a Ministerial Decree in October 2024.

- **Jordan**

The Energy and Minerals Regulatory Commission (EMRC) establishes the regulatory framework for integrating distributed flexibility resources into the grid. EMRC governs licensing and ensures that DERs comply with technical, safety, and environmental standards. Additionally, it facilitates stakeholder engagement to create balanced regulations, monitors DER performance to ensure grid stability, and oversees market rules to encourage the adoption of flexible energy resources.

- **Lebanon**

The Lebanese Ministry of Energy and Water, through its 2022 policy, has taken steps to diversify the country's power supply by promoting decentralised solar photovoltaic (PV) systems with storage. The removal of subsidies for fuel products and electricity tariffs has driven consumers to adopt energy efficiency measures, laying the foundation for DFR development. In December 2023, Lebanon's Parliament passed the Decentralised Renewable Energy Law (DRE), which allows for peer-to-peer energy exchange and various types of net metering for renewable systems under 10 MW, paving the way for future demand-side response programmes and further DER deployment.

- **Morocco**

The regulatory authority in Morocco plays a pivotal role in balancing the interests of stakeholders and ensuring the sustainable integration of DFR into the national energy system. This involves creating an enabling environment for the development of flexible resources and supporting innovations in energy storage and demand-side management.

- **North Macedonia**

Currently, there is no regulatory framework for DFR in North Macedonia. The country lacks experience in energy storage regulation and is working to build expertise in this area.

- **Portugal**

Portugal's regulatory authority promotes market participation by evaluating and defining contractual conditions, ensuring consumer protection, and advocating for smart grid deployment. The regulator supports innovation in the electricity network and creates incentives for market agents to develop new products, promoting consumer participation in distributed flexibility solutions. Additionally, the regulatory framework promotes non-discriminatory rules for regulated entities and supports the development of flexible energy resources.

- **Spain**

In Spain, the injection of renewable gases, such as biomethane and green hydrogen, into the natural gas grid is established by recent legislation. Royal Decree No. 376/2022 sets sustainability criteria and establishes a certification system for renewable gases, including biogas, biomethane, and hydrogen. Additionally, Royal Decree-Law No. 14/2022 provides guidelines for the direct connection of renewable gas facilities, such as hydrogen, to the gas network, recognising these connections as public utilities, thereby encouraging investment in renewable gas infrastructure. Natural gas transmission

operators have been designated as provisional network operators for hydrogen to facilitate its deployment. Furthermore, CNMC Resolution (April 2024) establishes procedures for connecting biomethane plants to the natural gas network, addressing logistical and operational requirements to support seamless integration amid a growing number of biomethane projects.

In the updated PNIEC for 2023-2030, Spain has outlined ambitious objectives for renewable gases. Key targets include producing up to 1.72 billion m³ of biogas annually by 2030, which would help to decrease reliance on fossil gas within the national energy framework. The plan also aims to achieve 12 GW of electrolyser capacity for green hydrogen production and 22.5 GW in energy storage capacity, supporting the smooth integration of variable renewable energy sources into the grid.

- **Türkiye**

Türkiye's regulator is actively promoting distributed flexibility in the electricity network. In May 2024, the regulator introduced legislation for energy aggregators, allowing them to manage distributed generation and consumption. This is expected to significantly enhance the country's efforts towards DFR deployment by creating new opportunities for flexible energy solutions.

6. Hybrid Power Generation in the Mediterranean Region

Hybrid generation, which typically combines renewable energy sources such as solar and wind with conventional technologies like diesel, is viewed as a means to enhance energy security, improve efficiency, and reduce carbon emissions.

- **Technology Overview**

  - **Hydro-solar hybrids** are the most common form of hybrid generation across the region. Pumped-storage hydroelectricity (PSH) acts as a large-scale battery, storing excess renewable energy during peak generation times and releasing it when needed, thereby enhancing the reliability of hybrid systems.

    This technology is used in countries like Albania, France, Greece, Lebanon, and Portugal. This combination effectively balances generation across different times of day and seasons, offering a reliable renewable energy solution.

    For example, the French pumped storage power plants (PSP) can mobilize 4 GW of power in less than ten minutes. Six STEPs are currently in service in France, with an installed capacity of around 5 GW, or approximately 17% of France's total installed hydroelectric capacity.
  - **Diesel-PV hybrids**, particularly in Algeria, serve remote areas that are not connected to the grid, providing cleaner energy alternatives and reducing dependence on costly and polluting diesel fuel.

- **Wind-solar hybrids**, as seen in France[5], Morocco, Spain and Türkiye, are gaining traction due to their potential to harness abundant renewable resources and reduce grid instability caused by intermittency.
- **Energy Storage (Batteries and Hydrogen):** In France, hydrogen is also emerging as a storage option, where excess renewable energy is used to produce green hydrogen, which can be stored and used during periods of low renewable generation.

The figure below highlights the varying degrees of implementation of hybrid generation power across different countries in the Mediterranean region.

