SMART METER AND SMART GRID INTEGRATION REQUIREMENTS

Empowering Mediterranean regulators for a common energy future

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Electricity Working Group (ELE WG)

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Abstract

The Mediterranean energy sector is witnessing a significant transformation with the rapid integration of smart meters and smart grid technologies. This report, prepared by the Mediterranean Energy Regulators (MEDREG) association, aims to provide comprehensive insights into the region's requirements for smart meter and smart grid integration.

The report begins by highlighting the importance of smart meters and their role in enabling efficient energy management and consumption. It underscores the potential benefits of smart grid technologies, such as improved grid reliability, enhanced renewable energy integration, and increased energy efficiency.

Furthermore, the report addresses the key requirements for successful smart meter deployment and smart grid integration in the Mediterranean context. These requirements include the establishment of a robust communication infrastructure, adherence to data privacy and security standards, and the development of interoperability protocols. The report emphasises the need for regulatory frameworks that promote fair competition, consumer protection, and cost-effective implementation.

Additionally, the report discusses the challenges and opportunities associated with smart meter and smart grid deployments in the Mediterranean region. It explores the technical, financial, and regulatory hurdles that must be overcome to achieve widespread adoption of these technologies and highlights the potential for job creation, innovation, and economic growth arising from their integration.

The report also discusses case studies and best practices from various Mediterranean countries that have made significant progress in implementing smart meter and smart grid solutions. It analyses successful initiatives, describing lessons learned and key success factors.

In conclusion, this MEDREG report underscores the importance of smart meters and smart grid integration for the Mediterranean energy sector. It emphasises the requirements, challenges, and opportunities involved, aiming to support policymakers, regulators, and stakeholders in making informed decisions for the successful deployment and integration of these transformative technologies.

ACKNOWLEDGEMENTS

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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.

ABOUT MEDREG

MEDREG is the Association of Mediterranean Energy Regulators, bringing together 28 regulators from 23 countries and spanning the European Union, Balkans, and Middle East and North Africa (MENA) region.

Mediterranean regulators work together to promote greater harmonisation of the regional energy markets and legislations, seeking progressive market integration in the Euro-Mediterranean basin. Through constant cooperation and information exchange among members, MEDREG aims to foster consumer rights, energy efficiency, and infrastructure investment and development, based on secure, safe, cost-effective, and environmentally sustainable energy systems. MEDREG acts as a platform providing information exchange and assistance to its members and capacity development through events such as webinars, training sessions, and workshops. The MEDREG Secretariat is located in Milan, Italy.

MEDREG wishes to thank all the experts for their efforts in preparing this report and for sharing their knowledge.

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

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TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION AND METHODOLOGY

1. Objective

As the global energy demand continues to grow, the need for more sustainable energy solutions has never been more pressing. Smart meters and smart grids are key technologies that enable a more efficient and sustainable energy infrastructure. Smart meters are advanced meters that provide real-time data on energy consumption, allowing consumers to monitor and adjust their energy use. Smart grids, on the other hand, are intelligent electricity networks that integrate advanced sensors, communication networks, and control systems to manage the flow of electricity more efficiently.

The Mediterranean region has access to a diverse mix of energy resources, including oil, gas, and renewable sources such as solar energy and wind energy. Yet, the region faces unique challenges in meeting its energy needs. The current energy infrastructure in the region is fragmented, inefficient, and vulnerable to supply disruptions. In this context, the implementation of smart meters and smart grids can play a crucial role in improving energy efficiency, enhancing grid reliability, and enabling the integration of renewable energy sources.

This report aims to provide an overview of the state of development of smart meters and smart grids in the Mediterranean region. Specifically, we focus on elaborating the best practices and guidelines to facilitate the implementation of smart meters while identifying the minimum technical requirements that the regulatory framework should include. The report will also highlight the benefits of these technologies and the potential for optimising energy consumption and promoting a more sustainable energy infrastructure.

Overall, this report aims to provide a comprehensive guide for policymakers, utilities, and stakeholders involved in the implementation of smart meters and smart grids in the Mediterranean region. The insights and recommendations presented here draw on the best practices and success stories from other regions and are tailored to the unique challenges and opportunities faced by the Mediterranean countries.

2. Methodology

The report is based on the MEDREG members' responses to a benchmarking prepared by the ELE WG chairs in collaboration with the MEDREG Secretariat.

This survey contains 6 parts, as follows:

1. State of the art smart meters and grids
2. Regulatory framework
3. Benefits of smart meters and smart grid integrations
4. Technical requirements and standards
5. Challenges and barriers
6. Market design and investments

The countries included in the report are shown in Figure 1 below.

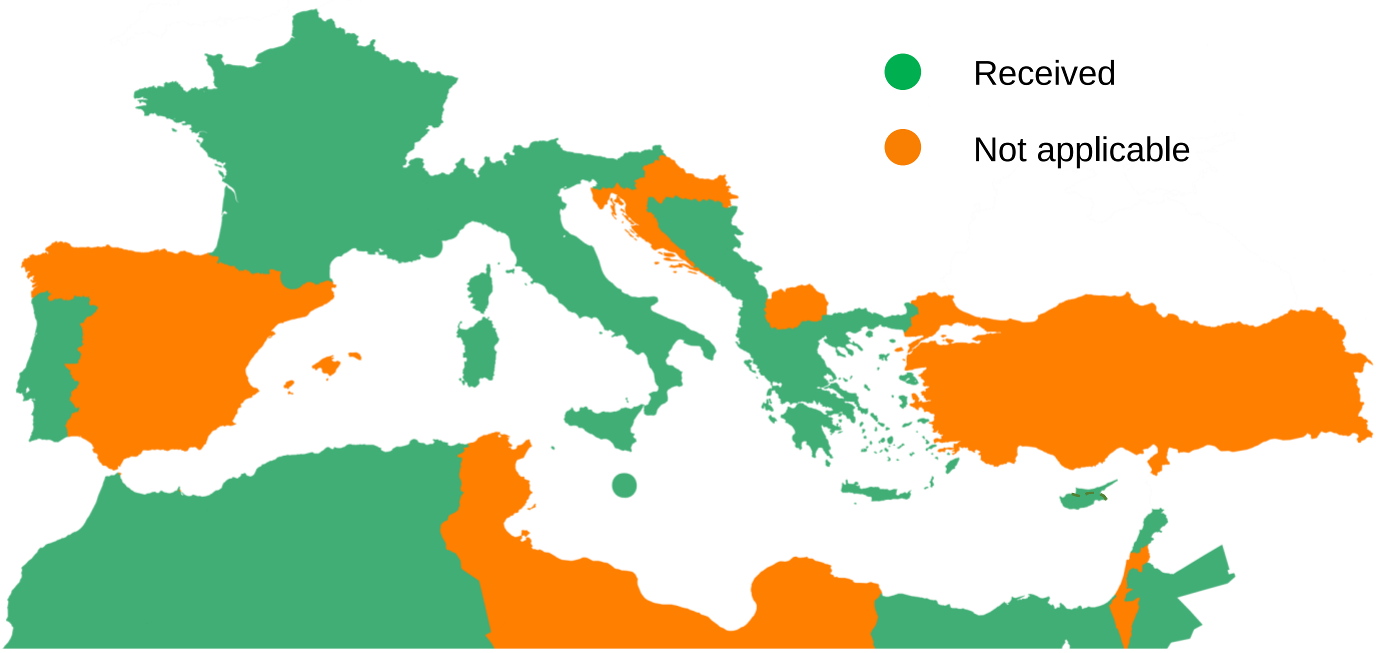

Figure 1. Benchmarking included in the report

1. State-of-the-Art Smart Grids and Meters in the Mediterranean Region

1.1. Energy Infrastructure in the Mediterranean Region

The energy infrastructure in the Mediterranean region is characterised by a mix of conventional and renewable energy sources. Historically, the region has heavily relied on fossil fuels, particularly oil and gas, for its energy needs. However, the recent years have witnessed a growing recognition of the importance of diversifying the energy mix and transitioning towards cleaner and more sustainable alternatives.

The Mediterranean region is blessed with abundant renewable energy resources, including solar, wind, and hydropower sources. Several countries in the region have made notable progress in harnessing these renewable sources to meet their energy demands. For instance, countries like Spain and Italy have developed significant solar and wind energy capacity, while Türkiye has been focusing on expanding its geothermal and hydropower resources.

Despite the potential for renewable energy, the current energy infrastructure in the Mediterranean region faces several challenges. These include limited or non-optimal use of interconnection capacity between countries, ageing and inefficient grids, high transmission and distribution losses, and a lack of flexibility in managing energy demand and supply. These challenges highlight the urgent need for modernisation and transformation of the energy sector in the region.

1.2. Market Design and Investments

The electricity market in each country has its unique characteristics and is diverse, and their evolution will be shaped by their unique regulatory frameworks and market dynamics. The integration of smart grids and smart meters is expected to play a pivotal role in modernising and optimising these markets. Here is a detailed overview of the current market design and the anticipated evolution in each country:

Albania

The electricity market in Albania is regulated and deregulated. The regulated market includes electricity sales by the public generation company, Albanian Power Corporation (KESH) to the universal public supplier (FSHU) under the public service obligation.

KESH and FSHU are bound by an annual contract, approved by the Energy regulator (ERE) The electricity price for this contract is approved by the Ministry of Energy and Industry. The import of electricity realized by public companies such as OST sh.a. and FTL sh.a. is based on the rules approved by the ERE by decision 103/2016 amended. The trading process based on the rules is realised on the electronic platforms owned by OST sh.a. and FTL sh.a. The ERE has the authority to monitor the process of trading realised based on the rules approved by the ERE.

The ERE approves the investment plans of system operators such as OST and OSSH, including investments in smart grid and smart metering.

Cyprus

The energy sector in Cyprus is undergoing fundamental transformations concerning its structure and organisation, institutional framework, and the diversification of its energy mix. To open the market to new participants, the Cyprus Energy Regulatory Authority (CERA) proposed the net-pool model as being the most appropriate trading arrangement approach for the Cyprus electricity market. This was after a technical support project was carried out regarding market reorganisation. The formulation of a net pool is based on the European target model. All transactions of purchase and sale of electricity are conducted at a wholesale market level. Specifically, under the proposed net pool design, bilateral physical forward contracts are notified, and corresponding schedules are nominated to the market operator (MO) before the counter (OTC) market gate closure on the day ahead. Suppliers and generators provide bid curves to a day-ahead market (DAM) on a half-hourly basis. Orders in the DAM are unit-based in the case of generators. Suppliers submit orders based on individually forecast demand. Orders in the DAM should correspond to quantities not already covered by bilateral contracts and consider any replacement reserve of type 2 commitments. The DAM is centrally managed by an MO. The MO runs a process of matching bid curves to optimise the dispatch of residual volumes scheduled for the day ahead. Contracts resulting from the DAM are between market participants and the MO at the DAM clearing price. An integrated scheduling process with a real-time balancing mechanism and a continuous intra-day trading platform will be later organised to further support market operations.

The installation of two software programs for the operation and monitoring of the electricity market are prerequisites for the full implementation of the new electricity market model in Cyprus. Due to the unavailability of these software, the CERA decided on a transitory regulation of the electricity market in Cyprus, before the full implementation of the new electricity market model. The transitional arrangement permits bilateral contracts between producers and suppliers above a threshold set by the CERA, with monthly clearing:

- for producers with a production license initially set above 4.5 MW and later, to enable a larger number of producers to participate in the transitional arrangement above 1 MW and finally above 50 kW.
- for suppliers with contracts to supply energy to consumers with a total agreed power above 10 MW,

The contracts involve only the provision of energy, and a simple arrangement would require no extra software for its implementation by the Transmission System Operator (TSO) and Distribution System Operator (DSO).

The transitory regulation of the electricity market in Cyprus started on 1 September 2017 and will be in force until the full implementation of the new electricity market model. As soon as the electricity market becomes fully operational, the concepts of demand response as well as local flexibility markets are expected to be introduced. Smart meters as considered one of the fundamental enablers of these concepts.

France

The market design is implemented in the European Union (EU). It is a competitive regime based on third-party access to the network and the choice of supplier for all categories of consumers. The wholesale market is located at the level of the transmission network and operates in a coordinated manner with neighbouring markets. The development of decentralised production modifies the general architecture because an increasing part of production is injected into the distribution networks. Information technologies must facilitate the interaction between transport and distribution networks and improve the resilience of networks downstream of the value chain. Smart grid technologies should therefore make it possible to better manage the supply-demand balance in a decentralised manner.

Thus, the integration of smart meters should contribute to the control of energy demand and the modulation of consumption. This is possible with consumer information and communication of relevant economic signals, which constitute an essential component of a possible implementation of smart grids.

Greece

The wholesale electricity market in Greece is operated by the Hellenic Energy Exchange (HENEX). It facilitates the trading of electricity among market participants, who submit bids and offers to trade electricity, as prices are determined through a competitive auction.

The retail market in Greece allows consumers to choose their electricity supplier. Consumers can either select the regulated tariff (provider of last resort) or opt for competitive offerings from licensed electricity suppliers. The retail market aims to promote competition and provide consumers with multiple choices according to their needs.

Regarding the integration of smart grids and smart meters, Greece has been actively working on their nationwide deployment and integration. The plan is to install smart meters for all electricity consumers, with a focus on large consumers, renewable energy producers, and vulnerable consumers.

The integration of smart grids and smart meters is expected to change the market design in Greece. It will enable more accurate and timely calculation of electricity consumption, facilitate demand response, offer more advanced pricing mechanisms, and support grid management and optimisation.

Italy

In Italy, the electricity market follows the European model, mainly organised into a day-ahead spot market and futures markets managed by a public company (GME). Unlike other national electricity markets in the EU, Italy has a public monopsonist for the purchase of electricity intended for protected customers such as households and small businesses, a category that will, however, disappear in 2024. A major development of bilateral Power Purchase Agreement (PPA) contracts is expected because of the recent energy price crisis. The integration of smart grids is crucial for market developments due to the increasing contribution of intermittent renewables and the development of demand response. A more responsive and flexible grid capable of accommodating intermittent renewables and variable loads will help “shave” price peaks.

Italy has two decades of experience in the introduction and consolidation of smart metering. The voluntary initiative launched by the main DSOs in the early 2000s was followed by a long and coherent series of legislative and regulatory innovations. Currently, the Italian electricity system is in a phase characterised by the diffusion of second-generation smart meters. The deployment strategy is established by Legislative Decree No. 102 of 2014, which implements a European directive on energy efficiency and mandates the national regulatory authority to supervise the installation and integration process. Currently, the legislative and regulatory strategy requires that by 2025 distributors must install electronic meters for at least 90% of their redelivery points. Distributors with at least 100,000 customers must also have installed smart meters for 95% of their customers by 2026.

Lebanon

The current market design for electricity in Lebanon is the vertically integrated model, where the Electricité du Liban (EDL) has the exclusive right for the generation, transmission, and distribution of electricity in the country. As per law 462/2002, the electricity sector shall be unbundled, and an energy regulatory authority (ERA) shall be formed. The smart meter integration will be in favour of the unbundling of the sector, especially on the distribution level.

Malta

The electricity market design in Malta is based on the single buyer model, where the DSO is also the sole wholesale buyer and sole retail supplier. There is no liquid wholesale market and retail tariffs are regulated. The regulator is not aware of future evolutions of this model.

