

EVALUATING ADEQUACY MECHANISMS IN THE MEDITERRANEAN REGION

3.2-MED25-40GA-3.2



Electricity Working Group
(ELE WG)

*Empowering Mediterranean regulators
for a common energy future*

ABOUT MEDREG

MEDREG is the Association of Mediterranean Energy Regulators, uniting 29 regulators from 23 countries across the European Union, 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 fosters coherent regulatory approaches and practices at the regional level, aiming at progressive market integration in 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 goal is to establish an integrated Euro-Mediterranean energy market that strengthens energy security and drives the 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.

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

ACKNOWLEDGEMENTS

This report is the result of the work of the MEDREG Electricity Working Group (ELE WG) and is based on the responses of MEDREG members to the benchmark prepared by the chairs of the ELE WG and the MEDREG Secretariat.

For any queries relating to this report, please contact:

MEDREG Secretariat

Email: info@medreg-regulators.org

DISCLAIMER

This publication was produced with financial support from the European Union. The contents are the sole responsibility of MEDREG and do not necessarily reflect the views of the European Union.

EXECUTIVE SUMMARY

This report provides a comprehensive analysis of the adequacy mechanisms currently in use in the Mediterranean region, based on a survey of 13 MEDREG members. It examines how these mechanisms, which are crucial for ensuring a stable and reliable electricity supply, are designed, implemented, and monitored from a regulatory standpoint. The report also addresses the challenges faced by these countries, as well as the approaches they are adopting to evolve their systems to meet new demands, particularly with the rise of renewable energy sources.

The key findings reveal a diverse landscape of adequacy mechanisms across the region. While some countries, such as Algeria and Türkiye, have operational mechanisms in place, others, like Greece, are still in the process of developing or planning them. The most common mechanisms include operating reserves, contractual load interruption, and strategic reserves, often combined in a hybrid approach. The primary goal across the board is to ensure security of supply, with a growing emphasis on renewable integration as a secondary objective.

A central theme is the critical role of National Regulatory Authorities (NRAs) in this process. NRAs are responsible for approving procedures, setting tariffs, and monitoring performance indicators, all of which are essential for the effective functioning of these mechanisms. Stakeholder involvement, particularly from producers and distributors, is a key part of the regulatory framework, typically through public consultation processes.

The report also identifies common challenges, such as grid flexibility limitations, financial constraints, and the absence of a mature regulatory framework for market-based solutions. To overcome these obstacles, countries are focusing on strategies such as modernising grid codes, promoting private sector participation in renewables and storage, and strengthening regional interconnections.

Based on these findings, the report recommends that MEDREG members prioritise:

- Developing market-based mechanisms that incentivise low-carbon technologies such as energy storage and demand response.
- Enhancing cross-border collaboration to create more resilient regional grids.
- Strengthening regulatory frameworks to ensure transparency, fairness, and a level playing field for all participants.
- Promoting knowledge exchange and technical assistance among members to share best practices and lessons learned.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	3
1. Introduction and Methodology	7
1.1. Security of Supply: A Key Objective	7
1.2. Report Objective	8
1.3. Methodology	8
2. Understanding Adequacy Mechanisms	10
2.1 Definition and Types of Adequacy Mechanisms	10
2.2 Key Principles: Reliability, Cost-Effectiveness, and Flexibility	13
2.3 Role in Enhancing System Security and Supporting Renewable Energy Integration	14
3. Electricity System Challenges in the Mediterranean Region	16
3.1 Increasing Demand and Electrification Trends	16
3.2 Renewable Energy Integration and Variability	17
3.3 Cross-Border Interconnections and Regional Resource Sharing	18
3.4 Regulatory Gaps and Alignment Needs	18
4. Benchmarking Adequacy Mechanisms in the Mediterranean	20
4.1 Current Mechanisms Across the Region	20
4.2 Overview of Adequacy Mechanisms by Country	22
5. Regulatory Framework for Adequacy Mechanisms	26
5.1 Role of National Regulatory Authorities (NRAs) in Enabling and Monitoring Adequacy Mechanisms	26
5.2 Policy Frameworks and Market Designs Supporting Adequacy	28
5.3 Used Performance Indicators and Monitoring	29
5.4 Adequacy Mechanism Cost Recovery and Investment	30
5.5 Best Practices in Balancing Stakeholder Interests and Ensuring Market Efficiency	32
6. Impact of Adequacy Mechanisms on Electricity System Efficiency	34
6.1 Enhanced Reliability and Stability of Electricity Supply	34

6.2	Cost Optimisation Through Demand-Side Participation and Efficient Resource Allocation	34
6.3	Supporting Renewable Energy Integration by Addressing Variability	35
6.4	Strengthening Cross-Border Collaboration and Market Development	35
7.	Recommendations and Conclusions	37

LIST OF FIGURES

Figure 1: Replies to the ELE WG Benchmarking.....	9
Figure 2: Types of adequacy mechanisms.....	12
Figure 3: Electricity demand/generation evolution in the Mediterranean region 2020-2023 (Source: MEDREG MEMO 2024)	16
Figure 4: MEDREG member countries - RES % in the energy mix by the end of 2024 (Source: MEDREG RES WG report 2025)	17
Figure 5: Current adequacy mechanisms across the Mediterranean region	21
Figure 6: Adequacy mechanisms cost recovery, and investment.....	30

1. Introduction and Methodology

1.1. Security of Supply: A Key Objective

In 2021, MEDREG published a report on the security of electricity systems. This fundamental issue involves various aspects that highlight the need for proper planning of production facilities and infrastructure to meet the needs of the population. The general rules for designing electrical systems include a set of mechanisms relating to installed capacity, as well as a set of technical parameters (voltage and frequency management, ancillary services, redundancy principles to deal with contingencies, etc.). In short, ensuring electricity supply security requires effective procedures for managing the existing system and planning for future needs according to different scenarios: tomorrow's security is being prepared today.

One of the important issues is the balance between supply and demand. This involves ensuring an adequate level of production to cope with different consumption scenarios, depending on various circumstances affecting the availability of production resources.

System adequacy measures the ability of a power system to cope with its load in all the steady states it may operate under standard conditions. This adequacy has different components:

- ability of the generation assets to cover peak load, considering uncertainties in generation availability and load level; and
- ability of the transmission system to perform, with the flexibility provided by interconnection and import and export flows.

MEDREG's work in recent years has shown a wide variety of situations depending on the countries and their degree of regional integration. In terms of supply security, considerable disparities exist, primarily due to the robustness of the networks and the level of production capacity compared to consumption. In several countries, needs are increasing rapidly, putting the supply/demand ratio under pressure. The trend towards greater penetration of intermittent renewable energies also poses new challenges regarding the stability of electricity systems.

Adequacy is a part of a cost-benefit approach. As a 100% reliable system is not achievable, it is a question of finding a balance between the desired level of reliability, characterised, for instance, by the volumes of undistributed energy and the costs devoted to supply security.

In the event of a power supply problem, various measures can be implemented. Improving demand flexibility is a vital focus of work on the reliability of the electricity system, particularly in Europe, although such solutions can be complex to implement.

1.2. Report Objective

This report provides a regulatory and technical analysis of the electricity resource adequacy mechanisms currently implemented, under development, or planned across the Mediterranean region. Leveraging the expertise of MEDREG members, the report primarily aims to benchmark national approaches, identify regional challenges, and propose concrete recommendations to enhance system efficiency, reliability, and support the energy transition.

The central focus is on evaluating how National Regulatory Authorities (NRAs) are fulfilling their critical role in

1. **Enabling and monitoring capacity mechanisms**, strategic reserves, and demand-side management (DSM).
2. **Balancing** the need for security of supply with the goals of **decarbonisation** and **cost-effectiveness**.
3. **Facilitating the smooth integration of high shares of renewable energy sources (RES) and energy storage**.

This analysis is crucial for promoting a fair, functioning, and integrated Mediterranean energy market. It aims to stimulate actionable discussions among MEDREG members on:

- The effectiveness and suitability of different adequacy mechanism types (e.g. capacity markets vs. strategic reserves).
- Best practices in aligning regulatory frameworks to encourage private investment in flexible resources (e.g. storage, demand response).
- The role of cross-border interconnections in sharing resources and bolstering regional adequacy.

1.3. Methodology

The report is based on a benchmarking survey prepared by the Electricity Working Group (ELE WG) chairs in collaboration with the MEDREG Secretariat. This survey specifically targeted regulatory and technical details concerning resource adequacy.