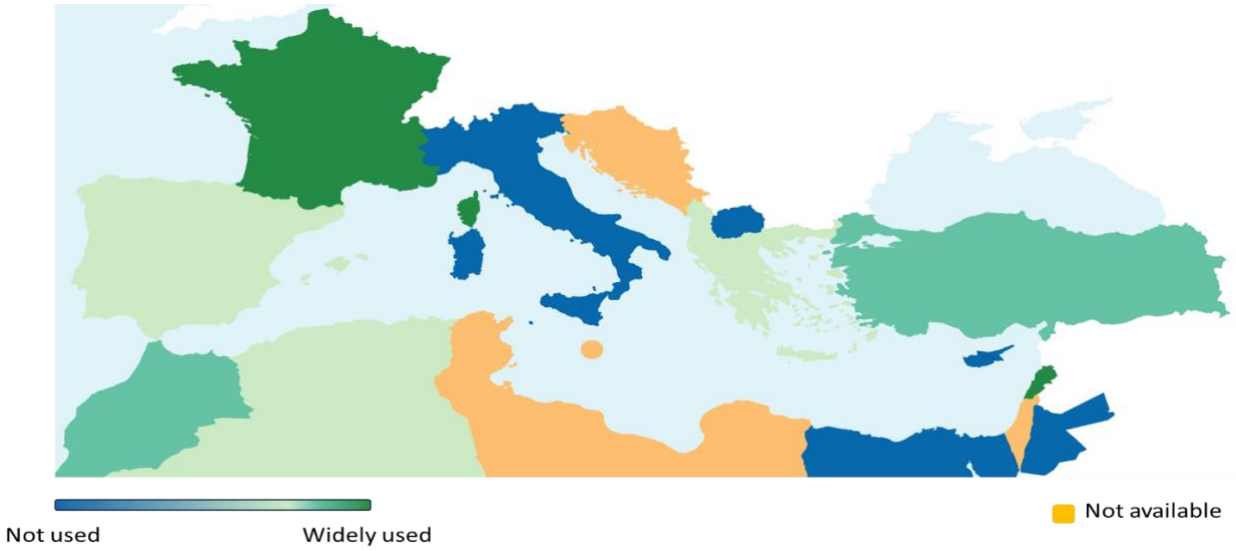

Figure 8. *Hybrid Power Generation Use in the Mediterranean*

- **Not Implemented at All**

Several countries, including Cyprus, Italy, Jordan, and North Macedonia, do not appear to have significant hybrid generation power projects in place. This could be attributed to several factors, including a strong reliance on traditional energy sources, a lack of incentives or regulatory frameworks supporting hybrid systems, or the adequacy of their current energy infrastructure. These countries may not yet view hybrid generation as a priority in their energy mix.

- **Limited Implementation in Specific Areas or Projects**

Countries such as Albania, Algeria, Egypt, Greece, and Portugal have limited implementations of hybrid generation power, often in specific areas or as pilot projects. In these regions:

[5] The Multi-Year Energy Plan (PPE) targets 40 GW of solar and 24 GW of wind by 2028.

- Albania and Greece primarily utilise hydro-solar hybrids, leveraging the complementarity between solar energy during the day and hydroelectric power at night or during peak periods. This setup optimises the use of natural resources while reducing reliance on fossil fuels.
- Algeria focuses on diesel-PV hybrids, particularly in remote or off-grid areas. This combination helps reduce diesel consumption and fuel costs, while photovoltaic solar systems provide cleaner energy.
- Portugal is exploring hybrid generation using hydro-solar systems as part of its renewable energy transition, although these projects are still limited to specific areas.
- Egypt has several hybrid generation projects, including fossil fuel/grid and renewable energy generation, but these are limited to specific locations.
- In Greece, a Hybrid Power Plant is defined as any power plant that:

  a) is installed in a non-interconnected island system and in Crete;

  b) uses at least one form of intermittent production of renewable energy;

  c) is obliged to provide the system with guaranteed power, which is understood as the maximum electrical power it must make available to the grid during specified periods of time;

  d) uses an electricity storage system;

  e) the energy it absorbs is consumed to fill its storage system.

- **Moderately Implemented with a Growing Presence**

In countries like France, Morocco, Spain, and Türkiye, hybrid generation power is moderately implemented and gaining momentum. These countries have focused on integrating wind and solar power with storage solutions to stabilise their energy grids. These hybrid systems:

- In France, hybrid generation—combining renewable energy sources like wind, solar, and hydro with traditional power generation or storage systems—is moderately implemented with a growing presence. This development is crucial for balancing the intermittent nature of renewable sources and ensuring grid stability.

  The PPE, central to France's energy transition strategy, emphasises increasing the share of renewable energy while maintaining nuclear power for reliability. Although sectors like solar and onshore wind have seen significant progress, hybrid systems that integrate storage solutions (such as batteries or hydro) have lagged somewhat. However, new initiatives, including tenders for energy storage projects, are being launched to support the development of these hybrid systems.