Morocco

The Moroccan market continues to undergo dynamic changes while engaging in ongoing discussions with key decision-makers. Within this evolving landscape, numerous potential scenarios are being explored and considered.

Palestine

The electricity sector in Palestine is regulated by the single-buyer model. This model is applied partially due to political and administrative issues. In this regard, Palestine is deeply dependent on electricity supply from Israel by Medium Voltage (MV), and Low Voltage (LV) connection points.

Portugal

Portugal's markets for electricity and gas are liberalised and open for competition.

When smart meters have been globally installed and integrated in Portugal, the transitory rules necessary to allow the coexistence of both smart and conventional meters will end, thus simplifying the rules for market agents, especially network operators.

The expected evolution is to increase market participation by engagement of consumers and demand response. It also involves establishing time-of-use tariffs and enabling participation in flexibility services through aggregation.

Slovenia

In Slovenia, electricity market regulation is based mainly on the Electricity Supply Act, which primarily implemented provisions of the clean energy package (such as active customers, independent aggregation, dynamic price contracts, and citizen energy communities) and the older Energy Act, which still applies for certain issues. Both aim to create a competitive electricity market by separating generation, transmission, and distribution activities.

Regarding the integration of smart grids and smart meters, Slovenia, like many other countries, is moving towards the deployment of smart grid technologies and finalising the widespread installation of smart meters. These advancements aim to improve energy efficiency, enhance grid reliability, and enable more dynamic pricing models. Smart meters allow consumers to better monitor and manage their energy consumption and enable real-time communication between utilities and consumers.

The integration of smart grids and smart meters could have several impacts on the electricity market in Slovenia including:

- dynamic pricing and tariffs
- improved market efficiency
- retail competition
- demand response programs
- energy trading and peer-to-peer energy sharing
- grid balancing and ancillary services
- integration of renewable energy
- reduced transmission and distribution losses
- market innovation and new business models.

In summary, integrating smart grids and smart meters into the electricity market in Slovenia leads to more efficient resource allocation, increased competition, demand-side management, and the integration of renewable energy sources. These changes have the potential to reshape the electricity market landscape, introducing new opportunities and challenges for market participants, consumers, and the national regulatory authorities (NRAs). From the viewpoint of the NRA, the most important effects of widespread smart meter deployment at present will be the exploitation of 15-minute smart meter data in the: 1) aforementioned reform of the network charging methodology; 2) improved distribution grid observability; as well and 3) innovative demand response programs of aggregators for providing services to the DSO/TSO.

The evolution in the future market model may include the exploitation of submetering, split supply and independent aggregation based on Directive (EU) 2019/944, as well as supporting the development of smart grid and advanced metering infrastructure (AMI) solutions. On the other hand, the digitalisation of smart grids and the advanced metering infrastructure (AMI) enable the evolution of the market model to segments where previous barriers existed because of the aspects of system security and unavailability of data.

1.3. Challenges and Opportunities

The Mediterranean region faces specific challenges and opportunities related to its energy infrastructure and sustainability goals. Some of the key challenges include:

- **Energy security:** The region is highly dependent on energy imports, which exposes it to supply disruptions and price fluctuations. Developing a resilient and diversified energy mix is crucial to enhancing energy security.
- **Environmental impact:** The reliance on fossil fuels has led to significant environmental challenges, including air pollution and greenhouse gas emissions. Shifting towards cleaner energy sources can help mitigate these environmental impacts.
- **Grid integration:** The intermittent nature of renewable energy sources presents challenges for grid integration. Smart grids can facilitate the integration of renewables by enabling real-time monitoring, demand response, and optimised energy management.

At the same time, the Mediterranean region presents unique opportunities for energy development and sustainability:

- **Abundant renewable resources:** The region benefits from ample solar irradiation, wind resources, and geothermal potential, which can be harnessed for renewable energy generation.
- **Cross-border collaboration:** Enhanced regional cooperation and interconnections can lead to a more integrated and efficient energy market, allowing for better resource utilisation and energy sharing.
- **Economic development:** Investing in sustainable energy infrastructure can stimulate economic growth, create jobs, and attract investments in the region.

In the following chapters, we will explore the current state of development of smart meters and smart grids in the Mediterranean region, along with the best practices and guidelines to facilitate their implementation. By leveraging the unique characteristics and opportunities of the region, the Mediterranean countries can pave the way for a more sustainable and energy-efficient future.

1.4. State of the Development of Smart Meters

Smart meters and smart grids are key technologies that can improve energy efficiency, enhance grid reliability, and facilitate the integration of renewable energy sources. In this chapter, we will provide an overview of the current state of smart meters and smart grids in the Mediterranean region.

The implementation of smart meters has been gaining momentum in the Mediterranean region in recent years. Several countries, including Italy, Spain, and France, have already deployed large-scale smart metering systems, while others such as Greece and Türkiye are in the process of implementing them.

Italy has been a pioneer in smart meter deployment, with over 40 million smart meters installed as of 2021. The country's ambitious roll-out plan was facilitated by a favourable regulatory framework that encouraged utilities to invest in smart meters. Spain and France have also made significant progress, with over 70% and 80% of households equipped with smart meters, respectively.

Other countries in the region such as Greece and Türkiye are in the early stages of smart meter deployment. In Greece, the regulatory framework for smart meters was introduced in 2019, and the country plans to deploy 6.5 million smart meters by 2028. Türkiye has also initiated a smart meter roll-out plan, aiming to install more than 21 million smart meters by 2023.

Despite the progress, there are still several challenges in implementing smart meters in the Mediterranean region. These include the high cost of deployment, the lack of interoperability standards, and the need for robust data protection and privacy regulations.

In terms of deployment, MEDREG's consumer working group (CUS WG) has assessed its state of play in the Mediterranean region in its 2021 report, "Role of Digitalization and Its Impact on Consumer Issues"[1].

The CUS WG work showed that in the Mediterranean region, several countries on the northern shores, such as France, Italy, Spain, Montenegro, Malta, and Portugal, have achieved a significant penetration of smart meters among consumers. Conversely, countries on the southern shores are in the initial stages of implementation, primarily through pilot projects. The figure below illustrates the status of smart meter deployment in the Mediterranean region (2022) and the role of NRAs in approving related investments.

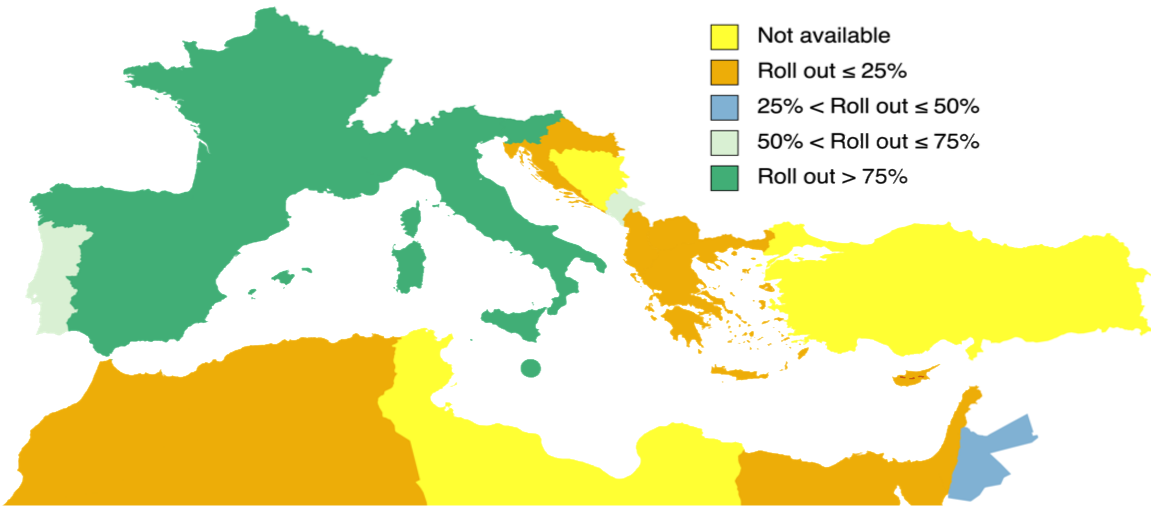

Figure 2. State of play of smart meters in the Mediterranean region[2]

[1] MEDREG's 2021 report, « Role of digitalization and its impact on consumer issues »
[2] In Egypt, the Gas Regulatory Authority (GASREG) approves the investments regarding smart meters.

The functions of smart meters can vary depending on the needs of the users. In the Mediterranean region, the main functions are given in Figure 3 below:

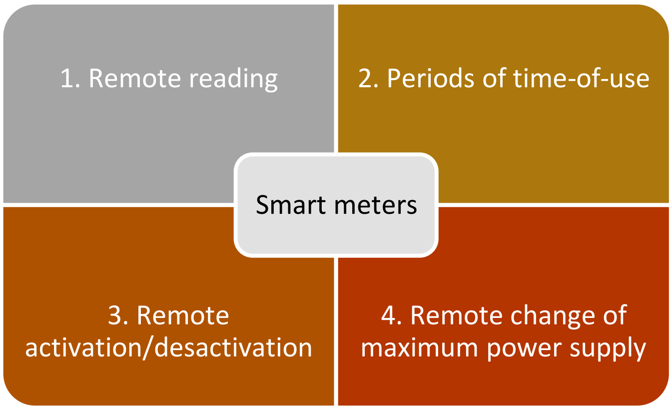

Figure 3. Main functions of smart meters in the Mediterranean region

The first three functions are used in all the countries listed in Figure 1. However, the remote change of maximum power of supply is used in six countries (out of 9).

Strategies and Objectives of Smart Meters

In the dynamic landscape of the Mediterranean region, governments and energy regulatory authorities have devised diverse strategies and set forth ambitious targets for the seamless integration of smart meters into their electricity systems. These strategies are tailored to cater to the unique priorities and objectives of each Mediterranean country. At the core of these strategies lies a set of common objectives that resonate with the overarching aim of modernising and optimising the energy sector.

Foremost among these objectives is the reduction of losses within the electricity grid. Smart meters, with their real-time monitoring and data collection capabilities, empower utilities to identify and address inefficiencies in the distribution system promptly. By minimising losses, energy providers can enhance the overall efficiency of the electricity network, thus ensuring that a larger proportion of generated power reaches the end consumers.

Another pivotal objective of the NRAs in deploying smart meters is the acquisition of comprehensive data for energy balance. Smart meters facilitate the granular measurement and analysis of electricity consumption patterns at both macro and micro levels. This wealth of data is invaluable for establishing a more accurate and responsive understanding of energy demand, enabling better resource allocation and planning.

In Portugal, the government didn't approve the roll-out of smart meters. Therefore, the ERSE couldn't approve either.
In France, out of the total objective of 37.4 million by 2021, the number of smart meters reached 32 million by the summer of 2021.
In Lebanon, 865 net meters were installed in 2022. Of these, 40 are smart meters and the remaining are digital meters with limited "smart" functionalities.

Furthermore, the integration of smart meters represents a significant stride towards the digitalisation of the energy sector. These devices serve as the linchpin of the modern energy ecosystem, allowing for the seamless exchange of data and information across the entire energy value chain. As a result, utilities can optimise their operations, enhance grid resilience, and deliver more responsive services to consumers.

Beyond the operational benefits, smart meters also play a pivotal role in rectifying billing inaccuracies. The automated data collection and transmission capabilities of these meters virtually eliminate the scope for errors in meter reading and billing, ensuring that consumers are accurately charged for the electricity they consume.

Additionally, the implementation of smart meters equips the NRAs and utilities with powerful tools to detect and deter illegal connections. By monitoring the flow of electricity at a granular level, smart meters can pinpoint unauthorised consumption, thereby curbing energy theft and safeguarding revenue streams.

Lastly, the deployment of smart meters fosters improved control over supply and collection processes. Utilities gain the ability to remotely manage connections, respond swiftly to outages, and optimise load distribution. This enhanced control bolsters the reliability of the grid and also empowers consumers to make more informed decisions about their energy usage.

In summary, smart meters in the Mediterranean region are emblematic of a broader strategy aimed at revolutionising the energy landscape. With a clear focus on loss reduction, data-driven decision-making, digitalisation, billing accuracy, illegal connection detection, and enhanced control, The NRAs and energy authorities are actively steering their respective nations towards a more sustainable, efficient, and responsive energy future.

Regulatory Framework Supporting the Adoption of Smart Meters and Smart Grid Integrations

In the Mediterranean region, the regulatory framework for smart meter implementation varies across countries. While some nations have specific legal mandates in place, others are in the process of formulating regulations or are reliant on international support and planning for future deployment. This diversity in regulatory approaches reflects the unique challenges and priorities each country faces in their journey towards modernising its energy infrastructure through smart metering and smart grid technologies. To provide a comprehensive overview of these regulatory frameworks, a table summarising the specifics for each country in the region will be presented.

Country	Regulatory framework supporting smart meter and smart grid integrations
Albania	There is a legal obligation in Law No. 43/2015 on the power sector, amended. Article 78 of the power sector law.[3]
Algeria	Not applicable.
Cyprus	The 2018 decision of the CERA (Regulatory Decision 2/2018) provisioned the implementation of the advanced metering infrastructure (AMI) at the distribution level. The AMI includes the rollout of the power line carrier (PLC) smart meters, LTE smart meters, ancillary equipment, HES software and Integration with the MDMS, programming of smart meters and data concentrators that will ultimately lead to the digitalisation of the distribution network. This smart metering transition would provide consumers with more control over power usage, modernise the grid and have a significant impact on the efficiency of electricity supply. It is anticipated that 80% of the meters will be installed by 2025 as provided in the CERA's regulatory decision.
France	The French initiative to deploy Linky meters aligns with the directive 2009/72/CE, which was later replaced by the directive (EU) 2019/944. These directives regulate advanced metering systems in Europe. Enedis, which is a utility company that

[3] https://ere.gov.al/doc/Law_no.43-2015_On_Power_Sector.pdf

Country	Regulatory framework supporting smart meter and smart grid integrations
	operates the electricity distribution network, conducted a year-long experiment with approximately 270,000 customers, leading the Commission de Régulation de l'Énergie (CRE) to propose the widespread adoption of Linky meters. This proposal, defining technical specifications, was submitted to the minister responsible for energy. As of now, the extensive deployment of advanced meters, initiated in late 2015, is nearly complete in Enedis' jurisdiction. Regarding smart grids, France, under the guidance of the CRE, has adopted a range of tools to support their development: • Financing and monitoring of research and development (R&D) by network operators. • Publishing demonstrator feedback for knowledge sharing. • Monitoring indicators as part of the incentive regulation for network operators. • Regulatory sandbox to facilitate experiments constrained by current regulations. The CRE also issues reports and roadmaps to guide initiatives such as electric mobility and energy storage.
Greece	According to Law 4001/2011, the regulatory authority for energy, waste, and water's (RAEWW's) role regarding the installation of smart meters goes as follows: RAEWW submits its opinion to the Ministry of Energy regarding the replacement of the previous metering infrastructure. The relevant stakeholder (DSO) needs to submit their proposal concerning the replacement of previous metering systems to the RAEWW, based on a cost-benefit analysis (CBA). If this project (meter replacement) is added to the projects of network development, then the RAEWW needs to regulate all relevant details (such as minimum standards, interoperability, and cost-sharing methodology). After that, the DSO can proceed with the next steps.
Italy	The regulator systematically cooperates with all stakeholders through hearings, meetings and, above all, public consultations. Public consultation is the tool that the authority uses to collect suggestions, observations, and information