The collected data enable a structured, comparative analysis across the following key dimensions:

1. **General status and mechanism type:** Identifying whether mechanisms are operational, under development, or planned, and specifying the types (capacity market, strategic reserve, demand response, hybrid, or ancillary services).
2. **Primary goals:** Defining the main drivers (security of supply, cost reduction, renewable integration).

3. **Regulatory framework:** Detailing the specific role of the NRA in design, implementation, and monitoring (e.g. approvals, tariff setting, compliance enforcement).
4. **Economic and financial aspects:** Analysing cost recovery methods and the balance between public and private investment.
5. **Performance and evolution:** Evaluating the indicators used (e.g. System Average Interruption Duration Index (SAIDI), and System Average Interruption Frequency Index (SAIFI)) and the strategies for mechanism evolution (e.g. grid modernisation, market coupling).
6. **Cross-border integration:** Mapping existing interconnections and exploring their formal role in national adequacy planning.

Out of 23 member countries, the Secretariat received 14 responses, as represented in the figure below.



Figure 1: Replies to the ELE WG Benchmarking

It should be noted that in the report, Montenegro will not be mentioned, as they do not have an adequacy mechanism in place. Additionally, in MEDREG, seven members do not regulate the electricity market.

2. Understanding Adequacy Mechanisms

2.1 Definition and Types of Adequacy Mechanisms

An adequate electricity system is one with sufficient resources, including generation, storage, demand-side management, and transmission capacity, to meet expected electricity demand reliably. Adequacy mechanisms are the tools or measures designed to ensure this balance, particularly in the face of evolving market dynamics.

There are many ways to promote power supply adequacy, which are influenced by the overall governance of electricity systems. In vertically integrated organisations, adequacy is ensured by a single entity managing generation, transmission, and distribution jointly. Operators then objectively combine different measures in a coordinated way. Conversely, market approaches consist of splitting generation, grid management, and supply to consumers. In such cases, maintaining generation adequacy requires implementing mechanisms that support appropriate anticipation of future system needs by generators. In the European Union, the internal market has long been governed by the energy-only principle, meaning that market prices are assumed to provide the relevant incentives for maintaining adequate generation. However, issues such as the “missing money problem” have led some member states to opt for procedures that add to the competitive market and secure the cost coverage of assets necessary to ensure supply (peak shaving stations for instance).

The EU approach to adequacy

During discussions on adequacy in the EU between 2014 and 2016, a wide diversity of practices in national adequacy assessment methods was observed. Countries use these adequacy studies to justify the introduction of capacity mechanisms. Beyond its competences in State aids, the European Commission has sought to provide a framework for capacity mechanisms via common terms for assessing their necessity in the so-called 4th legislative package. The Electricity Regulation¹, adopted in 2019, aimed to improve transparency regarding the level and needs of security of supply in Europe and establishing a common basis for calculating security of supply criteria in

¹ Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity

the Member States. It introduced additional constraints for Member States wishing to introduce or maintain their capacity mechanisms.

A key principle in Electricity Regulation is that capacity mechanisms, which Member States may introduce to address resource adequacy concerns, should be temporary, used only as a last resort, and permitted only if an adequacy issue is identified through a resource adequacy assessment based on an EU methodology. The Regulation specifically requires the following process:

- Member States must set a transparent reliability standard based on a methodology proposed by ENTSO-E and approved by ACER². This criterion, which must be updated regularly, represents the level of interruption to the electricity supply (load shedding) caused by an imbalance between supply and demand, accepted each year by the collectivity. It reflects an economic trade-off between the cost of power cuts for the community (VoLL – value of lost load) and the cost of measures to reduce their average duration and frequency (CONE – cost of new entry).
- Each year, a simulation of the number of hours of load shedding in the next decade, in the absence of a capacity mechanism (LOLE: Loss of Load Expectation) in the Member States, is conducted. This calculation is based on a methodology proposed by ENTSO-E and approved by ACER³, aimed at introducing an economic assessment of the viability of capacity and taking better account of interconnections. This calculation is carried out at the EU level by ENTSO-E (European Resource Adequacy Assessment, ERAA) and at the national level by the Member States as part of national adequacy assessments.
- If the simulated load shedding hours in a system without a capacity mechanism are lower than the national reliability standard, then no adequacy problem is identified, and the capacity mechanism must be suspended or abolished. If it is higher, the Member State can submit a request to introduce a capacity mechanism, which must be approved by the European Commission.

The EU energy crisis in 2021-22, which brought back the risks of load shedding in Europe, reopened discussions on the suitability of the EU adequacy framework. The EU electricity market design reform adopted in summer 2024 introduced measures aimed at streamlining the capacity mechanism approval process, which several Member States considered too complex and burdensome. The revised Electricity Regulation highlights the crucial role of capacity mechanisms in ensuring resource

² ACER Decision No 23/2020 on the Methodology for calculating the value of lost load, the cost of new entry, and the reliability standard.

³ ACER Decision No 24/2020 on the Methodology for the European resource adequacy assessment.

adequacy and removes the notion that those mechanisms should be last-resort measures. It also introduces the need for the Commission to propose measures to simplify the process of assessing capacity mechanisms and for a streamlining of the EU resource adequacy assessment methodology.

To that end, the European Commission published a communication on a Framework for State Aid measures to support the Clean Industrial Deal in June 2025, introducing the concept of a “fast-track” approval procedure for capacity mechanisms that meet a list of criteria. As for the revision of the EU resource adequacy assessment methodology, it should be completed in early 2026. Key changes under consideration include the introduction of a new scenario, more closely aligned with actual observed capacity and demand development trends rather than with Member States’ policy objectives, as well as an improved consideration of investors’ risk aversion in the models.

In the Mediterranean region, based on the survey responses from MEDREG members, several types of mechanisms are currently operational, under development, or planned:

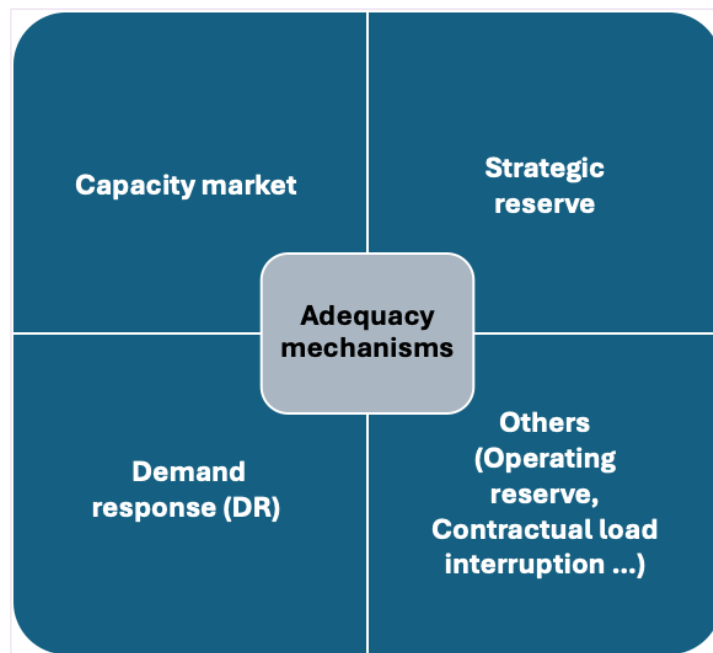


Figure 2: Types of adequacy mechanisms

Capacity market: A market-based approach where generation, storage, or demand-side resources are compensated for their availability, besides the electricity they produce. The core function is to ensure long-term supply. Capacity mechanisms, as defined in some new regulatory frameworks, are specific temporary measures and exclude system services or congestion management.

Capacity Remuneration Scheme (CRS) Evolution: Not all capacity mechanisms are structured as auctions. Spain, since 1998, initially used a fund-based capacity remuneration scheme relying on a unitary demand payment per MWh to incentivise new investments. This system evolved into a yearly capacity payment (€/MW-year) with an availability component. This demonstrates that capacity payments can take various forms—from demand-side funds to fixed annual payments—before adopting a competitive auction design.

Strategic reserve: An "out-of-market" mechanism where a central authority, such as a transmission system operator (TSO), maintains a reserve of power plants that are called upon only in emergencies. The secured capacity is generally not offered on the market.