  While hybrid generation is not fully widespread yet, efforts are underway to improve storage technologies, which are essential for hybrid systems. This is especially true in non-interconnected zones, where hybrid solutions are increasingly used to improve energy

autonomy and reliability. The pace of development is expected to accelerate as flexibility needs grow due to higher shares of intermittent renewables.

- Morocco has had a hybrid electricity production system since 2010, with the inauguration of the Ain Beni Mathar project—a 470 MW hybrid power plant composed of a combined cycle and a 20 MW solar thermal system. More recently, Morocco has been actively expanding its hybrid generation capabilities with several projects that combine different renewable energy sources. For instance, the NOOR Ouarzazate Solar Power Station, a solar complex with a total capacity of 580 MW, incorporates CSP technology with PV technology and molten salt storage to enable power generation even after sunset.

  Additionally, wind and solar projects are being developed by both the private and public sectors in Morocco, depending on the availability of land and natural resources.

- In Spain, since the inauguration of the Gorona del Viento hydro-wind project in El Hierro, the growth of hybrid projects has been moderate. However, with new regulations introduced in 2023 and 2024, the landscape has shifted dramatically, accelerating the approval and implementation of hybrid projects across the country.

  According to data from the system operator Red Eléctrica de España, 13 GW are already in service and operational; 5.5 GW have received permits but have not yet started construction; 1.6 GW are currently under construction. In total, 20.12 GW of capacity is projected for the transmission and distribution networks in these hybrid installations. These projects mainly combine solar photovoltaic and wind energy, with some also incorporating storage systems to enhance grid stability and maximise the utilisation of renewable sources.

- Türkiye has also embraced hydro-solar hybrid systems, leveraging its natural resources to ensure a more sustainable and reliable energy supply.

In these countries, hybrid power is viewed as a critical component in reducing dependency on fossil fuels, managing grid flexibility, and supporting renewable energy targets.

- **Widely Implemented and Playing a Significant Role**

Lebanon stands out as the only country where hybrid generation power is widely implemented and plays a significant role in the energy mix. The combination of hydro-solar power has become essential to Lebanon's strategy for addressing its energy challenges, such as by reducing reliance on imported fuels and stabilising the grid amidst frequent outages.

7. Best Practices & Guidelines for DFR and Energy Storage in the Mediterranean Region

The deployment of DFR and energy storage solutions is a key element for advancing energy transition goals and achieving decarbonisation across the Mediterranean region. Both DFR and energy storage are still maturing technologies with several challenges to overcome, including infrastructure upgrades, regulatory uncertainties, and the need for early-stage investments. However, they remain essential tools for decarbonising the energy sector as well as other sectors, such as transport. Below are best practices and guidelines that countries in the region can adopt to support the development of DFR and energy storage systems:

- **Regulatory Support and Clear Frameworks**

Establishing Clear Regulatory Guidelines: Developing a robust regulatory framework is crucial for the advancement of both DFR and energy storage systems. Countries like Portugal and Türkiye have begun implementing regulations that promote energy aggregation, demand-side flexibility, and storage. However, many countries still require clear long-term policies to provide certainty for investors and operators.

Streamlined Licensing Procedures: Simplifying and accelerating the licensing process for DFR and energy storage projects can attract more investments. Egypt, for instance, exempts smaller energy storage systems and distributed generation facilities from lengthy approval processes, thereby speeding up their deployment. The current framework also needs to be updated for grid connection and to explore new revenue mechanisms for these systems in addition to the existing regulations.

Spain has also simplified licensing for renewable energy and storage projects to accelerate the energy transition.

- **Incentive Mechanisms**

Financial Incentives for Early-Stage Projects: To promote the adoption of DFR and energy storage, governments should offer financial incentives, including grants, tax breaks, and subsidies for technologies like solar PV and storage. Countries like Morocco and Lebanon are using tax exemptions to encourage investment in renewable energy and storage systems.

Time-of-Use Tariffs and Market Participation: Implementing differentiated pricing schemes, such as time-of-use tariffs, helps encourage flexible consumption patterns and storage adoption. Additionally, market participation mechanisms for energy storage operators, such as capacity markets, should be designed to make storage a more viable business case, especially in countries with higher renewable energy penetration.

- **Technological Innovation and Pilot Programmes**

Supporting Pilot Projects: Countries should foster innovation by supporting pilot programmes that test and refine DFR and energy storage technologies. Portugal's demand response pilots are paving the way for more extensive future deployments, and similar initiatives in energy storage would help assess their technical and economic feasibility.

Electric Vehicles and Battery Storage: As energy systems evolve, technologies such as EVs and battery storage will play a key role in DFR. Countries like Morocco are testing vehicle-to-grid technologies and BESS to manage load and provide flexibility to the grid.

- **Public-Private Partnerships**

Encouraging Collaboration: Public-private partnerships are essential for scaling DFR and energy storage projects. Governments should incentivise private investments by offering favourable policies and reducing bureaucratic barriers. For instance, Greece and Egypt have seen success through partnerships in renewable energy and flexibility markets.

Shared Risk Models: Introducing shared-risk financial models between governments and private investors can provide early capital to DFR and storage projects, helping to reduce initial risks and making these ventures more attractive.