Country	Regulatory framework supporting smart meter and smart grid integrations
	before issuing a decision. For the most important resolutions, the authority submits the first draft of the measure to stakeholders to allow consumers and businesses to assess the consequences of that decision.
Lebanon	The Council of Ministers approved the updated policy paper for the electricity sector in 2019 and the national policy statement and plan for the electricity sector in 2022. Both are prepared by the Ministry of Energy and Water and include the deployment of the AMI system,[4] where the smart meters are an integral part of such a program. In addition, the Distributed Renewable Energy (DRE) law[5] will legalise for the first time in Lebanon, peer-to-peer trading of electricity generated from renewable energy sources of capacities up to 10MW, as well as monetary compensation of exported energy through the net metering scheme. In both cases, the smart meters are necessary for EDL (national utility operator) to determine wheeling charges whenever the national transmission network is used in peer-to-peer trading, and to properly compensate net metering users. The DRE law is approved by the Council of Ministers, and the concerned committees of the parliament and shall be officially adopted following a voting session in the parliament. Moreover, the Ministry of Energy and Water signed the first PPAs with 11 licensed companies in May 2023 to develop 11 solar farms of 15 MWp each. This will result in installing smart meters on the medium voltage level for each of these solar farms.
Malta	No specific regulatory framework is in place for this objective.
Morocco	In Morocco, there is a regulatory framework that supports the adoption of smart meters and smart grid integrations. Law 82-21 de l'autoproduction is a significant piece of legislation that requires the use of smart meters for self-producers. This legal requirement plays a crucial role in advancing the development and implementation of smart meter technologies in

[4] doc-100516-2019_05_21_04_50_46.pdf (energyandwater.gov.lb), and Microsoft Word - MoEW. Policy Statement. 22 03 29 1900 - FINAL.docx (energyandwater.gov.lb)
[5] Decentralised RE Law | LCEC

Country	Regulatory framework supporting smart meter and smart grid integrations
	the country. It ensures that self-producers of electricity use smart meters, promoting efficient energy management and integration into the broader smart grid infrastructure. This regulatory framework aligns to modernise the energy sector, improve energy efficiency, and enable the integration of renewable energy sources into the grid. It benefits self-producers and contributes to the overall sustainability and reliability of the electricity supply in Morocco. In parallel with the implementation of the AMI project, the utilities anticipate the transformation of their metering infrastructure through the discontinuation of the acquisition of electromechanical low-voltage meters in 2018. This transition involves the adoption of smart post-payment and prepayment meters. It will inevitably be accompanied by significant changes in business processes and information systems (IS). Due to this, the utilities have included a change management component in this program, encompassing the training, recruitment, and upgradation of the business processes to facilitate this transition.
Palestine	At this time, the Palestinian Electricity Regulatory Commission (PERC) is working with the international communities (World Bank and the twinning program) to increase the know-how and transfer the experience. Meanwhile, the PERC is studying the opportunities to implement the smart meter by developing plans proposed for the electricity sector.
Portugal	The current code for electricity distribution smart grid services was approved by Regulation no. 817/2023 of July 27 [the previous code was Regulation no. 610/2019, of August 2]. The code defines the services to be provided by network operators, suppliers, and aggregators, and also establishes the financial support for the services provided by smart meters and smart grids. In addition, Ordinance no. 231/2013, of July 22, approved the technical and functional requirements of smart meters that are still valid today. In addition, a legal obligation was established in 2022 for Portugal mainland [Dispatch no. 14064/2022, of December 6] to install smart meters and to integrate them in smart grids for 100% of low-voltage consumers by the end of 2024.

Country	Regulatory framework supporting smart meter and smart grid integrations
	The distribution system operators provide the individual consumption data to their clients, using electronic format (such as internet and apps), free of charge, which includes: • consumption alerts and monthly comparisons • 15-minute diagrams of daily collection and availability of active load and grid injection for 24 months • daily collection and availability of reactive load and grid injection 15-minute diagrams for 24 months, of the last 24 months, for low voltage installations with contracted power above 41,4 kVA • daily accumulated consumption and injection data of the last 36 months by tariff periods • monthly maximum values of the average active power of the last 24 months registered in 15-minute intervals. Consumers may consent to third parties to access their consumption data such as suppliers or aggregators.
Slovenia	There is currently a reform of the network charging methodology and the tariff system (legal act on the methodology for determining the network charges for the electricity system operators) underway, based on 15-minute measuring intervals for consumed energy with excessive power charging. Therefore, smart meters are mandatory for such advanced methodologies to be efficient. In setting the regulatory framework for periods 2023/2024-2028, the Slovenian NRA introduced a novel general incentive scheme for the performance of transmission and distribution investments in smart grids linked to the monitoring of a series of key performance indicators (KPIs) (output-based regulation). There is a functional link between the performance of smart grid investments and the eligible costs of the system operator. The KPIs are described in Annex 5 of the "Legal Act on the methodology for determining the regulatory framework for DSOs and TSOs". Optimisations and possible upgrades with potentially harmonised KPIs on the EU level are expected. Since 2015, there has also been a project-oriented incentive scheme for qualified specific smart grid projects to enable the introduction of new technologies. These types of projects include the Greenswitch and SINCRO.GRID and NEDO projects. Appropriate restrictions are considered to prevent multiple financial incentives for providing the same benefits.

Country	Regulatory framework supporting smart meter and smart grid integrations
	Finally, there is also a research and innovation (R&I) scheme available (regulatory innovation sandbox), aimed at (a) providing funding for system operators' research and demonstration projects that comply with the referenced legal act and enable wide potential net societal benefits; (b) incentivising researching or demonstrating innovative smart grid approaches, sector coupling and ecosystem for deep electrification to make better use of the existing electricity infrastructure and renewable energy sources, as well as low-carbon and energy-efficient solutions using the open innovation concept; (c) testing local dynamic network tariffs for energy in the distribution network based on voluntary customer participation; and (d) sharing the knowledge gained from the implementation of projects to deliver benefits and savings in the use of the network by end-consumers and to ensure more efficient network investments based on the results of the projects. The NRA publishes applications for qualified projects on its website and supervises the projects. R&I projects are qualified for implementation based on a standardised project application that can be submitted at any time.

In the current situation in Bosnia and Herzegovina (BiH), no strategy has been established in terms of the smart meter roll-out and smart grid development. There is a legal framework, which defines the following requirements for smart meters: measurement, registration and display functions, additional functions, measurement of electricity quality, software variability in the meter (firmware upgrade), auto-diagnostics of meters (self-check), data security, and communication with the meter.

The projects concerning the installation of smart meters are implemented at the level of DSOs in line with their development plans.

In the past 15 years, the DSOs have continuously been working on these projects and yielded satisfactory results. All consumers connected to high (110 kV) and medium (35 kV and 10 kV) voltage levels as well as commercial consumers connected to 0.4 kV have smart meters. All of them (130,000 of them) are active players in the electricity market and are supplied at market prices, which they negotiate with their suppliers. Furthermore, some 170,000 household consumers have smart meters and these are consumers who have been connected to the network for the past 10–15 years. The old consumers, approximately 1,300,000 of them, still have electromechanical meters but the DSOs assess that there is no need for their replacement as the household consumers are supplied within the universal service and as such, they are supplied with electricity at significantly lower prices than the consumers who buy electricity on the market. The universal service with the method of supplying small consumers with electricity is defined in the EU legislation, which is also applied in BIH.

Collaboration of the NRAs with Other Stakeholders for Smart Meters and Smart Grid Integration Development

In the pursuit of smart meter and smart grid integration development, the NRAs in the Mediterranean region actively collaborate with various stakeholders to ensure the success of these initiatives. Across the region, collaboration takes diverse forms, tailored to local needs and objectives. In Albania, the Energy Regulatory Entity (ERE) bears the obligation to ensure the interoperability of metering systems throughout the country, fostering seamless integration. Cyprus emphasises a consultative approach, with public consultation procedures allowing for feedback and suggestions from stakeholders before regulatory decisions are finalised. In Greece, the RAEWW engages in open public consultations, welcoming input from energy market stakeholders and consumer protection organisations.

In Italy, since the launch of the deployment of the second generation of electronic meters, the national regulatory authority has been responsible for setting the installation plans, monitoring compliance with the plans by DSOs, and establishing technical and interoperability characteristics of smart meters. Although European legislation does not provide for this obligation, the authority has spontaneously launched a policy of installing electronic meters also in the distribution of natural gas. Information, measures, and details can be found on the ARERA website.

In Lebanon, collaboration extends to multiple fronts, involving the governmental bodies as well as the EDL and distribution service providers (DSPs) to assess technical requirements and installation plans. Malta's collaboration sees the regulator working closely with the DSO on network development plans encompassing smart grids, while policy aspects fall under the jurisdiction of the ministry responsible for energy. Morocco sets a notable example of extensive collaboration, involving stakeholders from utilities, consumers, and relevant ministries. This multifaceted approach encompasses stakeholder engagement, grid code elaboration, technical guidelines, and investment assessments, all aimed at ensuring efficient, sustainable, and cost-effective integration of smart technologies into the energy grid. Palestine, on the other hand, focuses on enhancing experience and studying tariff reforms in collaboration with electricity distributors, particularly addressing time-of-use consumers.

In Portugal, besides regular meetings with network operators and market agents, all approved regulations are preceded by a public consultation process in which all stakeholders are invited to participate. Public discussion helps to clarify doubts and to establish goals.

These collaborative efforts underscore the significance of partnership and engagement in shaping the regulatory landscape for smart meter and smart grid advancements across the Mediterranean region.

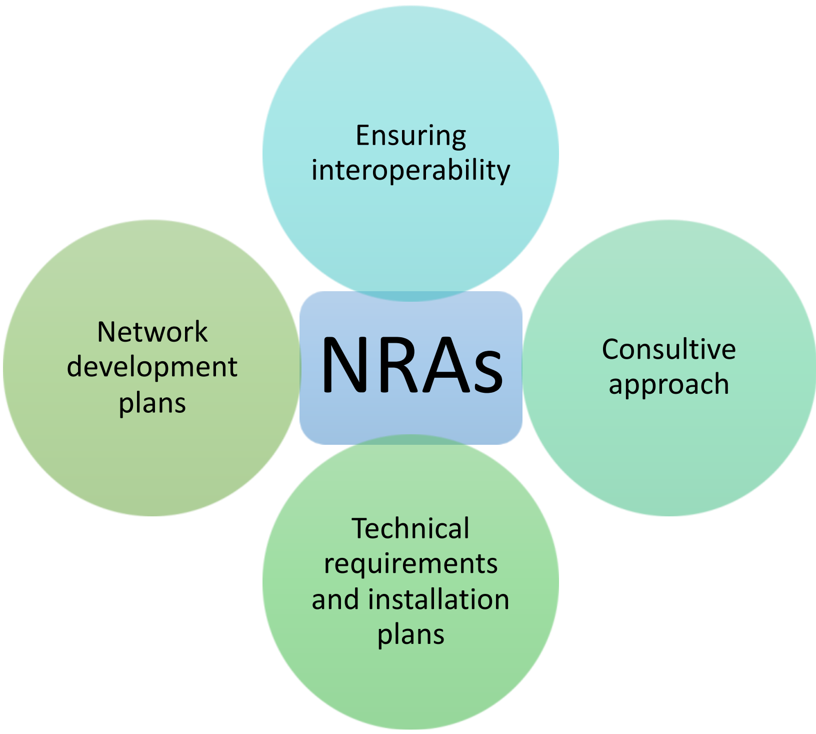

Figure 4. Topics of collaboration between national regulatory authorities and stakeholders

In some countries, the collaboration with stakeholders is stated in the law or regulatory decision such as in Albania and Cyprus, where Article 78 of the power sector law in Albania states that the ERE shall ensure the interoperability of different metering systems to be implemented in the entire country. In Cyprus, a regulatory decision is underway through a public consultation procedure where all comments and suggestions are considered before its actual implementation. The same public consultation is used in Greece, where all energy market stakeholders can submit their comments and arguments. During the public consultation period, the RAEWW usually receives comments from energy suppliers and consumer protection organisations.

In France, the regulator uses a regulatory sandbox (see the annexe for the detailed case study) to make it easier to carry out experiments hampered by the current regulatory framework. The CRE seeks to give free rein to the markets and therefore applies a principle of technological neutrality.

In addition to the Lebanese Council of Ministers and the Lebanese parliament, collaboration with the EDL is essential to check the technical requirements, capacities, and readiness of the electricity network. In addition, cooperation with the DSPs in updating the implementation policy is important to identify the share of smart meters that shall be installed by each DSP.

In the same way, the regulator in Malta is in contact with the DSO regarding the publication of the network development plan that will also deal with smart grids. Policy aspects are under the responsibility of the ministry responsible for energy.

In Morocco, the regulatory authority for electricity's (ANRE's) collaboration with the stakeholders, including utilities and consumers, is a crucial aspect of developing effective regulatory frameworks and policies for the integration of smart meters and smart grids in Morocco. As a regulator who adopts a participatory approach in decision-making, we engage in a multi-faceted collaboration including stakeholder engagement, grid code elaboration, prescriptions for smart solutions, and validation of investments.

In Palestine, the PERC is working with the electricity distributors to increase the experience and study the tariff reform, especially for the time-of-use consumers.

Lastly in Slovenia, the NRA operates by monitoring and validating network development plans, creating rules for the functioning of markets, monitoring of market functioning, changes in regulation methodologies by adaptive/dynamic regulation, and changes in the aforementioned regulatory documents. When changes to existing regulatory documents are needed, then stakeholders are included in public consultation processes. When implementing completely new regulations, studies are composed by engaging top-level external professionals in the studied field, which provides solid foundations for the new regulations. Stakeholders are included in public consultations based on these studies. The regulations are then optimised based on the feedback obtained in the public consultation processes and the NRA's position. Only then the new regulation is published and enforced. When needed, cost-benefit analyses (CBAs) are conducted as in the case of the AMI implementation. In addition, the NRA is sometimes directly included in the drafting of wider national strategies. Otherwise, it participates in public consultations.

All the above-mentioned factors impact the smart grid implementation plan and the AMI implementation plan. Currently, the AMI is transcending into the evolutionary phase (2.0), where the combined system operator has called for tighter NRA cooperation in the form of providing for a project-board member.

The NRA has standard processes in place to communicate regulatory activities and foreseen changes regarding regulation to the stakeholders. Specifically, in the scope of the network charging methodology and the tariff system reform (smart meters), the NRA has recently initiated a communication process at the early stages of the reform development, approximately two years before the official adoption. Public consultations have been organised and a public hearing of the act was carried out. The NRA has additionally started a preliminary sampling process based on which technical capabilities for reporting the performance KPIs are going to be assessed and the reporting process will possibly be revised based on the outcomes of that consultation process. This is specifically for the performance of transmission and distribution investments in smart grids linked to the monitoring of a series of KPIs.

2. Cost and Benefit Analyses for Smart Meters and Smart Grids

Smart meters and smart grids offer a wide range of benefits for both consumers and utility companies. In this chapter, we will explore the advantages of implementing these technologies in the Mediterranean region.