Demand response (DR): Programmes that incentivise electricity consumers to reduce or shift their energy consumption during peak hours or system stress events. Demand-side management is a change in consumption in response to market signals or incentive payments.

Operating reserve: A crucial component of system adequacy, consisting of FCR (primary), aFRR (secondary), and mFRR (tertiary). These reserves are used to maintain frequency and voltage stability on the grid.

Contractual load interruption: A specific demand-side measure where network users agree to reduce their load under certain conditions.

Interruptibility Scheme/Temporary Emergency Generation: Non-market mechanisms used to maintain system stability during short-term or mid-term generation shortages.

Ancillary services (AS): Services necessary to support the transmission of power from generation sources to consumers, maintaining system reliability and security. These services include frequency control, voltage control, and operating reserves, and are essential components of adequacy mechanisms.

In all the countries, a **hybrid approach** is used, combining several of these mechanisms to ensure a resilient and reliable electricity supply.

2.2 Key Principles: Reliability, Cost-Effectiveness, and Flexibility

Adequacy mechanisms are guided by a set of core principles that ensure they are effective and aligned with broader energy policy goals.

- **Reliability and security of supply:** The primary goal of any adequacy mechanism is to ensure a continuous and stable electricity supply. This is

paramount, especially during high-demand periods or system stress events. The system's reliability is a central concern for regulators and must be maintained despite the challenges of an evolving grid.

- **Cost-effectiveness:** Mechanisms must be designed to achieve their reliability goals at a reasonable cost, avoiding unnecessary capital investment and high operational expenses for consumers. For instance, the costs of mechanisms in Türkiye are recovered through tariffs applied to transmission system users.
- **Flexibility:** As the energy transition accelerates, flexibility has become a critical principle. This refers to the power system's ability to respond quickly to changes in supply and demand. Flexible resources, such as energy storage and demand response, are essential for balancing the intermittency of variable, renewable energy sources.

2.3 Role in Enhancing System Security and Supporting Renewable Energy Integration

The role of adequacy mechanisms has expanded significantly with the rise of RES. They are no longer just about ensuring enough generation capacity and are now central to managing the complex, dynamic challenges of a decarbonised grid.

- **Enhancing System Security:** By providing a safety net of available resources, these mechanisms prevent shortfalls and blackouts. They ensure that even when the sun is not shining or the wind is not blowing, there is sufficient backup capacity to maintain grid stability. In Portugal, the primary goal of the adequacy mechanism is more focused on operational security and frequency control. The capacity mechanism in Türkiye, for instance, makes conventional power plants available to support grid security and ensures the integration of variable RES.
- **Supporting Renewable Energy Integration:** Variable RES, like solar and wind, can introduce significant uncertainty into the grid. Adequacy mechanisms help by:
 - **Providing a “Firming” Function:** They ensure that there is enough flexible capacity to compensate for fluctuations in renewable output.
 - **Incentivising Flexible Resources:** By valuing availability and quick response times, mechanisms like capacity markets can encourage investment in energy storage and demand response. Egypt's goal is to integrate renewables as a key objective of its hybrid adequacy approach.
 - **Promoting Decarbonisation:** As the mechanisms evolve, they can be designed to support decarbonisation objectives. For example, by incentivising flexible resources and energy storage, they can reduce the need for fossil fuel plants and improve system efficiency. Morocco, for instance, is transitioning from centralised thermal reserves to more flexible solutions to integrate renewables.

The table below summarises the different adequacy mechanisms and their primary functions.

Adequacy Mechanism	Primary Function	Examples from MEDREG Members
Capacity market	Compensates resources for their availability, ensuring long-term supply.	Türkiye, France, Italy
Strategic reserve	Maintained as a “last resort” for emergencies.	Egypt, Morocco
Demand response	Incentivises consumers to reduce demand during peak events.	Egypt, France, Portugal and Türkiye.
Operating reserve	Provides ancillary services to maintain grid frequency and stability.	Algeria, Morocco
Contractual Load Interruption	Reduces demand by agreement with network users.	Algeria, France

3. Electricity System Challenges in the Mediterranean Region

The Mediterranean region is a critical hotspot for climate change, facing a range of complex challenges to its electricity systems. These issues are driven by a combination of increasing demand, the need to integrate variable renewable energy, and the complexities of cross-border trade and regulation.

3.1 Increasing Demand and Electrification Trends

Electricity demand in the Mediterranean is on a significant upward trajectory, fuelled by economic development, population growth, and a push towards electrification. In North African and Middle Eastern countries, this surge in demand is particularly pronounced.

- **Population Growth:** A rapidly growing population is a primary driver of increased energy consumption.
- **Economic Development:** Economic growth in the region, especially in the industrial and services sectors, contributes to higher electricity use.
- **Climate Change:** Rising temperatures and extreme weather events are increasing the demand for electricity for cooling, placing additional strain on power systems. The electrification of public transportation is also projected to add a significant new source of electricity demand.

This growth presents a major challenge for countries like Lebanon, which already suffer from a significant demand-supply gap.

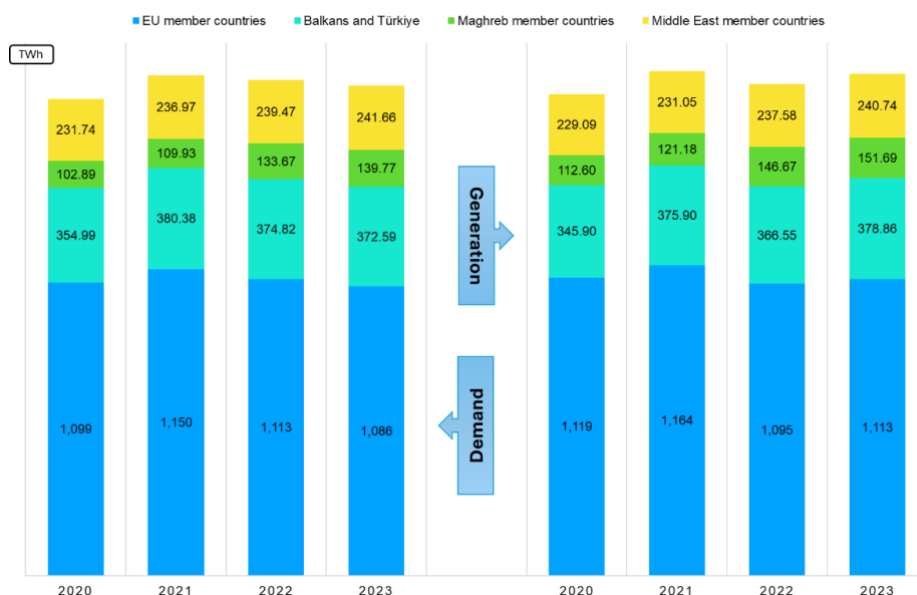


Figure 3: Electricity demand/generation evolution in the Mediterranean region 2020-2023 (Source: MEDREG MEMO 2024)

3.2 Renewable Energy Integration and Variability

While the Mediterranean has abundant potential for renewable energy from sources like solar and wind, integrating these variable sources into the grid poses significant technical challenges.

- **Intermittency:** Unlike fossil fuel-based generation, which can be dispatched on demand, solar and wind power are dependent on weather conditions. This inherent variability creates instability in the grid and can lead to over-frequency events or even blackouts if not effectively managed.
- **Curtailement:** In the absence of sufficient energy storage and transmission capacity, countries like Greece have been forced to curtail, or reject, excess green energy production to prevent grid overloads.
- **Infrastructure limitations:** Integrating high shares of renewables requires significant investment in advanced infrastructure, such as utility-scale storage and smart grids. Albania, for instance, faces challenges due to its hydropower dependence and infrastructure limitations.

The need for system flexibility is more urgent than ever. Adequacy mechanisms must evolve to enable intermittent renewable sources to participate in grid balancing services.