- **Cross-Border Cooperation**

Regional Collaboration: Mediterranean countries have a unique opportunity to work together, especially through knowledge-sharing, harmonising regulations, and facilitating the cross-border trade of electricity.

Interconnections and Storage Integration: Cross-border electrical interconnections can enhance the role of energy storage by enabling countries with excess renewable generation to store energy for future use, improving overall energy system efficiency.

- **Consumer Engagement**

Education and Awareness Campaigns: Raising consumer awareness about the benefits of DRPs and energy storage systems, such as home batteries and EVs, is critical. Countries like Lebanon, where rooftop solar and decentralised energy storage have gained traction, demonstrate the importance of engaging consumers early in the process.

Dynamic Tariffs and Demand Response Programmes: Encouraging consumers to participate in dynamic pricing programmes (such as real-time pricing) and demand response initiatives can further enhance grid flexibility. Smart meter deployment and user-friendly applications will empower consumers to manage their consumption more effectively.

- **Grid Modernisation and Smart Technologies**

Upgrading Grid Infrastructure: Grid modernisation is essential for integrating both DFR and energy storage technologies into the energy system. Portugal, Greece, and Jordan have already taken significant steps towards smart grid deployment, which will help enhance the ability to manage DERs and improve the system's resilience to fluctuations in supply and demand.

Investment in Smart Grids and Data Management: Implementing smart grid technologies, including advanced metering infrastructure (AMI) and real-time data management systems, will be crucial in managing the increasing complexity of DFR and energy storage systems. Governments need to prioritise investments in these areas to ensure the effective integration of renewable energy and storage technologies. Spain is enhancing its energy and digital infrastructure through significant investments in smart grids to support renewable integration, as well as major expansions in data management and cloud services, positioning the country as a key hub for energy and digital innovation in Southern Europe.

In conclusion, while DFR and energy storage are still developing and face several barriers, they are essential tools in the decarbonisation of the energy sector and industries like transport. Governments and regulators across the Mediterranean region must invest in infrastructure upgrades, establish clear regulatory frameworks, and incentivise early-stage projects to ensure the successful implementation of these technologies. Through innovation, regional cooperation, and public-private partnerships, the region can move towards a more sustainable, flexible, and decarbonised energy future.

ANNEX

I. Annex 1 — Distributed Energy Resources in Lebanon

• Introduction

The shortage of electricity supply in Lebanon has been a chronic issue that has worsened in recent years. However, the abundant renewable energy sources in the country, the local technical expertise in solar PV solutions developed over the last decade, and regulatory actions have created the opportunity to make the national energy mix more sustainable by enhancing energy security through distributed renewable energy sources.

This case study examines the impact of several factors on the Lebanese energy market, focusing on energy demand, renewable energy development, and the nature of the energy mix.

• Description

The turning point in boosting the development of small-scale solar PV systems occurred in 2021, when fossil fuel subsidies were removed in October of that year. Additionally, the tariff reform for electricity supplied by the utility Electricité du Liban (EDL), enacted in November 2022, played a role in increasing the economic savings that can be generated from using PV systems as an alternative energy source. This situation created an intense need for residents, industrialists, corporations, and healthcare providers to reduce their consumption from conventional power sources, primarily diesel generators, and invest in off-grid or hybrid solar PV systems.