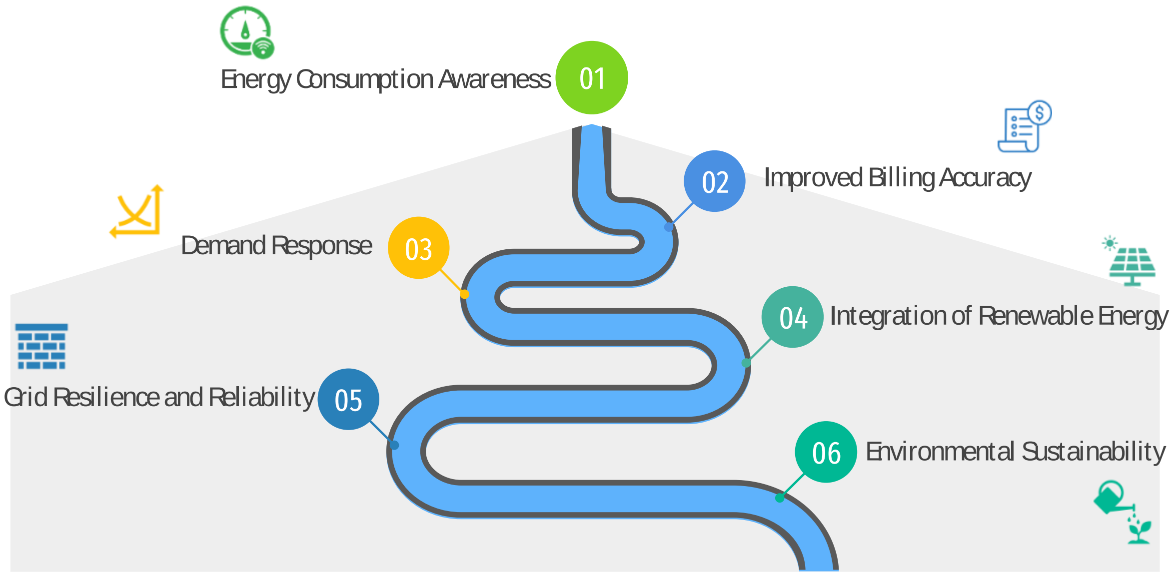

Figure 5. Benefits of smart meters and smart grids

2.1. Opportunities and Benefits of Implementing Smart Meter and Smart Grid Integrations

Implementing smart meters and integrating smart grid technologies in the Mediterranean region presents a multitude of opportunities and benefits for the countries involved. Here is a consolidated paragraph highlighting these opportunities and benefits:

In countries like Albania, where the initial phase of smart metering has begun, opportunities arise for developing a more balanced energy market, even for medium-voltage consumers.

In Algeria, the Algerian Electricity and Gas Regulation Commission (CREG) recognises the importance of the implementation of smart meters and smart grids, which offer several opportunities and benefits for the Algerian electricity system and aspires to gain experience and learn from other MEDREG members. The identified benefits for the Algerian electricity market are as follows:

- Improving energy management through real-time monitoring and measurement of energy consumption at a detailed level.
- Enabling global optimisation of grid operation and planning. The real-time data provided by smart meters gives a better understanding of demand, load, power quality, and network performance, which enables the optimisation of energy flows, anticipation of potential constraints and effective planning of investments.

- Facilitating market opening by creating a favourable environment for market competition. The availability of real load curve data enables distributors/commercial agents to adjust their prices in line with energy demand (commercial competitiveness).
- Allowing demand side management for demand curve levelling (peak reduction) by encouraging shifting certain loads to the lower consumption period.
- Enabling better demand forecasting and therefore better operation of the electricity system, taking renewable energies into account.
- Improving continuity and quality of service by reducing outage times and technical losses.
- Improving the safety of personnel, third parties, and property.
- Operating flexibility and Renewable Energy Sources (RES) development.

Cyprus anticipates that the AMI will empower consumers to actively engage in the electricity market, become prosumers, optimise grid usage, and participate in energy communities.

In France, the advanced meters offer several key benefits such as:

- Enhanced integration of intermittent renewable energy sources into the grid, optimising connections and production understanding.
- Support for electric vehicle charging control, reducing peak-hour strain on the grid, improved network operation with smart substations, sensors, and remote control, enhancing user service quality.
- Efficient meter data collection and remote operations, saving significant costs and contributing to financial balance.

For smart grids, the goal is to accelerate the energy transition by quickly adapting electricity networks to changes like decentralised production and bidirectional flows, meeting evolving needs and ensuring cost-effectiveness.

For Greece, consumers benefit from real-time energy consumption tracking and flexible pricing, leading to cost savings and environmental gains. Operators gain improved grid reliability and data insights for informed decision-making.

Italy is in the "first phase" of the diffusion of first-generation electronic meters (roughly, from 2001 to 2014). The main justification for the diffusion of this technology was cost savings and greater reliability and speed of reading and managing reading data. Once cost efficiency is achieved, goals evolve with smart meters. End-use energy efficiency is a long-term goal, which depends on consumers' ability to harness demand-side potential. In the short to medium term, the priority objective of smart meter integration is the efficient management of an increasingly complex grid, which accommodates increasing amounts of intermittent renewables and profound changes in load distribution (EV).

In Lebanon, smart grids reduce non-technical losses and enable efficient integration of decentralised solar PV systems, addressing energy crises. Malta's implementation focuses on grid stability and consumption pattern identification, enabling demand-side management (DSM). Morocco aligns with renewable energy goals, reduces losses, and customises tariffs. In Palestine, World Bank support, telecom infrastructure, and experience contribute to revenue growth, loss reduction, peak-hour handling, increased solar PV adoption, and the embrace of storage systems and other emerging technologies.

In summary, the Mediterranean region stands to gain significantly from the implementation of smart meters and smart grid integrations, fostering sustainability, efficiency, and customer-centric energy solutions.

In Portugal, studies were developed on the benefits and costs of smart meters. The Energy Services Regulatory Authority (ERSE) concluded the positive value of the option in the electricity sector, taking into consideration the cost reduction of smart meters due to the evolution of the global market for electric and telecommunications equipment, the long-term tendency of rise in electricity cost and electrification (giving more value to the potential benefits of smart grids on energy efficiency), consumption management, and the reduction of losses. In addition, the demand side flexibility markets rest on the ability to have detailed and fast available information. In the quantification of the expected outcomes, the highlighted benefits are:

- Consumption reduction by consumers.
- Decrease in commercial losses (fraud).
- Cost reduction of local operation activities, including the reading of meters.
- Avoid costs by acquiring conventional meters.

At the time of the study, it was not possible to analyse some benefits, such as more efficient management of distributed RES generation (due to the uncertainty level and the need for additional research on the matter), higher incorporation of microgeneration in the electric system, and facilitating EV deployment.

2.2. Assessment of Cost and Benefit Analyses of the Development of Smart Grids and Smart Meters

The development of smart grids and smart meters is commonly based on CBA and may consider many inputs in the analysis. Based on the experience of MEDREG members, the included benefits can be divided into three categories as shown in the figure below:

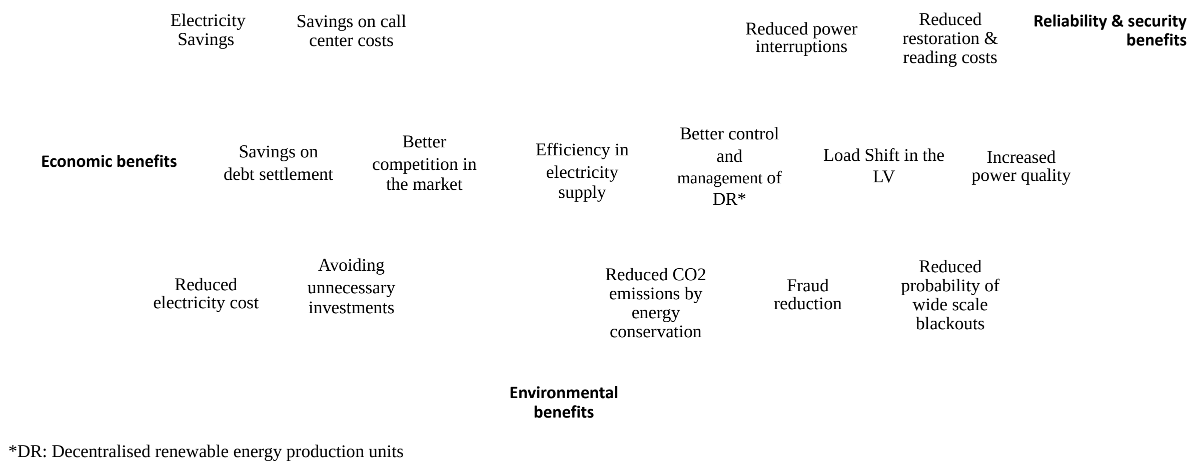

Figure 6. Assessment of the benefit of developing smart grids and smart meters in the Mediterranean region

From the experience of the French regulator, the implementation of smart meters allows a saving of €1,9 billion through the reduction of non-technical losses: the reduction of fraud and invoicing errors. In addition, the substitution of physical reading by remote monitoring (€0,7 billion) and the reduction in the cost of small interventions has become remotely feasible (€1 billion).

Moreover, smart meters and grids improve the knowledge of the network and help to reduce technical losses to a lesser extent. Overall, the gains from the implementation of smart meters in France surpassed the forecast gain in the 2014 business plan (+ €35 million/year by 2024). The 2014 Linky business plan predicted a positive effect of Linky on Enedis' expenses of €153 million in 2024. The update of these forecasts carried out as part of the tariff for the use of public electricity networks (TURPE) 6 work, estimates this effect at €188 million.[6]

[6] See CRE deliberation of March 17, 2022, on the decision on the incentive regulation framework for the Enedis advanced metering system in the LV voltage field ≤ 36 kVA (Linky) for the period 2022–2024 and modifying deliberation no. 2021-13 relating to the decision on the tariff for the use of public electricity distribution networks (TURPE 6 HTA-BT) - CRE)

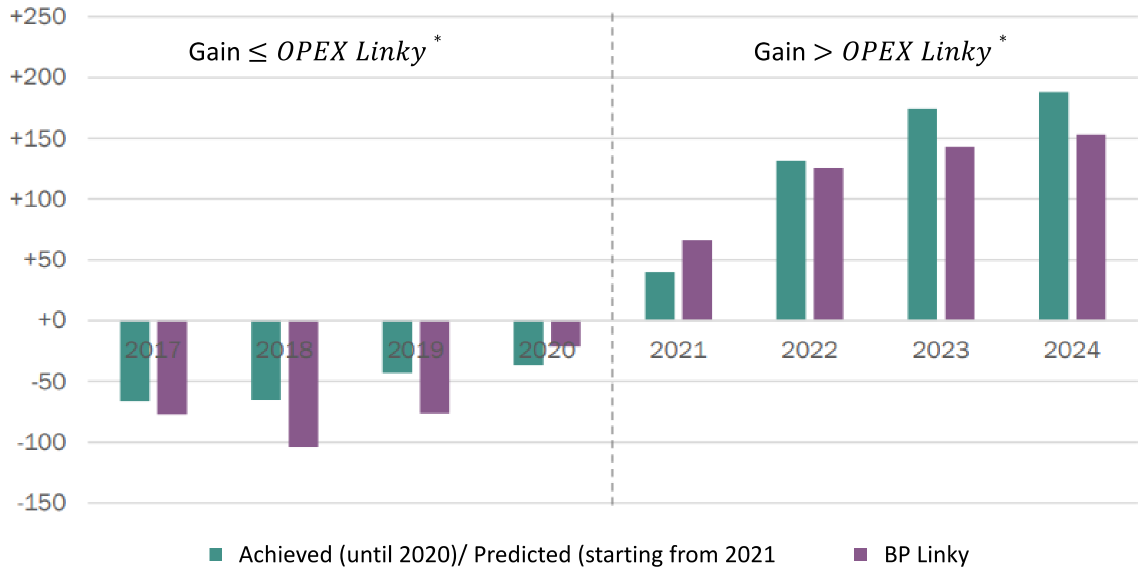

Figure 7. Linky gain - CRE

For smart grids, there is no fixed framework. However, within the framework of the regulatory sandbox, the CBA is at the heart of the system since indicators to enable it to be achieved are requested in return from the beneficiaries of the exemptions so that the regulator can justify a possible modification of the regulations in force at the time—the outcome of the experiment.

In addition, in Slovenia, the NRA has conducted a CBA for AMI with support from outsourced contractors. The CBA's goal was to help identify potential barriers, weigh the benefits against the costs, and obtain professional documentation for further decision-making to ensure the successful deployment of these technologies for a more sustainable and efficient energy future. The main costs associated with advanced metering are the costs for the purchase, installation, operation, and maintenance of system meters, the investment costs of data collection systems, the costs of data communication tools and the costs of introducing advanced metering. The main benefits usually associated with advanced metering include energy savings due to increased efficiency, flattened peak loads, lowered metering costs, improved reliability of supply, and reduced commercial losses. However, the recommended CBA roll-out scenario with the biggest net benefit has not been considered in the government's "decree on measures and procedures for the introduction and interoperability of advanced electric power metering systems", which is exhibited by the lack of timeline for AMI implementation, although the latter has been naturally implemented in reaching the target of 80% installed smart meters in 2020 set by the third package of EU directives. Compliance with the technical-functional requirements of Directive (EU) 2019/944 is limited to 70% out of all installed smart meters (> 90%) if the status is observed in 2023.

Specifically, for the aforementioned smart grid investment project-oriented incentive, each project larger in value than €300,000 must encompass a CBA according to EC guidelines, which supports the eligibility assessment of the investment. The guidelines include several aspects of cost savings, energy efficiency, as well as RES development (in terms of emission reductions).

2.3. Highlighted Benefits Included in a Cost-Benefit Analysis for a Smart Metering Implementation Programme

In all cases, the CBA needs to be included in the design process of smart metering and smart grid deployment. The parameters of the CBA are in general common to all the countries and include quantitative parameters and in some cases qualitative ones that can't be quantified.

In the tables below, we asked our members to highlight the benefits that are included in their CBA, the results are shown by country:

Country	Highlighted benefits included in the CBA
Cyprus	• Investment costs for advanced data collection and data communication tools. • Purchasing, installation, and operating costs of smart meters. • Energy savings due to increased efficiency or sufficiency. • Energy savings due to load shifting. • Reduced metering costs. • Improved security of supply. • Reduced non-technical losses. • Indirect benefits related to consumer empowerment.

Italy	• Investment and operating costs:
	  • Covered by distribution tariffs.
	  • Criteria established by the regulator.
	  • Mandatorily applied to distribution system operators (DSOs)
	• Benefits considered by legislator and regulator:
	  • Speed and accuracy in reading consumption.
	  • Rapid and secure access to consumption data.

