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ACCELERATING SMART METERING

REGULATORY DRIVERS FOR ITS DEPLOYMENT IN LATIN AMERICA

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01 INTRODUCTION

The modernization of electricity distribution systems has become a central component of the energy transition, driven by the electrification of new uses, the expansion of distributed generation, and a growing demand for more efficient, flexible, and resilient grids. In this scenario, smart metering has positioned itself as a strategic element to improve the management of the electricity system and strengthen the relationship between distributors and consumers. Its capabilities to generate granular information, improve service transparency and enable new participation schemes make Advanced Metering Infrastructure (AMI) a key component of the sector's digitalization.

Although the potential benefits of AMI are widely recognized, its adoption requires overcoming technical, economic, and regulatory challenges that condition the feasibility of its deployment. This is especially relevant in Latin America, where distributors face heterogeneous conditions in terms of non-technical losses, availability of investment, operational capacity, and evolving regulatory frameworks. At the same time, the region has the opportunity to incorporate modern standards and move directly towards second-generation solutions, avoiding intermediate cycles already surpassed in other markets.

This paper analyzes the role of smart metering in the transformation of electricity distribution systems in Latin America, identifying the technical, regulatory, economic, and operational conditions necessary to move towards larger-scale deployments. The objective is to offer a comprehensive vision that allows understanding the current state of digitalization in the region, assessing its challenges and opportunities, and providing concrete elements for the design of public policies and business strategies that facilitate a sustainable adoption of Advanced Metering Infrastructure.

The document is structured as follows. Section 2 describes the role of smart metering as an enabler of the new distribution model. Section 3 presents the regional snapshot of AMI deployment and national targets. Section 4 addresses the technical aspects of infrastructure, including functionalities and communications. Section 5 discusses their integration with corporate systems. Section 6 reviews data governance, consumer role, and cybersecurity. Section 7 examines economic and financing models. Section 8 summarizes the barriers facing the region. Finally, Section 9 reviews international experiences and lessons applicable to Latin America.

> “The modernization of electricity distribution systems has become a central component of the energy transition

02

SMART METERING AS AN ENABLER OF THE NEW DISTRIBUTION MODEL

Electricity distribution is undergoing a profound transformation driven by the electrification of demand, the expansion of distributed generation, and greater variability in energy flows (IEA, 2023a). These conditions make the traditional passive network model insufficient and require greater visibility, control capabilities, and high-resolution data. In this context, smart metering and, in particular, Advanced Metering Infrastructure (AMI), are consolidated as the digital basis that allows more dynamic and decentralized networks to operate, integrating measurement, communications, and data management in the same system (IRENA, 2025).

The evolution of electrical metering reflects this change. Basic telemetry made it possible to improve remote reading and reduce manual processes (IDB, 2023), but technological advancement incorporated two-way communications, frequent recordings, and control functions, transforming the meter into a component of a comprehensive digital infrastructure. AMI is the result of this trajectory: a platform that provides LV observability, granular data and continuous monitoring, essential elements to manage networks with greater operational complexity.

On this basis, AMI enables strategic functions for the new distribution model. High-frequency data allow utilities to identify losses, anticipate congestion and prioritize reinforcements; and they support advanced operating schemes such as FLISR. Its ability to manage bidirectional flows makes it possible to integrate residential PV generation, storage, and new load profiles, while temporal granularity is key for hourly tariffs, demand response programs (European Commission, 2023), and smart EV charging (IRENA, 2023). Together, AMI constitutes the minimum digital infrastructure to operate systems with high penetration of distributed resources and greater variability (IDB, 2023).

Despite its central role in the modernization of distribution, the deployment of AMI involves major economic challenges that strain the financial capacity of companies under current schemes. The magnitude of the effort is regional: a previous study by ADELAT and GME for seven Latin American economies (Argentina, Brazil, Chile, Colombia, Ecuador, Guatemala and Peru) estimates that the investment needed in AMI Infrastructure exceeds USD 51,400 million to achieve an effective transition by 2040 (ADELAT, 2024a). This volume of capital, which includes meters, communications, and data management, is evidence of a critical trade-off: technology is indispensable for future efficiency, but its present cost is difficult to assume when current regulatory frameworks have not evolved at the same pace as digitalization (IDB, 2023), and often privilege traditional physical infrastructure over digital solutions (IEA, 2023).