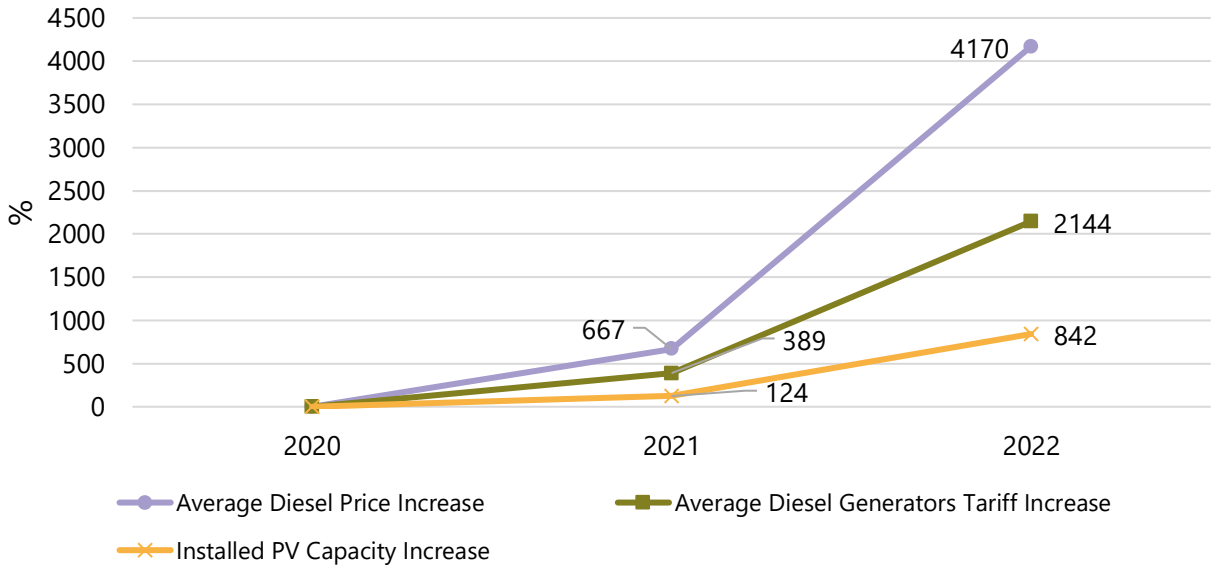

Figure 9. *Impact of Subsidies Removal*

Figure 9 illustrates how the installed PV capacity increased in tandem with the rising cost of electricity generated from diesel generators.

The solar standards decree number 6977, issued in October 2020, mandated national standards related to solar energy systems, which included standards issued by the Lebanese Standards Institution (LIBNOR) for all components of such systems. It designated the Industrial Research Institute (IRI) or any internationally accredited laboratory for verification. This step enhanced the quality of PV system components imported and used throughout Lebanon, which was critical to implement prior to the market's boom in 2021 and 2022.

- **Results and Analysis**

impact on the national electricity consumption was remarkable, as it shrank by 29% between 2021 and 2022, and the share of energy produced from distributed solar PV systems increased from 2% to 13% of the total electricity consumed in the country. In terms of environmental savings, more than 2 million tons of CO2e were saved by the capacity of PV systems installed in 2021 and 2022 alone.

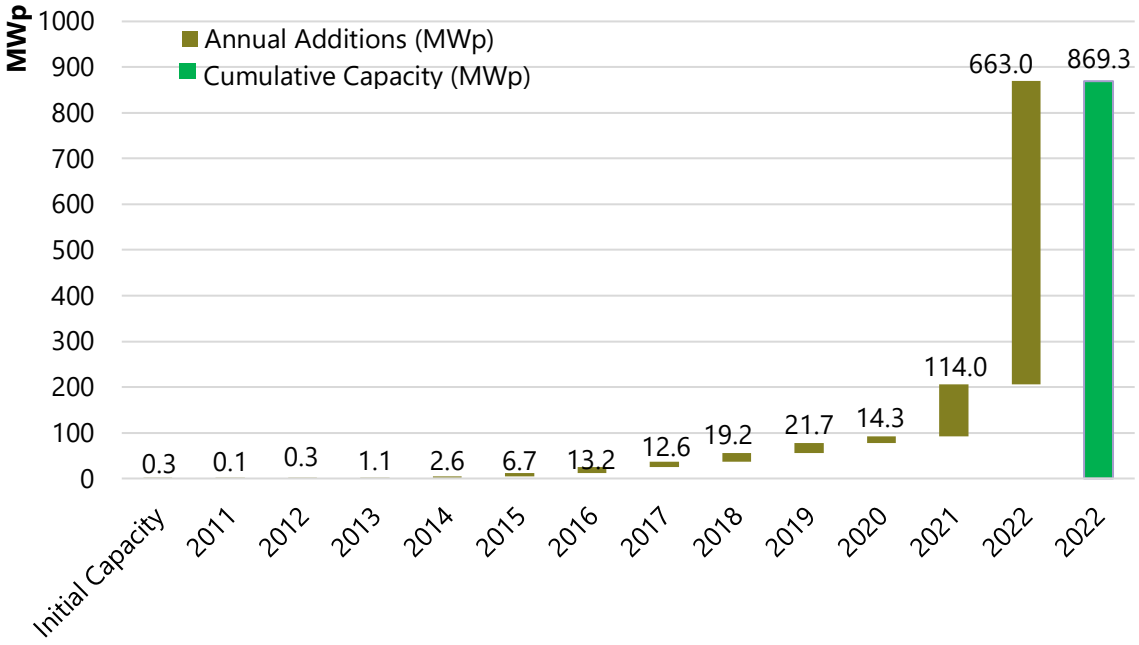

Figure 10. *Yearly and Cumulative PV Capacity*

As shown in Figure 10, by the end of 2020, less than 90 MWp were installed in the Lebanese market, whereas more than 777 MWp were installed in 2021 and 2022 alone. This reflects the unprecedented increase in consumer reliance on distributed energy resources across all sectors.

From an end-user perspective, the average price of 1 kWh saved from conventional power sources was $0.20 in 2021 and $0.60 in 2022 considering the generator subscription fees, the EDL hours of supply, and the change in EDL's tariffs in 2022.

Moreover, a shift in the type of systems was also witnessed during this transformation in the energy sector, where PV systems with batteries accounted for the biggest share of installed systems for the first time since 2010.

The figure below clearly shows how 65% of the cumulative installed capacity in the market is for systems with energy storage, noting that 98% of the capacity installed in the residential sector in 2021 and 2022 were systems with batteries.