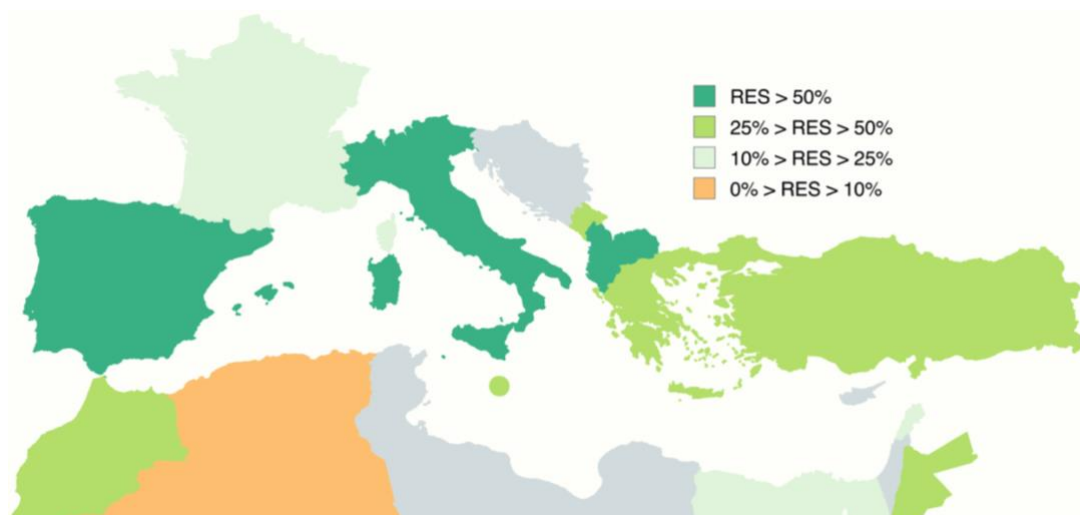


Figure 4: MEDREG member countries - RES % in energy mix by the end of 2024 (Source: MEDREG RES WG report 2025)

3.3 Cross-Border Interconnections and Regional Resource Sharing

Cross-border interconnections are essential for enhancing security of supply, integrating renewables, and enabling electricity trade. However, the Mediterranean region's interconnections are still in the early stages of development and the framework for regional resource sharing is limited.

- **Fragmented infrastructure:** While some countries have existing interconnections (e.g. Algeria with Tunisia, Greece with its neighbours), the overall landscape is fragmented, delaying the development of an integrated regional market. A major challenge is the lack of interconnection infrastructure and synchronisation, particularly between northern and southern Mediterranean countries.
- **Investment barriers:** The political and regulatory diversity between countries makes interconnection investments a high-risk undertaking. Morocco—currently the only country in the southern Mediterranean electrically interconnected with Europe—offers concrete lessons learned on governance, operations, and risk allocation at a time when many other trans-Mediterranean projects remain stalled.
- **Market and Operational Divergence:** Disparate market structures and a lack of harmonised regulatory frameworks create significant obstacles to effective cross-border trade and resource sharing. For instance, a common capacity calculation methodology and rules for operational security need to be predefined to optimise the use of existing networks.

3.4 Regulatory Gaps and Alignment Needs

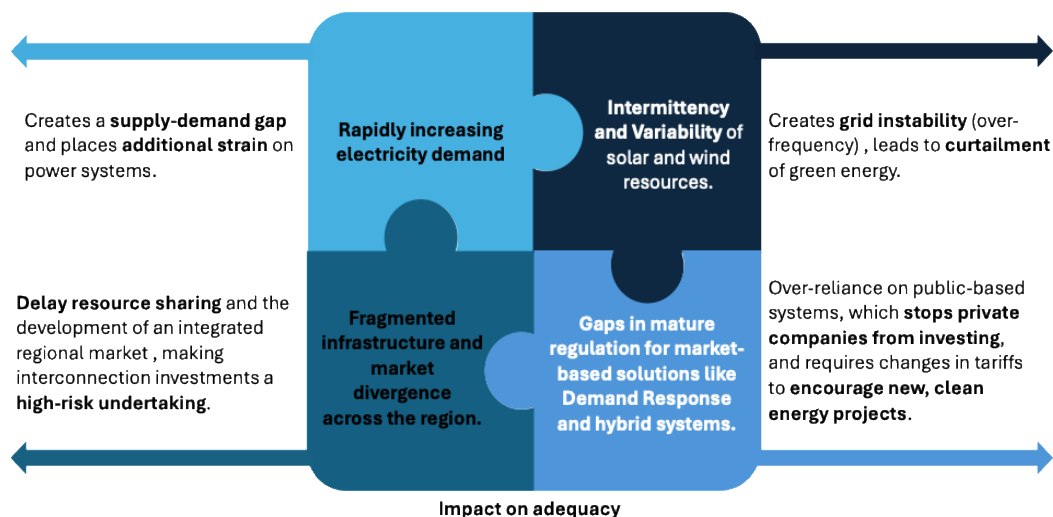
To address these challenges, a robust and aligned regulatory framework is crucial. The survey responses highlight several key regulatory gaps:

- **Market-Based solutions:** Many countries lack a mature regulatory framework to oversee emerging mechanisms like demand response and hybrid systems. This often leads to a reliance on centrally planned, public-sector-led adequacy solutions.
- **Harmonisation:** There is an urgent need for regulatory alignment to ensure interoperability and attract private investment. This includes standardising technical specifications and coordinating investment strategies.

- **Stakeholder engagement:** While some countries, like Algeria, Egypt, Morocco, and Türkiye, involve stakeholders through public consultations in the development of regulatory frameworks, the level of engagement varies. Ensuring all parties, including consumers, have a voice is crucial for designing effective mechanisms.
- **Tariff structures:** Regulators must design tariff structures that not only recover the costs of adequacy mechanisms but also incentivise investment in clean energy technologies. The gradual removal of fossil fuel subsidies, for instance, can improve price signals and incentivise cleaner investments. Egypt, for example, started a tariff structure to remove subsidies in 2014, while Morocco applied a System Services Tariff (TSS) to renewable generation—most recently revised by ANRE at the beginning of 2025.

Electricity System Challenges: Key Takeaways

The Mediterranean region's electricity systems face a convergence of climate-driven pressures, rapid demand growth, and structural limitations in market integration and grid flexibility. These challenges underscore the urgent need for robust and evolving adequacy mechanisms.



4. Benchmarking Adequacy Mechanisms in the Mediterranean

4.1 Current Mechanisms Across the Region

The electricity adequacy landscape is diverse, with all surveyed countries inherently using a hybrid strategy that combines generation, demand, and grid-support tools. However, they are primarily categorised based on their dominant regulatory mechanism and focus on resource procurement.

Capacity Market/Mechanism: Countries like Italy and Türkiye focus on a market-based approach, structured to compensate resources for their availability and long-term security.

Reserve/Centrally Planned: Algeria, Cyprus, Lebanon, and Morocco primarily rely on centrally governed, non-market mechanisms such as operating reserves or strategic reserves to ensure system stability.

Strategic Reserves, Long-Term Contracts, and Limited Demand Response: Albania and Egypt employ this combination of tools to balance supply, reflecting a transitional regulatory stage where a formal capacity market is not yet established.

- **Key Developments:**

Phased Implementation: The regulatory framework in North Macedonia demonstrates a phased approach, classifying a capacity mechanism as a “last resort” to be introduced only if resource inadequacy is identified after other market measures have proven insufficient.

RES Integration as a Strategic Goal: Four countries—Egypt, Lebanon, Morocco, and Türkiye—explicitly include RES integration as a strategic support goal for their adequacy mechanisms, besides the primary goal of security of supply.

Planning Future Markets: Currently, Greece has no operational adequacy mechanism but recognises the critical need to design a future market-based, technology-agnostic auction to ensure long-term capacity adequacy.

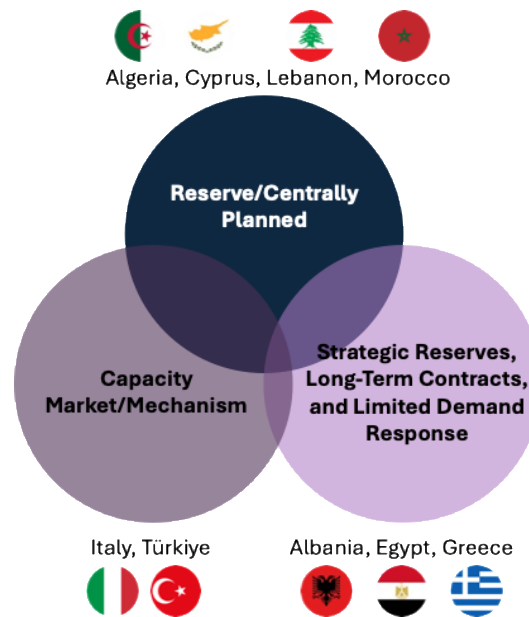


Figure 5: Current adequacy mechanisms across the Mediterranean region

- **Key Mechanisms and Approach**

The approaches to adequacy fall into three main categories:

Hybrid Approach (most common): The majority of operational countries, including Albania, Algeria, and Egypt, rely on a hybrid approach. This combines multiple mechanisms such as operating reserves, strategic reserves, contractual load interruption, and long-term contracts. Lebanon is also planning a similar system.