Country	Highlighted benefits included in the CBA
	• Customer awareness of consumption is facilitated by smart meters. • Interoperability of reading systems with network management systems. • Possibility for every consumer to become an active player in the electricity market. • Sale of self-produced energy. • The best management of demand is based on price signals.
Greece	• Duration of the project (in years). • Estimated life of the asset. • Free cash flow. • Discount rate. • Costs (CAPEX + OPEX). • The sum of any benefit identified.
Lebanon	• Savings generated from reducing non-technical losses. • Monetary savings for reallocating financial resources. • Impact of adding replacement fees on consumers. • Energy benefits from meter changes in the context of net metering schemes.
Morocco	• Reduction of non-technical losses, especially fraud. • Reduction of costs related to meter readings and field interventions.
Palestine	• Implementation of meter replacements for customers with big debts, bad collection history, and renewable energy projects, which drive the implementation of smart metering and smart grid.
Portugal	The evaluated parameters were: • Costs • Acquisition and installation of smart meters • Infrastructure and communications

Country	Highlighted benefits included in the CBA
	• Information systems • Implementation of the roll-out of smart meters as a whole • Opportunity for consumers with the installation of smart meters • Income reduction in the value chain by consumption reduction • Stranded costs • Benefits • Avoided costs of the acquisition of conventional meters • Reduction of consumption of energy by consumers • Transfer of consumption from peak hours • Reduction of CO2 emissions • Reduction of costs for meter reading • Reduction of costs in call centres • Changing of suppliers and increase of competition in the retail market • Reduction of commercial losses (fraud) • Changing in billing mode and period • Reduction of local operations by the distribution system operator • Reduction in interruption times • Reduction of investment costs in generation capacity • Reduction of investment in transmission and distribution capacity • Reduction of technical losses • Asset management • Allocation of costs and benefits through the several agents A financial incentive for low voltage network operators is foreseen in the regulatory framework, directly linked to the availability, at each moment, of a set of smart grid services defined by the regulator. This incentive, which assures the integration of consumer installation in smart grids, is based on the shared benefits of smart grid services made available by those operators, considering the number of low-voltage installations that fulfil the smart grid integration criteria in a given year.

Country	Highlighted benefits included in the CBA
Slovenia	• Costs of implementation • Operational costs • Energy savings • Reduction in distribution losses • Peak load management • Reduction of costs in the billing process • Customer benefits • Environmental impact • Quality of service improvements In Slovenia, electricity tariffs have been adjusted to recover the costs of smart meter deployment. This involved spreading the costs over several years to minimise the immediate impact on consumers (tuned with the roll-out implementation plan of an advanced metering system in the power distribution system of Slovenia - expert basis). Additional cofounding has also been applied in smart meter deployment via a public tender[7] of the Ministry for Infrastructure, where the eligible parties have been the companies that own the electricity grid connecting end consumers.

2.4 Smart Grid and Smart Meter Technologies Impact Investment and Funding of Electricity Infrastructure

The smart grid and smart meter have a significant impact on the investment and electricity infrastructure, especially when the system is in an early stage of implementation. However, all the MEDREG members recognise that these technologies can lead to increased investments, improved network efficiency, and various opportunities in the electricity sector.

The following table provides more details related to the investment in smart grids and smart meters and their impact in the Mediterranean region:

[7] www.energetika-portal.si/javne-objave/arhiv-energetika/javni-razpisi/r/javni-razpis-za-sofinanciranje-nakupa-in-vgradnje-pametnih-stevcev-elektricne-energije-za-1138/

Country	Investment in smart grids and smart meters impacts the investment and the electricity infrastructure
Albania	The Energy Regulatory Authority (ERE) approves investment plans, including smart grid and smart metering. Investments are included in approved tariffs.
Cyprus	Smart technologies enable observability and controllability, from transmission to the consumer side. This marks the beginning of full digitalisation, leading to more business opportunities.
France	Smart grids facilitate renewables integration and flexibility. Aims to reduce CAPEX by using flexibilities (OPEX) for network strengthening.
Italy	Since metering activities fall under the category of regulated activities, it is up to the authority to define how investments in smart meters and smart grids are covered. Investments are therefore "obliged" by dissemination programmes, while their remuneration is based on criteria of efficiency and effectiveness.
Greece	Modernisation of infrastructure through investments is required, including advanced metering, communication networks, data management, and grid automation. Investment funding sources include utility budgets and government incentives. Smart technologies make the sector more attractive for private investments.
Lebanon	Smart meters encourage investment in renewable energy and increase electricity supply capability. New investments can target the transmission network to absorb excess energy.
Malta	Smart meters are the norm for every connection for billing purposes. No investment assessment for smart grids was mentioned.
Morocco	Ongoing discussions and scenarios exploring the dynamic changes in the Moroccan market.

Country	Investment in smart grids and smart meters impacts the investment and the electricity infrastructure
Palestine	Smart technologies increase revenue collections, decrease power shortages, and promote investment in network upgrading, loss reduction, and renewable energy.
Portugal	Better knowledge of the system and constraints will allow for better planning, avoiding unnecessary investments and providing alternative, flexible solutions such as demand response or storage. In addition, technical and commercial losses (theft) will be easily identified.
Slovenia	Adjustments in terms of incentives for the DSO/TSO have already been implemented. Thus, the NRA foresees that shortly, there will not be any significant changes in the funding of electricity infrastructure in Slovenia, which will probably be based mostly on the income from network charges. Additionally, some investments and co-funding opportunities may be possible, such as the connecting Europe facility (CEF) for European projects of common interest (PCI) in the field of smart grids, as already employed in the innovative SINCRO.GRID project. In another example, for the deployment of smart meters, the Slovenian Ministry of Infrastructure provided a public call for the co-financing of the purchase and installation of smart electricity meters for the period 2017 to 2022.

3. Technical Requirements and Standards and the Role of NRAs

3.1 Technical Requirements and Standards:

Monitoring the technical requirements and standards of smart meters and smart grids is crucial in ensuring their effective implementation and operation across the Mediterranean region (a list of technologies and standards is given in the annexe). Different countries have established different standards and regulations to govern these aspects.

Albania

Albania's legal framework, Law No. 43/2015 on power sector, designates that the technical requirements for metering activities, including smart meters, are the responsibility of the transmission and distribution system operators. These requirements are typically based on the metering code.

Cyprus

Technical standards in Cyprus are based on European and International norms and consider the existing network infrastructure. The Cyprus DSO has set standards for the AMI and smart meters. The list of norms is given in the annexe.

France

For the Linky project in France, technical requirements and standards have been previously detailed and presented in MEDREG's 2018 reports on smart meters. The CRE stays informed about technological advancements in advanced meters and smart networks.

Italy

Smart meters must be equipped with two communication channels: the first to the "electrical system"—chain 1—can use the PLC in band A, RF 169 communication technology or other TLC technologies, and the second to the user devices—chain 2—which must be able to use at least the PLC in band C. For all communication solutions, the authority requires the use of standard protocols to ensure interchangeability when transferring concessions between distribution companies.

Greece

Smart meters in Greece are required to be interoperable, enabling consumers and network operators to use the information efficiently through digital platforms. These meters must adhere to European standards for information disclosure and cybersecurity. The technical requirements encompass various aspects, including timely data updates, remote accessibility for operators, data protection, and fraud detection.

The minimum technical requirements that smart meters need to satisfy are the following:

- Regarding the consumer:
    - Data should be timely updated (every 15 minutes).

    - Data should be available without any previous permission from the operator.
    - Data should be digitally stored for further use in the future (e.g. price comparison)
    - Data can be downloaded.
    - Data should be as comprehensible as possible.
    - Data should be managed according to personal information and cybersecurity frameworks.
    - The smart meter should be able to detect cases of fraud.
    - In cases where there is self-consumption, the amount of energy injected or consumed should be mentioned.
- Regarding the operator:
    - Data should be remotely accessible, while connection to the network should be remotely managed.
    - The Operator should guarantee that the smart meters can communicate with the network for monitoring and maintenance reasons (e.g. verifying consumption information).
    - Data should be retrieved frequently to better plan the use of the network.
    - Adopt an advanced billing system, which provides customised offers.

Lebanon

In Lebanon, the EDL sets technical requirements and specifications for smart meters in tender documents for the DSPs. They are responsible for importing meters that meet these requirements, subject to the EDL's certification and validation processes.

Malta

The Maltese regulator monitors the rollout of smart meters, ensuring compliance with established technical requirements and standards.

Morocco

Morocco's ONEE has designed its AMI Program based on international best practices and benchmarking with leading distributors. Key technical specifications include communication protocols, technologies, data recording, integrated cut-off relays, and integration with other systems to enhance efficiency. For the first phase of the Program, the main technical specifications of the AMI solution are as follows:

- Communication protocol: DLMS/COSEM
- Communication technology: Cellular (GPRS/3G)

- Measurement/Recording of data for monthly registers, daily records, load curves, and events
- Integrated cut-off relay in Low voltage meters
- Implementation of an advanced metering management system (AMM) and an MDM system
- Integration with SAP for automatic billing purposes (meter to cash) and remote services (cut-off/restoration).

Palestine

In Palestine, the set of standards is inspired by the standards set by the International Electrotechnical Commission (IEC), as well as the rules of the International Commission for the Approval of electrical equipment (CEE) and the standards of Comite Europeen de Normalisation Electrotechnique (CENELEC). It also emphasises that recognised national standards shall be applied for aspects not covered by the IEC and British Standards (BS) recommendations.

The standards are also listed in the regulator document on the smart prepaid meter's specifications. it outlines the general framework for compliance with international and national standards.

These various approaches emphasise the importance of adhering to technical requirements and standards to ensure the efficient functioning of smart meters and smart grid technologies across the Mediterranean region.

Portugal

In 2011, the law predicted the introduction of smart meter systems, reinforcing consumer rights and enabling their active participation in electricity and gas markets. The introduction of such systems needed a long-term economic evaluation of all costs and benefits by the regulator and a study that determined the economic rational solution and the horizon of its installation.

A consequence of this study was the establishment of the technical and functional requirements of smart meters, approved by Ordinance no. 231/2013, of July 22. Other characteristics such as bidirectional, local access, energy quality events log, and power limitation functionality, have a low impact (each one) on the cost of the meters and make the installed smart system more suited to adapt future services that may be necessary.

The technology itself is established by the network operators, who are responsible for the installation, operation, and maintenance of smart meters. Operators may request additional features and functionalities to those established by law and regulations, to the manufacturers.

Slovenia:

For smart meters (and smart meter concentrators), technical requirements and standards are defined in the system operating instructions for the electricity transmission network (SONPO) of the TSO and system operating instructions for the electricity distribution system (SONDSEE) of the DSO and are transposed into smart meter public procurements of the TSO/DSO. The baseline for standards is mandates M/441 and M/490. In the public procurement, at least the following standards are included: telecommunication standards (e.g. ITU-T G.9903, IEC 8482, and SIST EN 13757 family), low power line signalisation standards (e.g. SIST EN 50065 family), measurement equipment standards (e.g. SIST EN 50470 family, SIST EN 62052 family, SIST EN 62053 family, SIST EN 62054 family, MID and OIML R 46-1/-2), information technology standards (e.g. SIST EN 55022), EMC standards (e.g. SIST EN 61000 family), communication standards (e.g. SIST EN 61334), data exchange standards (e.g. SIST EN 62056), information security standards (DLMS/COSEM Green Book, Edition 7 | Edition 8), certificates (G3-PLC Alliance) and regulations (e.g. National Radio Equipment Regulation, Directive 2014/53/EU) on the harmonisation of the laws of the member states relating to making radio equipment available on the market and repealing the Directive 1999/5/EC and Directive 2014/32/EU on the harmonisation of the laws of the member states relating to making the measuring instruments available on the market.

Another regulation is the new "Commission Implementing Regulation (EU) on interoperability requirements and non-discriminatory and transparent procedures for access to metering and consumption data". Since 06 June 2023, under Commission adoption, this regulation has set requirements and non-discriminatory and transparent procedures for access to data on metering, consumption as well as data required for customer switching, demand response, and other services.

The NRA enforces the rules for the use of open standards and standard identification schemes for the electronic data interchange in the energy market based on its tasks for data exchange harmonisation on the regional level from the 3rd package of EU directives.

3.2 Regulators Collaborate With Other Stakeholders in Terms of Technical Requirements and Standards

Regulators play a pivotal role in fostering collaboration among various stakeholders to ensure that technical requirements and standards for smart meters and smart grids are well-defined and effectively implemented. Here's how regulatory authorities across the Mediterranean region engage with stakeholders in this aspect:

The Albanian regulator is not directly involved in setting technical requirements. Instead, system operators are responsible for establishing technical requirements, often based on the metering code.

Technical requirements and standards in Cyprus are primarily defined by the DSO, emphasising the importance of close coordination with the key entity responsible for network operations.

In France, Recognising the significance of integration into the European market and interoperability, the CRE regularly engages in discussions with various stakeholders, including governmental bodies, industry actors, network operators, and data protection authorities. These conversations focus on technology requirements and standards to ensure seamless operation and build consumer trust.

The RAEWW collaborates with the DSO on issues related to smart meters and smart grids, specifically focusing on functional requirements. While RAEWW monitors these aspects, it refrains from intervening in technical requirements.

For Italy, the regulator shall work with technical bodies and companies to establish the minimum technical requirements to be met by smart meters. In particular, the authority cooperates with the National Telecommunications Regulatory Authority (AGCOM). The authority also asks the Italian Electrotechnical Committee (CEI) to define standard communication protocols that guarantee the full interoperability of second-generation low-voltage electricity meters with customers' devices. It is important to underline that, once the minimum technical requirements have been established, the action of the regulator focuses predominantly on the execution of the installation plans and the economic evaluation of the plans to correctly assess the impact of deployment costs on metering and distribution tariffs.

In Lebanon, the EDL collaborates with external consultants to establish technical requirements and standards based on international specifications. The EDL also engages with third-party smart meter suppliers, certifying and validating their meters to ensure compliance with national standards.

The Maltese regulatory authority assumes the responsibility of adopting and publishing the minimum functional and technical requirements for smart metering systems to be deployed, thereby fostering a transparent and standardised approach.

The ANRE in Morocco actively involves various stakeholders in consultations to develop grid codes defining technical requirements and standards. ANRE stays abreast of industry standards and maintains effective communication with manufacturers, ensuring a strong foundation for discussions with utilities and developers in the field.

In Palestine, regulators do not actively engage in collaboration on technical requirements and standards. similarly, in Portugal, the regulator doesn't collaborate with the stakeholders in terms of technical requirements and standards and only collaborates on the necessary services, requisites for information and consumer protection.

In Slovenia, the NRA was actively involved on the EU level in defining information models for data exchange (e.g. via ebIX® and interoperability acts mentioned above) and the transposition of these open standards into the terms for market operation and other secondary legislation.

On a national level, the NRA is involved in the process of adoption of the requirements at a higher level—adoption of system operating instructions for the SONPO of the TSO and the SONDSEE of the DSO, as well as terms for market operation require the approval of NRA—but not necessarily with related more detailed documents where technical requirements and documents are specified (e.g. based on the minimum functional requirements stated in SONDSEE, DSO prepares technical requirements for measuring and communication equipment and instructions with conformity assessment procedures).

Through these collaborative efforts, regulatory authorities strive to ensure that technical requirements and standards for smart meters and smart grids are aligned with international norms and also cater to the specific needs and challenges within their respective regions. This approach enhances the reliability and efficiency of these systems, promoting seamless integration into the energy landscape.

3.3 Regulator Monitoring the Smart Meters and Smart Grid Deployment and Performance

Monitoring the deployment and performance of smart meters and smart grid initiatives is a vital aspect for regulatory authorities across the Mediterranean region. Different countries have implemented specific mechanisms to ensure the efficient execution of these projects:

Cyprus

While no predefined indicators or milestones are established, Cyprus' regulatory authority, the CERA, will monitor the annual installation rate of smart meters compared to the initial deployment plan as soon as the AMI implementation commences.