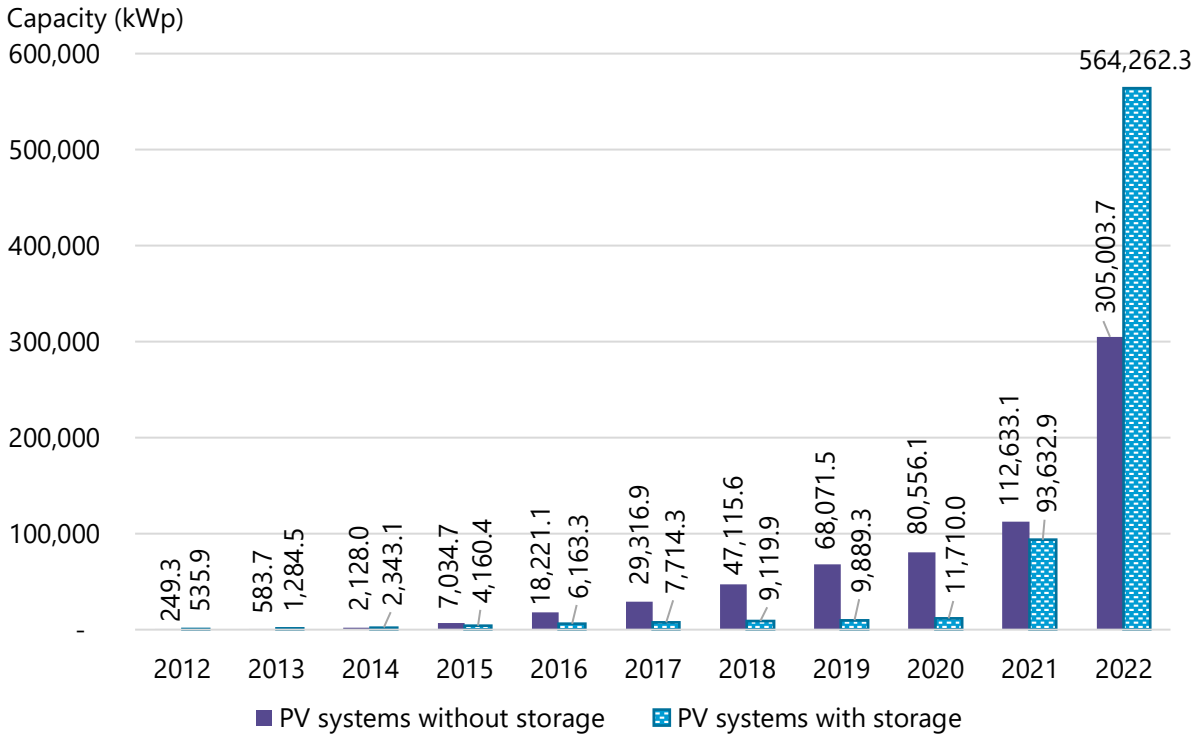

Figure 11. *PV Systems with and without Storage*

On another note, incentives for using BEVs and PHEVs were key to initiating the energy transition in the transport sector as well. All customs and internal usage fees are exempted for BEVs, and 80% of the same fees are exempted for PHEVs, in addition to a 70% exemption on the registration fees for both types.

These incentives, along with the removal of subsidies and the exceptional increase in installed PV systems installed, drove consumers to adopt more EVs for transportation and charging purposes, utilising electricity generated from solar energy. According to Lebanese customs data, 81% of EV imports to Lebanon occurred in 2022 and 2023, indicating how quickly the positive momentum for energy transition reached this sector.

- **Conclusion**

The energy storage and distributed energy resources in Lebanon is progressing on parallel tracks, as the implementation of distributed renewable energy sources with storage has gained importance due to energy and environmental savings and energy security considerations.

On a national level, this transformation has altered the nature of the energy mix for electricity consumption, reducing reliance on conventional sources and shifting towards more reliable energy sources. The overall impact extends beyond the energy sector, influencing all energy and electricity-demanding sectors, where the remarkable development in the transport sector, represented by the increase in BEVs, forms a new energy storage option that can be leveraged in the future for greater stability and flexibility in the grid.

II. Annex 2 — FIRMe: A Pilot Project of Flexibility Services in Portugal

The pilot project FIRMe, or "Integrated Flexibility in a Market Regime", promoted by the main DSO in mainland Portugal called E-REDES (Distribuição de Energia, S.A.), was approved by the ERSE at the end of 2023 under the rules of the Networks Operation Code of the electricity sector (ROR)[6].

The FIRMe pilot project aims to foster local flexibility markets and to integrate flexibility as a complement to network investment, establishing and contracting local service providers (consumers, generators, aggregators).

The services apply to specific situations such as responding to distribution network failure events, constraints arising during scheduled unavailability of distribution network assets, and the management of consumption peaks under normal distribution network conditions.

- **Introduction**

Flexibility[7] is very important to facilitate and accelerating the energy transition. The activation of this flexibility enables the network to accommodate new renewable generation and manage new electrical consumptions, such as EV charging or fuel switching for heating applications using heat pumps.