Market-Based Focus: Italy and France stand out with an operational capacity market designed to ensure long-term resource adequacy, driven by private investment incentives. Türkiye also uses a capacity mechanism alongside demand response services. North Macedonia is currently developing a system that includes a capacity market and demand response as part of a phased approach.

Strategic Reserves & Interruptibility: Morocco and Türkiye employ a strategic reserve mechanism to maintain system stability. Cyprus uses specific non-market mechanisms like an interruptibility scheme and temporary emergency generation.

- **Strategic Objectives**

Beyond security of supply, four countries explicitly include RES integration as a strategic support goal for their adequacy mechanisms: Egypt, Lebanon, Morocco, and Türkiye. This adaptation is critical for aligning adequacy with national decarbonisation targets.

4.2 Overview of Adequacy Mechanisms by Country

- **Algeria:** Operational mechanisms include an operating reserve (primary, secondary, and tertiary) and contractual load interruption. The primary goal is security of supply. CREG, the regulatory commission, approves TSO procedures and monitors the provision of reserves.

- **Albania:** Adequacy mechanisms are operational and evolving through the integration of renewables, market reforms, and regional cooperation. The regulator, ERE, has a strategic and supervisory role aligned with energy security goals. Investment is predominantly public, with a growing role for the private sector, especially in renewables.

- **Cyprus** uses specific non-market mechanisms classified as emergency measures. These include an interruptibility scheme for short-term generation shortages and a temporary emergency generation plan for mid-term adequacy concerns. The regulator (CERA) gives ultimate approval for the emergency generation plan, and its cost recovery is facilitated through network tariffs.

- **Egypt** employs a hybrid approach combining strategic reserves, demand response (DR) (limited programmes currently), long-term power purchase agreements (PPAs), and cross-border interconnections. The primary goal is security of supply, with renewable energy integration as a secondary goal. Key challenges include grid flexibility limitations in integrating variable RES and regulatory capacity gaps.

- **Greece:** RAAEY recognises its critical role in designing future capacity mechanisms to ensure adequacy in a high-RES market. Any designed mechanism should follow a market-based, competitive, technology-agnostic auction.

- **Italy:** ARERA's adequacy mechanism is operational and structured as a capacity market, which is a reliability option scheme. Its primary goal is security of supply at the least cost, achieved through a technology-neutral approach that includes a cap for the CO₂ emission factor to ensure that low-carbon technologies participate. Investment in the mechanism is primarily private. The system evolves through frequent auctions where the adequacy need is recalculated based on new forecasts and system conditions.

Key obstacles encountered during implementation include securing compliance with state aid legislation from the European Commission, correctly estimating adequacy needs in a multi-zone system, and defining key auction parameters such as the cost of new entrants (CONE) and the strike price. Other challenges involve ensuring

participation of demand response without distortions and considering the contribution to adequacy from variable renewables.

- **Lebanon:** The electricity sector faces a significant gap between supply and demand. The adequacy mechanism relies mostly on sustaining fossil fuel reserves and increasing renewable energy penetration. There are currently no investments in adequacy mechanisms, although a World Bank loan is planned to establish a national control centre.

- **Morocco's** is a centrally planned system that relies on operating and strategic reserves and is evolving towards more flexible and market-responsive solutions. Moreover, Morocco stands out among Southern Mediterranean power systems for two structural singularities that materially strengthen adequacy and balancing. First, Morocco is the only country in the region with established AC interconnections to Spain, which—beyond pure import/export capability—gives operators practical exposure to MIBEL market conduct and, by extension, to European reserve-market practices and operational know-how. Second, alongside the conventional fleet's operating reserves, Morocco benefits from a robust hydro backbone, including two pumped-storage (STEP) plants in service and a third under construction, plus multi-purpose hydro dams that together enable the reliable provision and scalable development of tertiary reserves. On the regulatory side, the ANRE has already published the CRENT (Transmission Grid Code), which includes a dedicated system services and balancing code that frames all technical and commercial transactions between the TSO and generators to secure minimum reserve levels and real-time balancing—well adapted to Morocco's distinctive market structure where a liberalised segment coexists with a regulated one. Since 2016, Morocco has also applied a system services tariff (TSS) to renewable generation—most recently revised by ANRE at the beginning of 2025—earmarked for the historical operator to invest in adequacy and system-service capabilities. Looking ahead to 2026, ANRE will publish a TSS exemption procedure targeted primarily at hybrid RES + BESS (Battery Energy Storage Systems) projects—several of which are already authorised—complementing the BESS programmes under development by ONEE and MASEN (e.g. around Noor Midelt) and further consolidating Morocco's leadership in system flexibility and security of supply. Under this procedure, participants providing reserves and flexibility services will benefit from partial or total exemptions from the TSS, creating a financial incentive to support grid stability.

- **Spain:** The current mechanism is gradually being phased out, applying only to the last seven commissioned CCGTs and two new hydropower generators. For renewable generation, Spain uses a form of contract for difference (CfD), including

the RECORE mechanism and the recent REER CfD implemented through competitive auctions to stabilise income while maintaining market exposure. Additionally, the Spanish Ministry is currently working on a new capacity remuneration mechanism (CRM) design. The draft plan involves competitive, centralised long-term (five years) and short-term (one year) auctions. The auctions would be open to all participants with an emission factor below 550 tCO₂/MWh who commit to providing availability during stress hours. The primary goal is to address long-term scarcity periods detected by resource adequacy assessments.

- **Portugal:** Pursuant to the Regulation (EU) 2019/943, there is a procedure defining the guidelines for any Member State that intends to implement a capacity mechanism. A very important part of this procedure is to define the adequacy metrics to evaluate the need to implement mechanisms to assure security of supply (e.g. reliability standard). In Portugal, ERSE, along with other relevant entities, is currently in the process of defining the reliability standard (an indicator defined in terms of Loss of Load Expectation - LOLE). This process follows a methodology approved by ACER, requires the calculation of the following indicators: the national Value of Lost Load (VOLL), through questionnaires to pre-defined groups of consumers; and the Cost of New Entry (CONE) for the different possible reference technologies. The assessment of these indicators is close to conclusion, which will allow for the definition of the reliability standard, that is to be approved by the Government following a proposal by ERSE. The evaluation of the need for capacity mechanisms is done by comparing the defined reliability standard to the results of the adequacy studies performed on the national level by the Portuguese Directorate-General for Energy and Geology or at European level by the European Resource Adequacy Assessment (ERAA). Only after these steps are concluded and if an adequacy concern is identified, will the procedure for the definition of a capacity mechanism be initiated by the Government.

- **France:** The French capacity mechanism, operational since 2017, was approved by the European Commission until the end of 2026. It remunerates capacity operators for their availability during periods of tension for the supply-demand balance of the power system. It is market-wide, meaning that all capacities in the country (production, storage, and demand response) participate in it. It operates based on a “decentralised obligation” system: suppliers are obliged to purchase capacity certificates corresponding to their customers’ power consumption during winter peak hours; these certificates are sold by capacity operators following certification by the TSO of their capacity availability during winter peak hours. Capacity certificates are traded at several auctions. Work is currently underway to

introduce a new capacity mechanism after 2026, subject to the European Commission's approval. Alongside the capacity mechanism, France has a specific support scheme for decarbonised flexibility consisting of a call for tenders open to DSR and storage. Successful candidates must commit to providing their DSR or storage capacity on the balancing market and/or the day-ahead or intraday wholesale markets via the so-called NEBCO mechanism on the tightest days for the French power system. Finally, an interruptibility scheme is also in place. This contingency reserve allows the TSO to interrupt industrial consumers within 5 seconds in the event of a frequency drop leading to an emergency state. Since 2022, up to 1,200 MW of interruptible capacity can be procured through annual auctions (for the following delivery year), with participants selected via tenders.

Adequacy mechanisms are critical because they

Ensure Security: Guarantee a continuous and stable electricity supply, especially during peak demand.

Enable Renewables: Provide the necessary flexibility to manage the intermittency of solar and wind, supporting the energy transition.

Optimise Costs: Reduce system costs by promoting efficient resource allocation and demand-side management.