France

The CRE has established a robust regulatory framework to incentivise Enedis to adhere to the deployment schedule, control costs, and guarantee performance levels. An incentive bonus system, linked to Enedis' investment efficiency and compliance with the schedule, encourages the timely deployment of the Linky project. The bonus comprises two components, one based on investment cost and deployment schedule, and the other on the quality of service provided. Any deviations from these criteria can impact the incentive bonus, potentially leading to lower project remuneration.

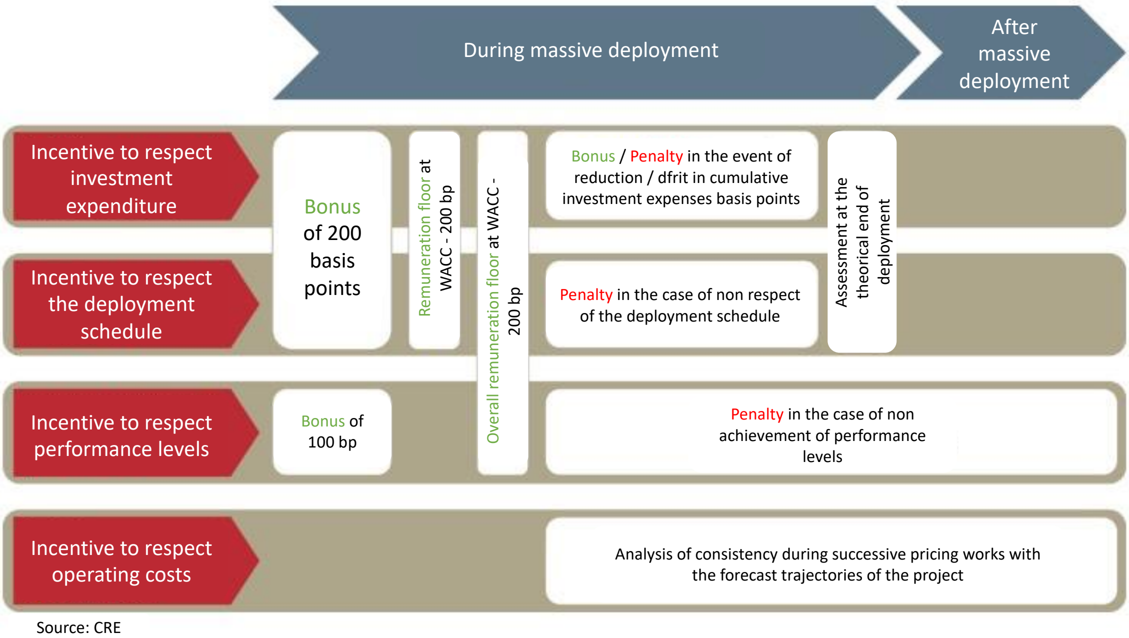

Figure 8. Regulatory principals for the metering system Linky - CRE

For smart grids in general there is no monitoring. However, on certain subjects, the regulator wishes to be able to regularly monitor the deployment, and the impact, of new uses (which may be related to smart grids) such as stationary storage, management of the charging of electric vehicles, offers of innovative supplies, and data made available actors.

Greece

The RAEWW in Greece offers a positive opinion to the Ministry of Energy regarding smart meter installations for low-voltage consumers. The monitoring process involves confirming the practical verification of the CBA results and identifying suitable business models for nationwide smart metering.

Italy

The regulator approves, monitors, and verifies the smart meter deployment plans drawn up by the DSOs. They are required to report to the regulator on the implementation of the installation plans and the costs incurred, for tariff coverage.

Lebanon

The DSPs monitor the installed smart meters and share data with the EDL. The first stage of installation is complete, and data from smart meters are analysed by the EDL, including logs, events, and meter behaviour. Unfortunately, the establishment of an AMI centre for the EDL was delayed due to the Beirut port explosion and remains pending.

Malta

The Maltese regulator requires a cost-benefit analysis for the approval of any related projects.

Morocco

At present, there is no specific monitoring mechanism in place for smart meters and smart grids.

Palestine

Data collection and approval of meter replacement costs play a role in monitoring smart meter initiatives as part of development plans and tariff calculations.

Portugal

The code for smart grid services foresees that operators report information quarterly, semi-annually, and yearly. This information refers to smart grid deployment and functioning:

- Total number of installed smart meters – semester.
- Number of requests to access the serial communications port – semester.
- The success rate of remote operations (access to metering data and contract changes) – semester.
- Percentage of failed remote readings up to three days after the defined day – semester.
- Number of remote changes of contracted power, requested by clients – semester.
- Percentage of total installed smart meters and smart grid integration, by municipality (until the end of the process of integration of smart meters in low voltage smart grids) – quarterly.
- A report for reactive energy transit, a report on the impact of electric mobility in the local distribution network, and a report on the impact of self-consumption in the local distribution network – one report each year.
- Information regarding the quality of service of scheduling of operations such as remote change of contracted power and tariff options, remote activation and deactivation of supply, and remote operations of quality of service that replace the physical presence – semester.
- Performance evaluation to include in the quality-of-service report: of the frequency of meter reading, remote changes on contracted power or tariff options, activation, and deactivation of supply (with or without client responsibility) – yearly.

In addition, under the responsibility of supervision committed to the regulator, ERSE publishes yearly reports on the evaluation of distribution smart grid deployment, concerning the installation of smart meters, available smart grid services, use of the available services by consumers and market agents and functioning of the smart system.

Slovenia

The NRA is monitoring the scope and quality of measurement data provision within the framework of the AMI, based on the regulation of measures and procedures for the introduction and connectivity of advanced electricity measurement systems and the regulatory control related to this task.

In the context of managing the risks associated with the implementation of the reform of the network charge methodology and tariff system, the NRA has defined a set of indicators for monitoring the availability and quality of data, comprising more than 20 different KPIs, because the reported KPIs within the annual DSO reports on the status of the AMI implementation project were not as expected. Through these KPIs, the NRA monitors progress in implementing AMI at the share level roll-out and AMI integrated smart meters, accessibility to different ranges of measurement data of various types (e.g. 15-minute measurement data for the previous day [D-1] and the past month [M-1], validated/not validated) at the level of point of delivery (point of change of title), metering point and also at the user level, the share of measuring devices by factors such as individual communication technologies.

The new network charging methodology and tariff system in Slovenia is based on 15-minute billing data on consumption and power achieved. Therefore, the largest possible share of users must be provided with adequate measurement of network usage, which will enable the calculation of quantities based on the agency's new methodology in 2024 and provide users with all the advantages that this methodology. This complies with the clean energy package (CEP) requirements and supports the green transition by design. A selection of KPIs monitored every month (in a limited timeframe) is given below:

- The proportion of installed meters per point of delivery (with 15-minute resolution): It is the proportion of measuring equipment that provides the necessary measurement data for the calculation of network charges and other services
- Share of users with guaranteed access to 15-minute measurement data (D-1): This is user access to unvalidated 15-minute consumption data or production for the past day at the level of the national data hub.
- Share of users per point of delivery with guaranteed adequate quality of 15-minute data (M-1): This is user access to validated 15-minute consumption data or production for the past month (any missing values are replaced) at the level of the national data hub - billing data (15-minute profiles).
- Share of AMI built-in meters: The share of meters that are fully (adequately) connected by communication technology into AMI and with data processed by the set of standard services within AMI (the share also includes legacy meters that record measurements with a resolution of more than 15 minutes).

Incentives for efficient smart grid investments linked to the monitoring of a series of efficiency KPIs are described in the following paragraphs. The NRA provides a performance incentive for efficient smart grid investments for DSOs and TSOs, which are linked to the monitoring of a series of KPIs in the following areas (but current KPIs do not necessarily cover all these areas):

- exploitation of flexibility
- network capacity utilisation
- increasing transmission capacity
- hosting capacity and the level of integration of distributed elements
- voltage quality
- losses (where network losses due to transit energy flows are not considered)
- asset lifetime
- forecast accuracy
- Provide real-time information to interested stakeholders
- openness to third-party innovation
- environmental impacts.

Two types of key performance indicators are used to monitor the performance of smart grid investments, namely:

- Key preparedness indicators; and
- Key performance indicators.

An individual KPI is defined as a weighted composite of indicators. The assessment of the performance of investments based on the KPIs may be conditional on the achievement of an appropriate level of each KPI or individual preparedness indicator. Based on the KPIs of each type, an umbrella preparedness KPI and an umbrella efficiency KPI are calculated.

The principles of performance-based regulation of smart grid investments are:

- public publication of performance indicators, which shall include the publication of indicators in the context of the development plans of the distribution system operator and the system operator
- a functional link between the performance of smart grid investments and the eligible costs of the distribution system operator or the transmission system operator
- the definition of minimum standards for the preparedness of the distribution and transmission networks.

Performance-based regulation for smart grid investments referred to in the second and third indents of the previous paragraph represents a feedback management process, where the NRA influences the process by adjusting the eligible costs in such a way that it seeks to maximise the level of efficiency.

The scheme is described in Articles 81 through 93 of the aforementioned Legal Act[8].

The project-oriented incentive scheme for smart grid investments has project-specific KPIs. The scheme is described in Articles 102 through 109 of the aforementioned legal act. Appropriate restrictions are considered to prevent multiple financial incentives for providing the same benefits, which is described in Article 110 of the aforementioned act.

These diverse monitoring approaches emphasise the importance of tracking the progress and performance of smart meter and smart grid implementations, ensuring that they meet their objectives efficiently and effectively.

[8] Published act - https://www.uradni-list.si/glasilo-uradni-list-rs/vsebina/2022-01-2907?sop=2022-01-2907 and its correction - https://www.uradni-list.si/glasilo-uradni-list-rs/vsebina/2023-21-0026?sop=2023-21-0026), whereas the KPIs are described in Annex 5 of the aforementioned legal act.

4. Implementation Challenges of Smart Meters and Smart Grids

4.1 Economic and Financial Challenges in Promoting the Adoption of Smart Meters and Smart Grids

Promoting the adoption of smart meters and smart grids in the Mediterranean region is not without economic and financial challenges. Here's how each country addresses these challenges and explores solutions. The following table provides a concise overview of the challenges and solutions for each country in promoting the adoption of smart meters and smart grids.

Country	Economic and financial challenges	Solutions to overcome challenges
Albania	Not applicable	Not applicable
Cyprus	Capital investment, organised system, data integration complexity, and cost increase.	Meticulous planning, efficient resource management, and long-term cost-benefit analysis.
France	Investment costs and gradual savings realisation for smart meters (Linky). Obstacles in deploying market-driven technologies.	"Tariff deferral" mechanism to smooth costs, cost-benefit analysis, and removal of deployment obstacles.
Greece	No identified challenges.	The favourable economic environment for adoption.
Italy	Inevitable Initial Increase in metering and distribution tariffs due to investment costs.	Establishes standard costs and efficiency incentives to reduce the impact of tariffs on consumers as much as possible.
Lebanon	Economic challenges due to the Electricité du Liban's (EDL's) financial situation.	The policy statement aims for the EDL's financial stability, facilitating meter procurement, and installation.
Malta	Collaborative management of technical requirements with the DSO.	A collaborative approach to address potential economic challenges.

Country	Economic and financial challenges	Solutions to overcome challenges
Morocco	High financing costs and extended return on investment period.	International funding, phased implementation, and cost management.
Palestine	Financing the project cost.	Innovative funding solutions and possible international support.
Portugal	Disruption of supply chains, higher cost of components necessary to manufacture smart meters, higher fuel costs, higher costs in human resources, and the need to train specialised people.	
Slovenia	No identified economic-financial challenges in the implementation of AMI. However, there are other challenges such as: • due to insufficient preparedness levels in the domain of observability (not on the edge but on the level of MV/LV nodes), the distribution side does not efficiently recognise the need for the implementation of smart grids. • potential shortcomings in the regulatory incentive schemes for smart grids – CAPEX bias problem is not eliminated for some specific investments or the incentive scheme is too challenging for operators. • preserving BoU investment strategy (planning conventional	

Country	Economic and financial challenges	Solutions to overcome challenges
	investments only) by operators despite available incentives.	

4.2 Technical Challenges and Barriers to the Implementation of Smart Meters and Smart Grids

The implementation of smart meters and smart grids brings forth several technical challenges and potential barriers. Addressing these issues is crucial to ensuring the seamless deployment and efficient operation of these technologies. Specific challenges and solutions vary by country. The following figure provides a snapshot of these challenges and solutions:

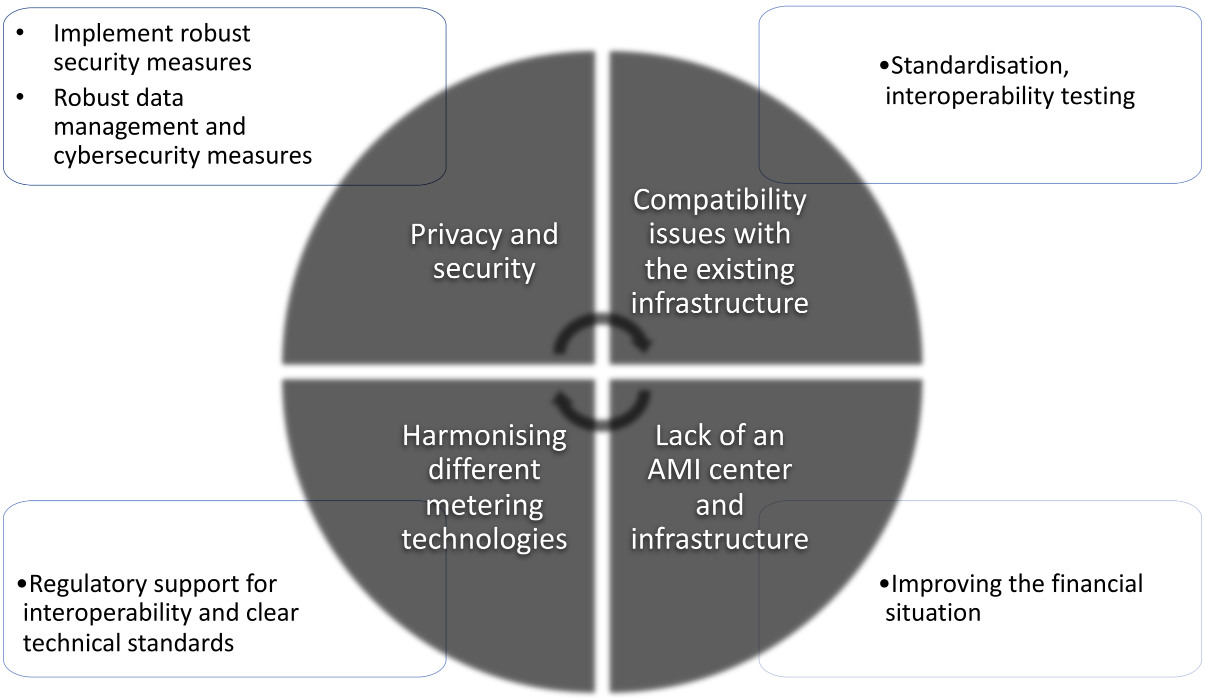

Figure 9. Technical challenges and barriers in the implementation of smart meters and smart grids

MEDREG members also identified specific challenges and possible solutions corresponding to their national case and the results are provided below:

Cyprus

Challenges:

- Potential privacy and security concerns due to data transmission, including sensitive customer information.
- Issues with securing a high quantity of data transferred via low-bandwidth networks.

Solutions:

- Implement robust security measures.
- Choose the right network.
- Prioritise data security to prevent unauthorised access and protect consumer privacy.