Flexibility access may be classified into different categories depending on the mechanisms used by the DSOs[8]. One of these is market-based procurement, where DSOs can explicitly procure flexibility that benefits grid services from the market(s).

The legal principles of the Portuguese electric system are established in Decree-Law No. 15/2022, of 14 January[9], which transposes into Portuguese law Directives EU 2019/944 (Internal Market for Electricity) and EU 2018/2001 (promotion of the use of energy from renewable sources). Article 123 of Decree-Law No. 15/2022 foresees the use of flexibility services by system operators as an alternative to new investments in infrastructure, echoing Article 34 of Directive 2019/944. The use of flexibility services is recognised as increasingly crucial for the transition to an electric system with high levels of renewable generation integration. Network development plans are required to evaluate alternative options to conventional investments. The assessment must include a cost-benefit analysis considering the contracting of flexibility services from distributed resources, including storage, demand response, and generation when these services ensure the objectives of guaranteeing security of supply and the existence of capacity to receive and deliver electricity with adequate levels of security and quality of service.

[6] https://www.erse.pt/en/activities/regulations-electricity/networks-operation/
[7] Regulation (EU) 2024/1747 of the European Parliament and of the Council of 13 June, Electricity Market Design, defines flexibility as "the ability of an electricity system to adjust to the variability of generation and consumption patterns and to grid availability, across relevant market timeframes".
Flexibility may also be understood as the ability of facilities connected to the network to change their consumption or injection into the network, temporarily, depending on the needs communicated by the operator.
[8] CEER Paper on DSO Procedures of Procurement of Flexibility, 2020
[9] National electric system legal framework

E-REDES began preparing the project in early 2022 by performing workshops, webinars, conferences, and meetings with potential flexibility service providers (FSP), which were required to register in PicloFlex[10] platform. FSPs were hired through auctions held on this platform in July 2023. A timeline of the FIRMe project can be found in the image below:

Figure 12. *FIRMe Timeline (Source: E-REDES)*

The FIRMe pilot project, expected to last two years, identified and designed **eight use cases** grouped into **three types of products**:

- **Restore:** Flexibility service for the restoration of energy supply during sporadic events of interruption of supply and network failure; availability of the asset paid annually with activation during the interruption event; interruption probability of between 1% and 5% annually (Bragança, Beja, Marinha Grande, Bombardeira, and Milfontes);

- **Dynamic:** Flexibility service for use during periods of network maintenance, as an alternative to the utilisation of a mobile substation; availability request one week ahead and activation with a 15-minute warning; estimated frequency of one maintenance event every two years (São Martinho do Campo);

- **Secure:** Flexibility service for managing consumption peaks in specific network locations (Paredes de Coura and Tondela); periods of availability of the flexible assets defined in advance; frequent utilisation during the defined periods of availability.

[10] https://prt.picloflex.com/
https://piclo.webflow.io/profiles/e-redes

Figure 13. *Location of the Use Cases for the Pilot Phase (Source: E-REDES)*

The reserve prices for the auctions associated with each product were defined with fixed and variable components[11]. For each of these products, different costs and benefits methodologies were developed, considering the probability of activation, cost of alternatives, and energy not supplied associated with network failures.

The project has two main objectives:

1. To test the concept of contracting flexibility services through FSPs and the use of digital platforms (identification of opportunities and use cases, communication with potential providers, evaluation of the potential to launch tenders, and the use of these contracts in network operation);
2. To develop the DSO's internal knowledge and capacity to implement cost-benefit analysis methodologies, specify the services and requirements for participation, and develop the rules and procedures necessary for the use of flexibility (including the development and testing of baseline and settlement methodologies, qualification tests, contracts, and communications with the participants of the project).

[11] https://cdn.prod.website-files.com/6123718de4b96c44035b9af8/649d857e659ee768d7f00aeb_Prec%CC%A7os_Indicativos.pdf

This project will also identify potential interest from aggregators, suppliers, generators, consumers, and energy storage owners.

The experience and recommendations arising from the pilot project will reflect on regulatory developments, particularly in the rules to be created in the Procedures Manual for the Technical Management of Electricity Distribution Networks (currently in development), proposed by E-REDES.

- **Description**

The ROR established a set of rules for pilot projects to enable agents and regulated entities to submit experimental or innovative projects for approval. In these rules, a specific assignment was given to the DSO to present a pilot project that includes at least congestion management services (No. 12, Article 78 of ROR).

The project aims to engage demand response technologies and other flexibility assets (generation, storage, aggregated services).

FIRMe is the first project of its kind in Portugal. It started with a few use cases with the aim of developing flexibility services markets and attracting interest from potential participants, and it has a limited lifespan. For this initial approach and within the framework of a pilot project, it allows for knowledge acquisition and learning.

The locations were chosen by the DSO based on experience and identified constraints within the distribution network.