NRAs must focus on

Closing Regulatory Gaps: Developing mature frameworks for emerging flexible resources (like storage and demand response) to move away from centrally planned solutions.

Balancing Objectives: Aligning security of supply with decarbonisation goals and protecting consumers from unjustified price increases.

Regional Integration: Facilitating and harmonising rules to enable cross-border participation and resource sharing.

5. Regulatory Framework for Adequacy Mechanisms

5.1 Role of National Regulatory Authorities (NRAs) in Enabling and Monitoring Adequacy Mechanisms

NRAs play a pivotal and multifaceted role in establishing, overseeing, and evolving adequacy mechanisms in the Mediterranean region. Their responsibilities range from foundational design to ongoing performance monitoring.

- **Design and Approval:** NRAs are typically responsible for designing and approving the regulatory frameworks, licenses, and contractual templates for adequacy mechanisms. For instance, Algeria's CREG approves procedures for operating reserves and medium-term system operation forecasts based on proposals from the TSO. Similarly, Morocco's ANRE approves the national electricity transmission grid code, which includes the balancing and system services code, covering adequacy and flexibility service mechanisms. The Energy Regulatory Commission (ERC) of North Macedonia is tasked with adopting a methodology for determining fees and penalties related to a potential capacity mechanism. Lastly, in Portugal, ERSE is involved in the overall design of all adequacy mechanisms, along with other relevant entities.

- **Tariff Setting and Cost Recovery:** NRAs often have a crucial role in establishing tariffs to recover the costs associated with adequacy mechanisms. Morocco's ANRE sets a tariff (TSS) for the remuneration of system services. In Türkiye, the costs of both the capacity mechanism and demand-side participation are recovered through tariffs applied by the TSO to transmission system users.

- **Market Operation:** In countries with capacity markets, the NRA sets the criteria and conditions. Italy's ARERA defines auction parameters, such as the price cap for the CONE and the strike price. Further, the NRA is responsible for the technical implementation and definition of support values in politically mandated incentive schemes, such as delegating the tariff definition for smaller power plants in the DM FER X scheme.

- **Monitoring and Enforcement:** NRAs monitor the performance of adequacy mechanisms using a variety of technical and economic key performance indicators (KPIs). For example, EgyptERA monitors metrics such as frequency

deviations, System Average Interruption Duration Index (SAIDI), and System Average Interruption Frequency Index (SAIFI). ANRE in Morocco supervises grid quality metrics, including voltage and frequency deviations. This oversight ensures that mechanisms achieve their intended goals of reliability and efficiency. ERSE as well has a very relevant role in the monitoring of the adequacy mechanisms, namely reviewing the implementation of the mechanisms to ensure their alignment with the European legal framework.

Country	NRA Role in Adequacy	Key Functions and Responsibilities
Algeria	CREG	Approves TSO procedures for operating reserves and forecasting, involving producers and distributors in consultation processes.
Cyprus	CERA	The interruptibility schemes are submitted to CERA for review and feedback; however, they do not require CERA's formal approval. The Temporary Emergency Generation Plan is formulated by the TSO under the direct guidance and ultimate approval of CERA.
France	CRE	<p>CRE proposes security of supply criteria to the government, based on a proposal by the TSO, which is used to determine the need for a capacity mechanism and to dimension it. Once the capacity mechanism is approved and implemented, CRE provides an opinion on the TSO's proposal for the capacity mechanism rules. It is also responsible for monitoring the proper functioning of the mechanism and ensuring the publication of relevant market data. CRE fixes some parameters of the mechanism (e.g. maximum auction price and reference prices used for financial settlements related to capacity readjustments of suppliers and producers) and approves specific agreements (e.g. contracts between the French and neighbouring TSOs in case of participation of foreign capacities in the French capacity mechanism).</p> <p>Regarding the interruptibility scheme, CRE approves the requirements and the contract framework proposed by the TSO, under which the TSO contracts interruptible capacity.</p>

Country	NRA Role in Adequacy	Key Functions and Responsibilities
Italy	ARERA	ARERA sets criteria and conditions for the capacity market and defines parameters for auctions (e.g. price cap for CONE and strike price).
Morocco	ANRE	Approves the transmission grid code, sets tariffs for system services, and ensures compliance among the TSO and transmission grid users. It oversees contracts and supervises grid quality metrics.
Türkiye	EMRA	Issues secondary legislation and sets annual budgets, involving stakeholders through public consultation.
Egypt	EgyptERA	Designs and updates regulatory frameworks, issues the Grid Code, and monitors KPIs. It leads public consultations for new schemes.
North Macedonia	ERC	Proposes methodology for capacity mechanism fees and penalties and approves the TSO's resource adequacy assessment.
Portugal	ERSE	Involved in the overall design and monitor the adequacy mechanisms.

5.2 Policy Frameworks and Market Designs Supporting Adequacy

The policy frameworks across the region are a blend of top-down strategic planning and evolving market-based designs.

- **Hybrid and Phased Approaches:** Many countries, such as Egypt, are employing a hybrid approach that combines strategic reserves, demand response, and long-term contracts. The new Energy Law in North Macedonia demonstrates a phased approach, where a capacity mechanism is considered a “last resort” only if resource adequacy assessments indicate a need therefor after exploring other market solutions.
- **Supporting Renewable Integration:** Policy frameworks are increasingly being adapted to support the integration of high shares of RES. For instance, Algeria is progressively adapting its adequacy mechanism to include the participation of intermittent RES in primary frequency control. In Türkiye, the capacity mechanism

ensures that conventional power plants are available to support grid security and the integration of RES.

- **Decarbonisation Alignment:** Regulators are working to align adequacy mechanisms with national decarbonisation goals. This includes approaches such as market liberalisation, the development of ancillary services, and the gradual removal of fossil fuel subsidies to create better price signals for clean investments. This is evident in Spain's proposed new CRM design, which would be open only to participants with an emission factor below 550 tCO₂/MWh. This approach, similar to the CO₂ cap used in the Italian Capacity Market, employs market mechanisms to enforce low-carbon compliance.

5.3 Used Performance Indicators and Monitoring

Monitoring is a critical function performed by NRAs to ensure that adequacy mechanisms are effective, reliable, and efficient. The monitoring activities are directly linked to the specific adequacy mechanisms in place.

Capacity Market (Italy): Performance standards for the Capacity Market are defined and checked exclusively using the LOLE, which is the sole parameter used to reflect desired adequacy standards.

Demand Response Monitoring (Portugal): The indicators that are being used by ERSE to monitor the performance of its adequacy mechanism are focused on the reduction in frequency, duration of outages and impact on consumer electricity bills.

Capacity Mechanism & Demand-Side Participation (Türkiye): Monitoring focuses on the fulfilment of the service obligation.

- **Capacity Mechanism:** Power plants receiving payments are monitored for availability and their adherence to load-taking instructions (generation or increase of generation) given by the TSO (TEİAŞ).
- **Demand-Side Participation:** Aggregators are monitored by checking that they reduce total consumption by the instructed amount, using consumption meter data from their portfolio.

Reserves/Hybrid System (Algeria & Egypt): Monitoring in these hybrid systems relies on fundamental reliability metrics. Algeria uses transmission indicators such as SAIFI, SAIDI, and AIT (Average Interruption Time). EgyptERA also monitors general reliability, including frequency deviations, SAIDI, and SAIFI.

Strategic Reserve & Grid Quality Focus (Morocco, Greece): Oversight extends beyond simple reliability metrics to include grid quality. Indicators used are the Voltage Deviation Indicator (IET) and system loss metrics like Active Loss Rate (IPRT), alongside Underserved Energy (END) and Equivalent Downtime (TCE), linking the strategic reserve's value to overall system stability and quality. In Greece, RAAEY monitors a wide range of indicators, including Energy Not Supplied (ENS), AIT, and specific Forecast Error Indicators for Demand and RES Generation. This baseline

monitoring will be critical for assessing the need and impact of any future adequacy mechanism.

5.4 Adequacy Mechanism Cost Recovery and Investment

The financial mechanisms supporting adequacy vary, with costs primarily recovered through tariffs and investments sourced from a mix of public and private funds, reflecting the level of market liberalisation in each country.