Italy

Challenges: The interoperability and maximum adaptability of smart measurement technologies. Smart meters must be able to communicate effectively with the end customer's devices, with the general consumption detection system for balancing the grid and with the technologies used by different distributors (the distribution concession may go to an operator other than the one who installed the smart meters).

Solutions: Defining ex-ante technical standards, communication protocols, and interoperability obligations helps to prevent obstacles.

Greece

Challenges: Integration with existing legacy infrastructure can lead to compatibility issues. Harmonising different metering technologies, communication protocols, and data management systems is essential.

Solutions: Standardisation, interoperability testing, and careful planning to ensure compatibility. Robust data management and cybersecurity measures are vital. Regulatory support for interoperability and clear technical standards are important.

Lebanon

Challenges: Shortage of electricity supply, lack of an AMI centre, and technical problems arising from poor internet connectivity in some areas.

Solutions: Improving the financial situation can help mitigate these challenges.

Malta

Specific challenges in Malta are addressed in collaboration with the DSO and the ministry responsible for energy.

Morocco

Challenges: Rapid evolution of communication technologies leading to swift obsolescence of deployed solutions.

Solutions: Continuous monitoring of technological advancements, staying updated, and adapting to the latest technologies. Relying on high levels of technical expertise to manage challenges effectively.

Palestine

Challenges: Integration of different types of smart meters working through various technologies (such as GPRS, fibre, and PLC) can create difficulties in unifying the system.

Solutions: Develop compatibility solutions and establish a unified system to accommodate various smart meter types.

Portugal

Challenges: Significant changes for the operators' systems and procedures and the period necessary for the rollout of smart meters.

Solutions: A defined calendar of objectives and milestones lowers the risk of investment by the grid operator, accelerates the effort for the replacement of meters, and reduces the time (years) in which two realities (smart and non-smart grid) coexist.

Slovenia

Challenges: The main challenges are listed below:

- Non-optimality in observability at low voltage level:
  - Lack of crucial data below the MV/LV transformer station, with about one-third of the transformer stations lacking optimal monitoring.
  - Inadequately observable distribution grid, hindering informed decision-making for smart grid applications.
- Cybersecurity concerns:
  - Ongoing challenges and the need for constant improvement in the realm of cybersecurity.
  - Scrutiny of operational technology (OT) within the upgraded NIS directive (NIS2) and concerns about its comprehensive coverage.
  - Emphasis on stakeholders in Information Technology (IT) and OT technologies to implement necessary security measures for a more resilient grid.
- Regulatory barriers in smart meters:
  - Alignment with the conclusions of the Agency for the Cooperation of Energy Regulators (ACER) regarding the measuring instruments directive (MID) as a barrier to submetering.
  - The MID's conformity assessment and CE marking requirements are seen as unduly burdensome for submeters, impeding their introduction to the market.
  - Hindrance to the progress of smart grids and innovative energy technologies due to regulatory burdens on submeter manufacturers.
- Technical limitations in power line communication technology:

- Challenges recognised by the NRA in the use of PLC technology for data transfer to measuring centres.
- Difficulties in achieving data completeness, lead to challenges in accurately categorising users into measured and non-measured groups.
- Implications for energy providers in efficiently managing and optimising their services.

In terms of solutions, the regulator has identified some areas—such as enhancing observability at low voltage levels, strengthening cybersecurity measures, and regulatory adjustments for smart meters—and advocates for regulatory adjustments to the MID to ease the burden on submeter manufacturers and address technical limitations in PLC technology.

These challenges, though diverse, can be successfully addressed through a combination of technical expertise, careful planning, standardisation, and robust security measures tailored to each country's specific needs and circumstances.

5. Best Practices for Smart Meter Implementation

Successful implementation of smart meters requires careful planning, stakeholder engagement, and adherence to industry best practices. In this chapter, we will outline key considerations and best practices for the deployment of smart meters in the Mediterranean region.

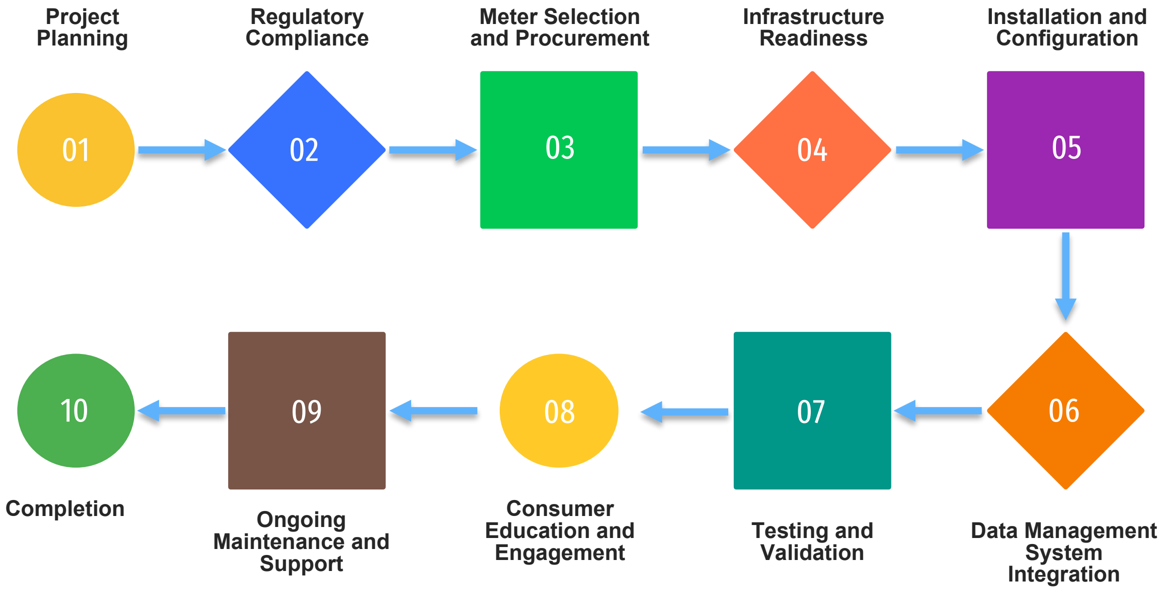

Figure 10. Implementation steps of smart meters

5.1. Meter Installation and Infrastructure

- **Robust project planning:**

  Develop a comprehensive project plan that includes clear objectives, timelines, and resource allocation. Engage all relevant stakeholders, including utilities, regulators, consumers, and technology vendors to ensure a coordinated and efficient deployment.

- **Grid readiness assessment:**

  Assess the readiness of the existing electricity grid infrastructure to support smart meters. Ensure that the grid can handle increased data flows, accommodate two-way communication, and support remote meter reading capabilities.

- **Standardisation and interoperability:**

  Emphasise the use of standardised communication protocols, data formats, and interoperability standards to ensure compatibility between different metering systems and enable seamless integration with existing infrastructure.

5.2 Communication Infrastructure

- **Robust communication networks:**

  Establish reliable communication networks capable of handling the increased volume of data generated by smart meters. Consider technologies such as cellular networks, PLM, or dedicated wireless networks, depending on the specific requirements of the deployment.

- **Data security and privacy:**

  Implement robust security measures to protect the integrity and confidentiality of the data transmitted between smart meters and utility systems. Encrypt communication channels, ensure secure data storage and comply with relevant data protection regulations to safeguard consumer privacy.

- **Scalability and flexibility:**

  Design communication infrastructure with scalability in mind to accommodate future growth in the number of smart meters. Ensure that the infrastructure can support additional services, such as demand response programs or time-of-use tariffs and can easily adapt to evolving technology advancements.

5.3 Data Management and Analytics

- **Data collection and management:**

  Establish efficient processes for collecting, validating, and storing meter data. Implement robust meter data management systems that can handle large volumes of data, ensure data integrity, and provide analytics capabilities for insights generation.

- **Consumer engagement:**

  Develop user-friendly interfaces and tools that allow consumers to access their energy consumption data and receive personalised energy feedback. Promote consumer engagement through energy management platforms, mobile applications, and online portals to encourage energy-saving behaviours.

- **Data analytics and grid optimisation:**

  Leverage advanced analytics techniques to gain actionable insights from meter data. Utilise data analytics to identify consumption patterns, forecast demand, detect anomalies, and optimise grid operations for improved efficiency and reliability.

5.4 Regulatory Framework and Consumer Protection

- **Regulatory support:**

  Establish a supportive regulatory framework that incentivises smart meter deployment, ensures cost recovery, and promotes interoperability and standardisation. Provide clear guidelines on consumer rights, data protection, and privacy to build trust and protect consumer interests.

- **Consumer education and awareness:**

  Launch comprehensive consumer education campaigns to raise awareness about the benefits of smart meters, address concerns, and promote responsible use of energy. Provide clear information on data privacy, security measures, and the availability of energy-saving opportunities.

5.5. Role of Market Incentives and Demand Response Programs in the Adoption of Smart Grid and Smart Meter Technologies

From MEDREG members' experiences, we can understand that the market incentives and demand response programs facilitate the implementation of smart meters and smart grids in the electricity system. The process of designing these tools is specific to each country's needs. However, through the best practices of the MEDREG members, we identified five main steps to be taken into consideration as demonstrated in Figure 11 below:

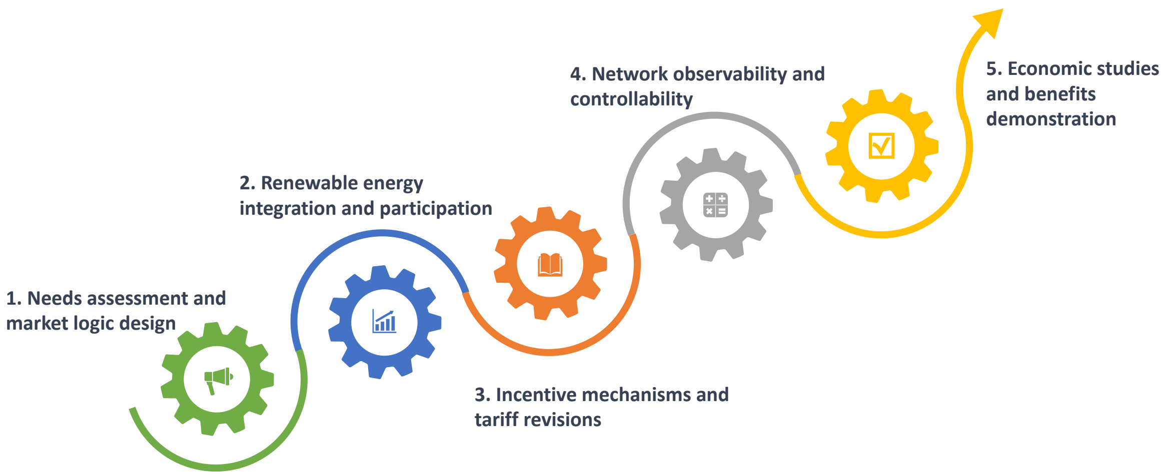

Figure 11. Implementation of market incentives and demand response programs

The tools of market incentives and demand response programs need to be designed through a market logic without public subsidies. The electricity market should operate under the umbrella of a cost-effective approach to ensure a sustainable and reliable power network.

Taking into consideration the given challenge of integrating renewable energy, the demand response mechanism will be a useful tool in better managing peak demand, while balancing electricity loads. The rationalisation of network investments will be achieved through the active participation of demand response in the electricity market, as the network operator will have a better view of what investment is more sustainable. However, demand response measures will not provide the right signal (incentive) to market participants without the development of smart meters.

In Italy, market incentives played a key role in the early phase of smart meter deployment, when installation programs were voluntary, and distributors chose electronic meters to reduce metering and distribution costs. Since 2006, the smart metering strategy has essentially regulatory origins, in the sense that the regulator and legislator have progressively made smart metering mandatory, thus signalling to the market that smart grids would be the future platform of the electricity market. When meters and networks are completely "smart", the market will determine incentives for companies in the form of the different services and pricing models that energy sellers will be able to offer to end customers.

One of the mechanisms that can be implemented is the replacement of meters free of charge and the net metering scheme allowing consumers to reduce their energy bills, such as those adopted in Lebanon. Moreover, in November 2022, a new tariff system was adopted by the EDL after around 30 years of having fixed subsidised tariffs. This opened the door for implementing multiple tariffs in the future, which will indirectly incentivise the adoption of smart meters as well.

In Slovenia, market incentives and demand response programs are used to drive the adoption of smart grid and smart meter technologies. These include subsidies and grants, performance-based incentives on the market incentives side and several programs encouraging consumers and businesses to adjust their electricity usage during peak times. This can reduce strain on the grid and minimise the need for additional infrastructure such as time-of-use (TOU) pricing, critical peak pricing (CPP) and automated demand response.

In conclusion, market incentives and demand response programs work in harmony to promote the adoption of smart grid and smart meter technologies. Market incentives make the initial investment more attractive, while demand response programs provide a mechanism for more efficient and flexible management of electricity demand, contributing to grid stability and sustainability.

However, to introduce flexibility markets and demand response programmes, a fully observable and controllable network is considered a prerequisite. This level can only be achieved with a large-scale rollout of smart meters and the adoption of smart grids.

In the absence of market incentives or demand response programs such as in Algeria, Morocco, and Palestine, one of the critical factors that will be discussed is the need for comprehensive economic studies. These studies will play a crucial role in demonstrating the potential benefits of adopting smart grid and smart meter solutions over continuing with traditional business practices. By showcasing the economic advantages, such as increased energy efficiency, reduced greenhouse gas emissions, and enhanced resource management, decision-makers can make informed choices regarding the adoption of these technologies.

6. Case Study: CRE's Regulatory Sandbox

Concerning smart meters, the Energy Regulatory Commission (CRE) defines the TURPE, which takes into account all the costs of network operators (transport and distribution), paid by individuals and businesses on their electricity bills.

In 2014, the CRE set the financing mechanism for the Linky industrial project, as well as the deployment objective of 90% of customers. The Linky industrial program generated investment costs borne entirely by Enedis and completely offset over time by the savings generated by the deployment of 35 million meters at the end of 2021.

This mechanism includes a "tariff deferral", which was put in place by the regulator because the savings are noted once the deployment is completed, while the investment costs are immediate. The tariff deferral, therefore, allows for smoothing and thus prevents an increase in TURPE at the time of deployment of the programme and then a decrease at the end.

In its January 2021 deliberation on the TURPE 6 tariff, the CRE verified and confirmed that:

- the total cost of the project will ultimately be lower than the initial budget
- the planned load savings are there, and therefore included in the tariff trajectory.

Consequently, the forecasts made at the start of the programme are well confirmed and the savings in Enedis charges will compensate for the sums to be paid for the Linky investment. Consumers will therefore not pay an additional cost due to Linky.

On smart networks, two cases must be distinguished uses and technologies:

- implemented by network managers (such as advanced meters and dynamic line rating). As a regulator, the CRE ensures that network managers have the means (financial and human) to deploy these technologies.
- responding to a market logic (such as storage and offers of innovative supplies). The CRE considers that these activities and technologies must be deployed according to a market logic without public subsidy. However, to ensure that this deployment can be done without conflict, the CRE is working to remove existing obstacles (e.g. for storage and ensuring and facilitating participation in several markets)

6.1 Regulatory Sandbox

In France, the law of November 8, 2019, relating to energy and climate, known as the "Energy-Climate law", introduced a regulatory experimentation system, also called "sandbox" in the energy sector.