The regulator endorses and even supports the project when necessary, and it is publicised on the regulator's website[12]. The project developer also has obligations resulting from the approval, such as:

- The project is monitored by ERSE and is subject to a final report by the DSO containing the main conclusions;
- The project and the reports are publicly disclosed by the DSO according to the communications plan presented;
- The contracted flexibility services and their technical requirements, including those for data interoperability between the DSO and the FSP, should be published, simplifying and reducing the burden of participation;
- Every four months, the DSO should provide information to ERSE regarding the main advances in implementing the pilot project and a mid-term assessment by the end of 2024.

One of the options of the project was the exemption of penalties for failure to comply with the instructions of the DSO in this initial approach to the flexibility markets, in order to lower the risk of participant attrition. As an experimental measure, this facilitates engagement from potential providers.

[12] https://www.erse.pt/media/arhjj0bz/lista_projetos_piloto_ror_pt.pdf

Regarding the acceptance of the costs of the project, the concept of a pilot project allows for some flexibility between the direct costs and the potential benefits for the electric system.

In FIRMe, the costs associated with the "Dynamic" and "Secure" services are not reflected in the tariffs since the DSO will assume them. The "Restore" service has its fixed and variable costs accepted and will be reflected in the tariffs; however, the accepted costs were limited by ERSE, considering activation scenarios and the risk-sharing between the electricity sector and consumers.

- **Results and Analysis**

The project successfully attracted attention and engaged potential service providers, with 63 FSPs (102 flexibility assets and a total of 260 MW) registering nationwide, including demand response, storage aggregation, generation, and electric vehicles. Of these, only 36 were available within the pilot areas (46 assets representing 89 MW). There were 21 different FSPs bidding in the tenders using 32 flexibility assets connected at various points in the distribution network, including generation (1 MW), storage (12 MW), consumption (23 MW), and aggregation (<0,1 MW)[13].

Currently, 15 FSPs are participating in the pilot project.

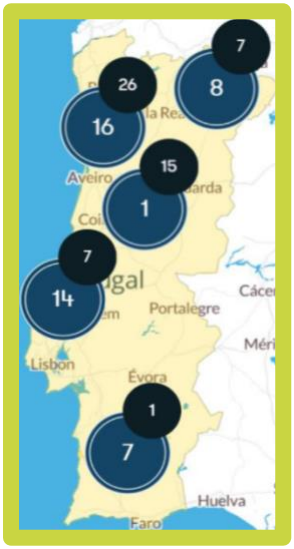

Figure 14. *Registered Flexibility Assets (Pilot Areas in Blue) (Source: E-REDES)*

The necessary information and documentation to launch the tenders and contract with FSPs was developed and made publicly available:

- FSP Standard Contract
- Tender Rules
- Opportunities Details
- Guide Prices

[13] https://www.e-redes.pt/pt-pt/transicao-energetica/redes-do-futuro/firme

- Bid Indications

3 Flexibility Products	Requested by the DSO	Offers	Viable Offers
Dynamic	5.5 MW	16.0 MW	12.5 MW
Secure	2.2 MW	1.9 MW	0.9 MW
Restore	48.0 MW	18.0 MW	16,0 MW
Total	55.7 MW	35.9 MW	29.4 MW

Figure 15. *Tenders' Results*

The objective of developing a flexibility services contract platform and contracting services was achieved. The project engaged service providers and identified potential new providers, developed the tenders, and established the necessary rules, contracts, and communication procedures for the providers. Additionally, the use of digital platforms (third-party) for the tenders was successfully tested.

At this point, the project is still ongoing, so the evaluation of the project is expected in the mid-term final report.

In identified situations of grid asset failures, when flexibility resources are activated, the electricity supply is expected to be maintained without current or voltage constraints.

The **Dynamic** product utilises flexibility for maintenance periods, expecting to yield financial and environmental benefits by reducing emissions associated with mobilising a mobile substation.

In the **Secure** product, by managing peak load at certain times, the investment needs of the network can be deferred.

As for the **Restore** product, since it is used to support the re-establishment of the network during grid failure events, the main benefit would be social, as consumers will not be curtailed. The benefit is associated with reduction of the energy not supplied.

At this development stage, it is not possible to accurately assess the relationship between the liquid benefits for the system. This evaluation may only be possible with the final results of the project or even in a later stage, possibly in the mid-term report.

One of the challenges was a storage FSP that participated but did not have the storage unit built or even licensed. Although it demonstrated proof of being able to deploy and operate the storage asset, it was necessary to assess with the licensing authority the viability of the project before it could be accepted as a viable asset.

Some products did not have enough offers or participants to satisfy the needs of the DSO, indicating the need to further develop interest from providers in these areas or services in future procedures.

There are generators, consumers, and energy storage owners interested in participating in flexibility markets. The willingness to participate and develop procedures with the network operators and the necessary technology among the various types of flexibility providers (consumption, generation, storage, aggregation) exists.

- **Conclusion**

The final objectives are still to be met as the project is ongoing. That said, we may consider the project a success; it has identified potential flexibility providers with different technologies and successfully engaged them in participation. Thus, at first glance, we found out that there is interest in such services, and several entities are eager to participate with flexible assets. The expectation is that, based on the experience gathered, we may begin establishing the regulatory framework applicable to flexibility services even before the project's completion.

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