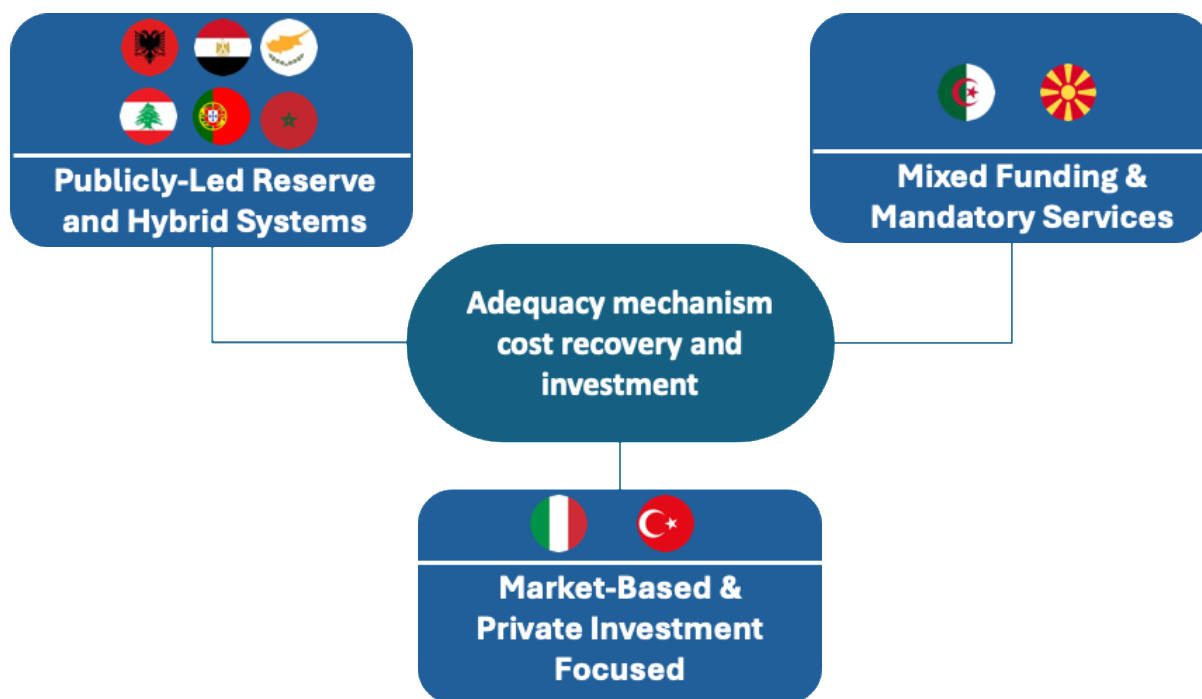


Figure 6: Adequacy mechanisms: cost recovery and investment

- **Publicly Led Reserve and Hybrid Systems**

In these models, investment is primarily driven by the public sector or through regulated costs recovered via general tariffs, reflecting centrally planned systems or initial market stages.

Morocco: Costs are primarily recovered through the ANRE-set System Services Tariff (TSS).

In Morocco, adequacy-related investments are led by the TSO (ONEE) and complemented by independent producers and private market participants. ONEE invests in operating and strategic reserves, such as Open Cycle Gas Turbine (OCGT) and Storage and Pumped Energy (STEP) plants and ensures overall system adequacy. Independent Power Producers (IPPs) support generation capacity and system reliability through long-term contracts (PPA). Additionally, the liberalised market is increasingly investing in flexibility assets such as BESS and hybrid renewable projects. These initiatives will be further encouraged by the forthcoming

TSS exemption procedure, designed to promote investment in system flexibility and strengthen security of supply.

Egypt: Investment is largely public-sector led, especially for strategic reserves and grid expansions. Costs are primarily recovered through tariffs embedded in the electricity pricing structure.

Albania: Most investments are public, with costs recovered via tariffs. However, the private sector participation is growing.

Lebanon: There are currently no investments or cost recovery mechanisms in place; the country is relying on planned measures, such as a World Bank loan, for future infrastructure.

Cyprus: Cost recovery for the Emergency Generation Plan is facilitated through network tariffs levied on consumers, while the Interruptibility Scheme involves no remuneration.

Portugal: The investment in the adequacy mechanism is mainly public, with costs recovered through tariffs and taxes.

- **Market-Based & Private Investment-Focused**

This category represents more liberalised models where private entities are compensated for providing capacity or services.

Italy: Investment in the capacity market is overwhelmingly private. Costs are recovered through tariffs.

Türkiye: Investment is private for the capacity mechanism and for Demand-Side Participation (carried out by private aggregators). Costs are recovered via the TSO's (TEİAŞ) tariff applied to transmission system users.

France: The capacity mechanism's costs are borne by suppliers (who must buy capacity certificates), which they subsequently pass on to consumers. The costs of the interruptibility scheme are recovered through tariffs.

- **Mixed Funding & Mandatory Services**

These countries use a combination of non-remunerated mandatory services and tariffs for ancillary services.

Algeria: Investment is a mix, primarily ensured by a generation fleet consisting of both publicly and privately owned facilities. Primary frequency control is a mandatory and non-remunerated service. Other ancillary services are remunerated via tariffs.

North Macedonia: The mechanism is currently under development. The costs will be recovered through fees/tariffs, with the ERC adopting a methodology for determining the fee for provided capacity. Investment is expected to be a mix, as

capacity providers include public and private entities such as electricity producers, energy storage operators, and demand-side management providers.

5.5 Best Practices in Balancing Stakeholder Interests and Ensuring Market Efficiency

Effective adequacy mechanisms require a delicate balance between diverse stakeholder interests, including those of regulators, TSOs, generators, and consumers.

- **Stakeholder Consultation:** A key best practice is the use of public consultation processes to involve stakeholders in the design of mechanisms. In Türkiye, draft legislation is shared with all stakeholders for their comments before being finalised and published. Similarly, in Egypt, public consultations are held for new regulations. In Italy, stakeholders are continuously consulted by the NRA and the TSO whenever there is a change in the regulatory framework. This ensures broader buy-in and a more robust design.

- **Balancing Financial Incentives and Consumer Protection:** Regulators must design mechanisms that provide sufficient revenue for power providers to cover their costs while also protecting consumers from unjustified price increases.

- **Promoting Market Efficiency:** To ensure market efficiency, regulators should design mechanisms that are **technology-agnostic** and promote a competitive, market-based approach. Greece's RAAEY, for example, believes that any designed mechanism should follow a market-based approach based on a competitive, technology-agnostic auction. This approach helps remove obstacles to the participation of demand-side resources, renewable capacity, and storage, enabling low-emitting technologies to compete on an equal footing.

- **Leveraging Data and Digitalisation:** The evolution of adequacy mechanisms is supported by continuous monitoring and data collection. Egypt, for example, is focusing on digitalisation and smart grid upgrades to meet evolving system needs.

- **Limited in time and frequent revision:** Guaranteeing that the implementation follows the design of the mechanisms correctly, ensuring the needs of the system, while assuring that there is no abuse of power from the different stakeholders. It is also important that the mechanisms are limited in time and undergo frequent revision in their designs.

Regulatory Framework Analysis

NRAs' Role

NRAs act as market architects, designing rules, setting tariffs (e.g. TSS in Morocco), and monitoring performance. Their authority ranges from technical approval (e.g. Algeria's CREG approving reserve procedures) to setting economic parameters (e.g. Italy's ARERA defining CONE/strike price).

Policy Evolution

Policy is moving towards hybrid and phased approaches, with a key focus on decarbonisation alignment. Mechanisms are adapted to enable RES participation (e.g. Algeria including solar/wind in frequency control) and rewarding flexibility through technology-agnostic competitive auctions (e.g. Greece's planned approach).

Performance & Funding

Monitoring is becoming mechanism-specific: LOLE is key in Italy, while grid quality metrics (IET, TPRT) are used in Morocco. **Funding models vary:** investment is shifting from public-led reserves (Egypt) to private-led compensation in capacity markets (Italy, Türkiye).

6. Impact of Adequacy Mechanisms on Electricity System Efficiency

Adequacy mechanisms are no longer solely about preventing blackouts; they are now key to optimising the entire electricity system's efficiency. They enhance reliability, manage costs, and facilitate the transition to a low-carbon energy mix.

6.1 Enhanced Reliability and Stability of Electricity Supply

The primary function of adequacy mechanisms is to ensure that a power system can supply the load under all conditions with a certain level of confidence. They provide a safety net of resources to prevent shortfalls and blackouts, ensuring a stable and reliable supply, particularly during peak demand or system stress events. For example, in Algeria, the use of operating reserves (primary, secondary, and tertiary) is a core part of their adequacy strategy to maintain frequency stability. Similarly, Egypt maintains a strategic reserve to ensure grid reliability during peak demand periods.