This system provides that the CRE can grant exemptions to the conditions of access and use of networks and installations to deploy innovative technologies or services in favour of the energy transition and intelligent networks and infrastructures on an experimental basis for a maximum duration of four years, renewable once. This new system provides a legal framework adapted to projects making it possible to test innovations, which would ultimately require changes to the applicable regulatory and legislative framework.

Eligibility criteria:

Projects are examined against the following cumulative eligibility criteria:

- Contribute to the objectives of the energy policy defined in article L. 100-1 of the energy code.
- Present an innovative dimension.
- Face an identified legislative or regulatory obstacle relating to the conditions of access and use of networks and installations resulting from Titles II (Transport and Distribution), IV (Access and Connection to Networks), and V (The Use of Electricity) of Book III (Provisions Relating to Electricity) and Titles II (Storage), III (Transport and Distribution), and V (Access and Connection to Networks and Installations) of Book IV (Provisions Relating to Gas) of the Energy Code
- Present potential for further deployment, particularly if the experiment achieves its objectives.
- Present a benefit for the community if the solutions were ultimately deployed.

The application file must specify the regulatory obstacle for which an exemption is requested and explain how it harms the completion of the project.

6.2 History and Feedback from the System

After having defined the modalities for implementing this sandbox, the CRE organised two application processing windows:

During the first window, 41 applications were submitted, including 20 meeting the eligibility criteria. Of the 10 eligible projects falling within all or part of its powers, the CRE granted exemptions to nine projects. The projects falling under the jurisdiction of the General Directorate of Energy and Climate (DGEC) were transmitted to it, with two of them benefiting from exemptions.

During the second window, 38 applications were submitted, including 22 meeting the eligibility criteria. Of the 16 eligible projects falling within all or part of its powers, the CRE granted exemptions to 14 projects.

The projects falling under the jurisdiction of the Ministry of Energy (DGEC) were transmitted to it.

At the same time, the DGEC, not organising a counter, was contacted by three project leaders, with two of them benefitting from exemptions.

In total, 26 projects have benefited from exemptions under the system since its creation.

In a deliberation dated July 22, 2021, the CRE published feedback from the first window based on feedback from the stakeholders involved. It emerged that the organisation of counters brought visibility and transparency. However, the fixed timetable could force project leaders to wait or rush to submit their applications. Drawing on the experience gained from these two windows, the CRE will now process applications as they are received.

The procedure followed is given below:

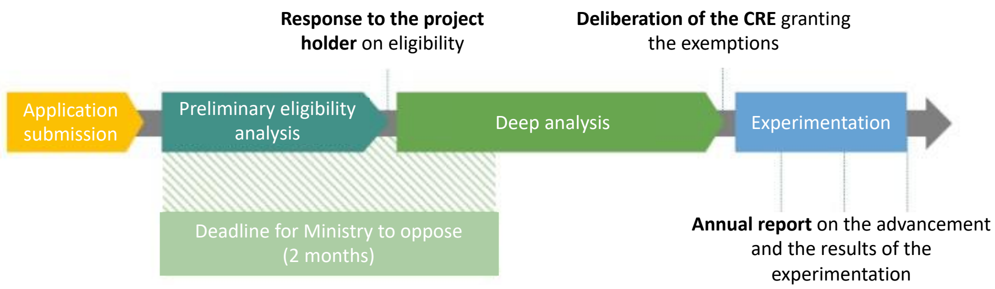

Figure 12. Regulatory sandbox application procedure - CRE

6.3 Some Examples

- **Synthetic Methane Injection**

  In deliberation no. 2021-5918 of March 11, 2021, the CRE granted exemptions to synthetic methane injection projects for periods of four years:

  - Access to the detailed study service
  - The possibility of registering projects in the biomethane capacity register
  - Access to services allows (i) the realisation of the connection of the project leader and (ii) the analysis of the quality of the gas produced and (iii) the injection of the gas produced.

  The methanation project leaders are awaiting the decision of the DGEC on the granting of exemptions making them eligible for the reduction of connection costs and the right to injection system. These exemptions, which are not essential for the implementation of the injection, would nevertheless improve the financial sustainability of the projects.

- **Engie Mobile Point**

  A first exemption was granted to deliberation no. 2021-13 of the CRE of January 21, 2021, relating to the decision on TURPE 6 HTA-BT was granted to the company Engie. It can experiment with a specific "mobile peak" tariff scale, activated on a signal from the distribution network manager, aiming to smooth out local peaks and therefore avoid long-term investments.

The CRE has granted an exemption to the rule that requires customers to subscribe to a tariff option for 12 consecutive months. This exemption applies to customers who wish to subscribe to the "mobile peak" option and also to those who have already subscribed to this option and wish to change to another option. This means that customers who use these offers are free to switch to other suppliers without any restrictions.

The monitoring of indicators carried out by the CRE returns the following information:

Enedis activated mobile peak hours during certain periods of the day, which resulted in disadvantageous billing for some customers, highlighting the need to update off-peak hours according to network reality.

During the experiment, consumption during mobile peak hours decreased by an average of 10% compared to other days, which could be valuable for power network sizing.

For customers to save money with the mobile peak option, there would need to be around 24% curtailment during mobile peak hours. Education and automation measures could help achieve this goal.

- **Valorisation of Upward Modulations of Consumption Eqinov**

  The Eqinov company wishes to be able to promote consumption modulations via symmetrisation of the erasure block exchange notification mechanism (NEBEF), to encourage consumers to shift their consumption to the most favourable price periods. Only the valuation of cancellations is currently provided for by the NEBEF rules, which in practice prevents the implementation of this source of downward flexibility.

  The CRE has granted an exemption from the NEBEF rules in force. Eqinov will be able to value through the NEBEF mechanism, the modulations of consumption of its customers, upwards or downwards, within the limit of a portfolio to be defined in number and power in the experimentation convention.

  This experiment was requested as part of the second window and its analysis by the CRE is underway.

Annex

Annex 1

1. Minimum technical requirements for regulatory framework

To ensure the successful implementation and interoperability of smart meters and smart grids in the Mediterranean region, it is essential to establish minimum technical requirements within the regulatory framework. In this chapter, we will outline the key technical requirements that should be considered.

Technical requirements	Smart meter	Smart grid	Data management	System integration	Customer engagement
Accuracy	✓				
Communication	✓				
Interval data	✓				
Real-time monitoring	✓				
Remote disconnect/reconnect	✓				
Load profiling	✓				
Tamper detection	✓				
Data security	✓				
Firmware upgrades	✓				
Interoperability	✓				
AMI		✓			
Distribution Automation		✓			
Demand response		✓			
Energy storage integration		✓			
Renewable energy integration		✓			
Grid monitoring and analytics		✓			
Fault detection and restoration		✓			
Voltage management		✓			
Cybersecurity		✓			
Grid resilience		✓			
Data collection			✓		
Data storage			✓		
Data analytics			✓		

Technical requirements	Smart meter	Smart grid	Data management	System integration	Customer engagement
Data visualisation			✓		
Privacy protection			✓		
Data sharing			✓		
Data access			✓		
Integration standards				✓	
Compatibility				✓	
System scalability				✓	
Real-time data exchange				✓	
Integration testing				✓	
Consumer education					✓
Energy usage feedback					✓
Consumer portal					✓
Billing transparency					✓
Energy efficiency programmes					✓

2. Technical requirements for smart meters

- Accuracy and measurement standards:

  Specify the accuracy requirements for smart meters by internationally recognised standards, such as the IEC standards. Ensure that smart meters provide accurate and reliable measurements of energy consumption.

- Communication protocols and interoperability:

  Mandate the use of standardised communication protocols, such as Zigbee, DLMS/COSEM, or open standards like OpenADR, to enable interoperability between smart meters and utility systems. This ensures seamless data exchange and integration with other grid components.

- Data security and privacy:

  Define security measures for smart meters to protect against unauthorised access, tampering, and data breaches. This requires encryption of data transmission, secure storage of consumer information, and compliance with relevant data protection regulations.

- Remote disconnect/reconnect capabilities:

Specify the inclusion of remote disconnect/reconnect functionalities in smart meters to enable utilities to remotely manage service activation, deactivation, and reconnection processes without the need for physical intervention.

3. Minimum Technical Requirements for Smart Grid Regulatory Frameworks

- Communication infrastructure:

  Establish requirements for robust and reliable communication infrastructure to support smart grid operations. Define the necessary bandwidth, latency, and coverage for communication networks, taking into account the specific needs of the smart grid applications.

  AMI: Define technical requirements for AMI systems, including the frequency of data collection, data storage capacity, and remote meter reading capabilities. Specify the interoperability of AMI systems with smart grid components for seamless integration and data exchange.

- Grid automation and control:

  Specify the technical capabilities and functionalities of grid automation and control systems. This includes real-time monitoring, fault detection and isolation, voltage regulation, and load balancing to enhance grid performance and reliability.

- Distributed energy resources (DER) integration:

  Define technical requirements for the integration of DERs, such as solar panels and wind turbines, into the smart grid. Specify the communication protocols, data exchange formats, and control mechanisms for effective DER management and optimisation.

- Testing procedures:

  Establish testing procedures and protocols to ensure the compliance of smart meters and smart grid components with the defined technical requirements. Define the testing methodologies, accuracy verification processes, and performance benchmarks to validate the functionality and reliability of the deployed systems.

- Certification and compliance:

  Implement a certification process to ensure that smart meters and smart grid components meet the established technical requirements. Mandate third-party certification bodies to verify compliance and issue certificates to validate the conformity of the deployed systems.

By incorporating these minimum technical requirements into the regulatory framework, the implementation of smart meters and smart grids in the Mediterranean region can be standardised, interoperable, and aligned with industry best practices. The next chapter will provide recommendations for the effective engagement of stakeholders throughout the implementation process.

Annexe 2

- ## Standards set by the Cyprus DSO for the AMI and Smart Meters

Reference	Title
Directive 2000/84/EC	Directive 2000/84/EC of the European Parliament and the Council of 19 January 2001 on summer-time arrangements
Directive 2006/66/EC	Directive 2006/66/EC of the European Parliament and of the Council of 6 September 2006 on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC (Text with EEA relevance)
Directive 2014/32/EU	Directive 2014/32/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the member states relating to making the measuring instruments (recast) available on the market. Text with EEA relevance
EN 50065	Signalling on low-voltage electrical installations in the frequency range 3 kHzto 148,5 kHz
EN 50470-1	Electricity metering equipment (a. c.) - Part 1: General requirements, tests, and test conditions – Metering equipment (class indexes A, B, and C)
EN 50470-3	Electricity metering equipment (a. c.) - Part 3: Particular requirements – Staticmeters for active energy (class indexes A, B, and C)
EN 55022	Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement
EN 60068-2-1	Environmental testing - Part 2-1: Tests - Test A: Cold
EN 60068-2-2	Environmental testing - Part 2-2: Tests - Tests B: Dry heat
EN 60068-2-14	Environmental testing - Part 2-14: Tests - Test N: Change of temperature
EN 60068-2-30	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, and cyclic (12 h + 12 h cycle)
EN 60068-2-78	Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, and steady-state
EN 60529	Degrees of protection provided by enclosures (IP code)
EN 61000-4-2	Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test

Reference	Title
EN 61000-4-3	EMC – Part 4-3: Testing and measurement techniques – Radiated, radiofrequency, and electromagnetic field immunity test
EN 61000-4-4	EMC – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test
EN 61000-4-5	EMC – Part 4-5: Testing and measurement techniques – Surge immunity test
EN 61000-4-6	EMC – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields
EN 61000-4-8	EMC – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test
EN 61000-4-11	EMC – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions, and voltage variations immunity tests
EN 61000-4-12	EMC – Part 4-12: Testing and measurement techniques – Oscillatory waves immunity test. Basic EMC publication
EN 61000-4-13	EMC - Part 4-13: Testing and measurement techniques - Harmonics and inter-harmonics including mains signalling at the AC power port, low-frequency immunity tests
EN 62052-21	Electricity metering equipment (AC) - General requirements, tests, and test conditions - Part 21: Tariff and load control equipment
EN 62052-31	General requirements, tests, and test conditions - Part 31: Product safety requirements and tests
EN 62053-23	Electricity metering equipment (AC) - Particular requirements - Part 23: Static meters for reactive energy (classes 2 and 3)
EN 62053-52	Electricity metering equipment (AC) - Particular requirements - Part 52: Symbols
EN 62054-21	Electricity metering (AC) - Tariff and load control - Part 21: Particular requirements for time switches
EN 62056-21	Electricity metering - Data exchange for meter reading, tariff and load control - Part 21: Direct local data exchange
EN 62056-7-6	Electricity metering data exchange - - The DLMS/COSEM suite – Part 7-6 - The 3-layer, connection-oriented HDLC-based communication profile
EN 62056-8-5	Electricity metering data exchange - The DLMS/COSEM suite - Part 8-5: Narrow-band OFDM G3-PLC communication profile for neighbourhood networks.

Reference	Title
EN 62056-9-7	Electricity metering data exchange - The DLMS/COSEM suite - Part 9-7: Communication profile for TCP-UDP/IP networks
FCC Part-15 (Title 47 CFR Part 15)	FCC Part-15 Rules: Unlicensed RF Devices (TITLE 47 - Telecommunication, CHAPTER I - FEDERAL COMMUNICATIONS COMMISSION, SUBCHAPTER A - GENERAL, PART 15 - RADIO FREQUENCY DEVICES)
IEC 11770-1	Information technology - Security techniques - Key management - Part 1: Framework
IEC 62059-31-1	Electricity metering equipment - Dependability - Part 31-1: Accelerated reliability testing - Elevated temperature and humidity
IEC 62059-41	Electricity metering equipment - Dependability - Part 41: Reliability prediction

The technical requirements and standards for smart grids in Slovenia are defined by various international organisations, industry associations, regulatory bodies, and government agencies. These standards provide guidelines and specifications for the design, deployment, and operation of smart grid technologies to ensure interoperability, reliability, and security. Here are some key organisations and standards related to smart grids:

- **International Electrotechnical Commission (IEC):**

  IEC 61850: Standard for communication networks and systems in substations. It defines communication protocols, data models, and engineering methods for integrating various devices and systems in substations.

- **Institute of Electrical and Electronics Engineers (IEEE):**
  - IEEE 2030.5: Standard for the communication interface between electric vehicle (EV) charging stations and utility control systems, enabling demand response and integration of EVs into the grid.
  - IEEE 1547: Standard for the interconnection and interoperability of DERs with the power grid.
  - IEEE 802.15.4g: Standard for wireless communication in smart grid applications, particularly for AMI and other low-power, long-range communication.
- **National Institute of Standards and Technology (NIST):**
  - NIST SP 1108: Framework and roadmap for smart grid interoperability standards.
  - NIST IR 7628: Guidelines for smart grid cybersecurity.
  - European Telecommunications Standards Institute (ETSI):
  - M2M and smart grids: ETSI produces standards for machine-to-machine (M2M) communications and their application to smart grid technologies.
- **International Smart Grid Action Network (ISGAN):**

  - This organisation works to advance the development and deployment of smart grids globally. It doesn't create standards directly but facilitates collaboration among member countries and organisations to share best practices and knowledge.
- **Smart Grid Interoperability Panel (SGIP):**
  - SGIP is an industry consortium that supports the development of standards and interoperability for the modern grid. It works to identify gaps, prioritise standards, and coordinate efforts across stakeholders.