These mechanisms are vital in an increasingly complex grid environment. The concept of adequacy has expanded beyond a simple capacity balance to include flexibility and inertia support, which are critical as the share of synchronous generators declines. The new Energy Law in North Macedonia, for example, is establishing a reliability criterion that will demonstrate the required level of security of supply.

6.2 Cost Optimisation Through Demand-Side Participation and Efficient Resource Allocation

Adequacy mechanisms can lead to significant cost optimisation by reducing the need for new, expensive generation capacity and by incentivising more efficient resource allocation.

- **Demand-Side Management (DSM):** Demand-side mechanisms incentivise consumers to reduce or shift their electricity consumption during periods of high demand, thereby reducing the need for costly peak generation. In Türkiye, a **Demand-Side Participation Service** is used as an ancillary to manage the supply-demand balance and grid congestion. Such mechanisms

enable the more efficient use of existing resources, rather than building new power plants that would operate only for a few hours a year.

- **Efficient Resource Allocation:** Adequacy mechanisms can also ensure that the most efficient and cost-effective resources are used. In a competitive market, a technology-agnostic auction, as is being considered in Greece or implemented in Italy, could allow demand-side resources, renewables, and energy storage to compete on equal footing, thereby driving down costs and improving overall efficiency.

6.3 Supporting Renewable Energy by Addressing Variability

The shift towards a decarbonised energy system presents the challenge of integrating a high share of RES, such as solar and wind. Adequacy mechanisms play a crucial role in addressing the variability of these sources.

- **Grid Flexibility:** By rewarding flexibility, adequacy mechanisms incentivise resources that can quickly ramp up or down to compensate for fluctuations in renewable output. This is a core part of the evolutionary strategy in countries like Albania, which is evolving its mechanisms through the integration of renewables, market reforms, and technological upgrades to ensure resilience to future challenges.
- **Ancillary Services:** Adequacy mechanisms can support renewable integration by including them in ancillary services markets. Algeria's adequacy mechanism is progressively being adapted to include the participation of solar PV and wind in primary frequency control. Similarly, Türkiye's capacity mechanism supports the integration of variable renewable energy sources (VRES) by making conventional power plants available to provide grid security.

6.4 Strengthening Cross-border Collaboration and Market Development

Cross-border interconnections are essential for enhancing supply security and enabling electricity trade. Meticulously designed adequacy mechanisms can strengthen this collaboration and contribute to a more resilient regional market.

- **Shared Adequacy:** Interconnections enable countries to import or export electricity to address domestic supply shortfalls. Egypt uses its interconnections with Sudan, Libya, and Jordan to support supply adequacy. This regional cooperation is a key lesson learned from Egypt's experience.

- Regional Market Development:** By facilitating cross-border participation in capacity mechanisms, regulators can create a more integrated and efficient regional market. North Macedonia's new law mandates that any capacity mechanism, except for strategic reserves, must enable cross-border participation from Energy Community and EU Member States under equal and competitive conditions. This ensures that countries can benefit from a wider pool of resources, improving both reliability and market efficiency.

Table: Impact of Adequacy Mechanisms on System Efficiency

Aspect of Efficiency	Description	Example from MEDREG Members
Reliability & Stability	Provides a safety net of capacity to prevent shortfalls and maintain grid stability.	Egypt's and Morocco's use of strategic reserves to ensure grid reliability during peak periods
Cost Optimisation	Incentivises demand-side management to reduce peak demand and associated costs.	Türkiye's Demand-Side Participation Service to ensure supply-demand balance and manage congestion Italy's Capacity Market aims to ensure adequacy at the least cost.
Renewable Integration	Provides flexibility to manage the intermittency of renewables.	Algeria's adaptation of its mechanism to include RES in primary frequency control.
Cross-Border Collaboration	Enables countries to share resources and manage adequacy on a regional scale.	North Macedonia's new law requires cross-border participation in its future capacity mechanism. Italy must address the integration of foreign capacity into its operational Capacity Market.

7. Recommendations and Conclusions

Based on the comprehensive review of adequacy mechanisms and their regulatory frameworks across the Mediterranean, the following recommendations are provided to MEDREG members to enhance electricity system efficiency, support decarbonisation, and ensure long-term reliability.

- **Strategies for Adopting and Improving Adequacy Mechanisms**
 - **Move Towards Market-Based and Technology-Agnostic Solutions:** Countries with centrally planned systems should work to develop regulatory frameworks that enable market-based solutions. A key strategy is to move towards competitive, technology-agnostic auctions to procure capacity. This enables all resource types—including generation, demand response, and energy storage—to compete on an equal footing, driving down costs and promoting innovation. Italy’s reliability option scheme has proven effective in ensuring the right amount of new capacity through competitive auctions.
 - **Prioritise Flexibility and Demand-Side Measures:** Adequacy mechanisms must be designed to reward flexibility, which is essential for integrating high shares of variable renewables. This includes the development of robust markets for ancillary services and demand-side participation. In Türkiye, for instance, a demand-side participation service has been introduced to ensure grid stability and manage congestion. Regulatory frameworks should facilitate the participation of aggregators who can bundle small consumers to provide these services.
 - **Align Adequacy with Decarbonisation Goals:** Adequacy mechanisms should be designed to support national climate targets. This can be achieved by
 - **Incentivising Low-Carbon Technologies:** Mechanisms should provide clear revenue signals for flexible, low-carbon resources such as utility-scale battery storage and fast-ramping gas plants. In Italy, the capacity market employs a technology-neutral approach with a cap on the CO₂ emission factor accepted to ensure the participation of low-carbon technologies.
 - **Removing Market Barriers:** Policies should work to gradually eliminate fossil fuel subsidies to create a level playing field and more accurate price signals that incentivise clean energy investments.

– **Promoting Collaboration and Knowledge Exchange**

- **Strengthen Regional Interconnections and Market Coupling:** Cross-border interconnections are a crucial adequacy mechanism, allowing countries to share resources and manage adequacy on a regional scale. Members should prioritise the development and optimisation of these links. North Macedonia's law on capacity mechanisms, for example, is designed to enable cross-border participation from neighbouring countries. This fosters a more resilient and cost-effective regional market. Moreover, Morocco's successful interconnection governance with Spain also offers a concrete model for effective cross-border coordination and structural adequacy, highlighting how robust operational links can reinforce regional stability during major system challenges.
- **Foster Peer-to-Peer Learning and Dialogue:** Regulators in the Mediterranean should actively engage with knowledge-sharing platforms like MEDREG to discuss best practices, challenges, and lessons learned. The experience of Türkiye in adapting its demand response service to address initial consumer reluctance and the phased implementation approach in Egypt are valuable lessons that can be shared with other NRAs in the region.
- **Participate in Regional and International Organisations:** Collaboration with organisations like the International Confederation of Energy Regulators (ICER) and the Council of European Energy Regulators (CEER) provides access to a wider pool of global expertise and best practices. This collaboration can help align regional efforts with broader international standards and methodologies.
- **Enhancing Regulatory Capacities Through Training and Technical Assistance**
 - **Address Capacity Gaps:** Adequacy is an increasingly complex area, and many NRAs, such as those in Egypt, face capacity gaps in overseeing emerging mechanisms. MEDREG, in collaboration with partners, should offer training and technical assistance programmes specifically tailored to its members' needs.
 - **Provide Targeted Training:** Training programmes should be designed to cover specific, critical topics such as the regulation of demand response, energy storage, and hybrid adequacy mechanisms. These programmes can be delivered through various formats, including online courses, on-site workshops, and peer reviews. Organisations like the Florence School of Regulation and CEER offer a range of courses designed by regulators for regulators, providing both theoretical knowledge and practical skills.

- **Encourage Cross-Institutional Staff Exchanges:** Short-term staff exchanges between MEDREG members can facilitate the direct transfer of knowledge and experience. For example, a regulator from a country with a developing market could spend time with a more experienced regulator to learn about the practical aspects of designing and implementing a capacity market or a demand-side programme.

*Empowering Mediterranean regulators
for a common energy future*

Follow us on



www.medreg-regulators.org

Via Lazzaretto, 3. 20124 Milano - Italy

info@medreg-regulators.org



Co-funded by
the European Union