The role of the National Regulatory Authority (NRA) is, therefore, decisive in making this modernization viable. A sustainable deployment is based on clear mechanisms for investment recovery, minimum technical standards, and the conduct of a national Cost-Benefit Analysis that guides decisions and determines the scope of the project (IDB, 2023). Without tariff recognition, adequate incentives, and explicit definitions of recoverable costs, investment in AMI tends to be restricted to isolated pilots. For this reason, several countries have made progress in national strategies that establish objectives, implementation sequences and institutional responsibilities, aligning digitalization with the long-term goals of the electricity sector.

In Latin America, these challenges are particularly intense due to structural conditions specific to the region. The persistence of high non-technical losses, socioeconomic heterogeneity, limited capital availability and disparity in technical and financial capabilities between distributors have led to fragmented progress and uneven implementation rates. These factors explain to a large extent why the penetration of AMI remains relatively low and why many of its benefits have not yet fully materialized. Faced with this, it is necessary to accurately analyze the current state of the deployment. The following section presents the levels of AMI penetration in low voltage and the strategies followed by the distributors, identifying priorities, implementation approaches and the factors that explain progress and delays in the region.

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PROGRESS OF AMI DEPLOYMENT IN LATIN AMERICA AND IMPLEMENTATION STRATEGIES

AMI PENETRATION IN LV

On a global scale, the deployment of advanced metering infrastructure has advanced significantly over the past decade, with more than 1.2 billion smart meters installed (European Commission, 2023). Europe and North America account for a substantial part of this development, driven by regulatory mandates and positive cost-benefit (CBA) analyses. In the European Union, AMI deployment was underpinned by a regulatory framework built progressively to provide clarity on objectives, minimum requirements and interoperability. Together, this regulatory framework, developed and refined over more than 15 years, has provided stable and predictable support to incentivize mass deployments, by defining in advance when to move forward, with what minimum requirements, and how to consistently manage critical data and security elements. In this context, it is understood that average penetration has reached 56 percent in 2022 (Eurelectric, 2024), and that several countries have completed the total replacement of their metering fleet, such as Italy, Spain, Sweden and Finland (European Commission, 2023). The United States exceeds 68 percent penetration, while Japan and China are moving towards second-generation cycles with tens of millions of equipment installed (European Commission, 2023). In contrast to these trajectories, Latin America is in an early phase of adoption, with penetrations generally below ten percent and advances concentrated in a limited number of countries and distributors. This gap evidences an uneven starting point and reinforces the need to accurately understand the current state of deployment in the region before evaluating regulatory strategies and implementation models.

Within this incipient regional panorama, Uruguay, Costa Rica and Honduras are positioned as the countries with the highest degree of progress in smart LV metering, with penetration levels of 80%, 54% and 23%, respectively. Although they share a prominent position in relative terms, their trajectories have followed differentiated regulatory, institutional and operational approaches. Uruguay has implemented a centralized deployment since 2016, led by its state-owned company and articulated with national energy planning. Costa Rica has advanced under an explicit regulatory strategy, with defined goals for 2028 and a mandatory deployment executed in geographical phases. Honduras, on the other hand, has promoted the adoption of AMI from an operational logic associated with the reduction of non-technical losses, first under a concession scheme and, more recently, through targeted interventions from the State. These three cases are relevant references for analyzing how different institutional frameworks have made it possible, with different rhythms and objectives, to achieve levels of penetration above the regional average.

A second group made up of Chile, Guatemala, Mexico, Brazil, Colombia and Ecuador shows more moderate penetration levels, between 3% and 9%. In Chile (8.8%), the rollout began from an explicit regulatory mandate in 2018, but was partially reversed after a process of social rejection, which led to a voluntary and gradual implementation supervised by the regulator. Guatemala (8.4%) has advanced without a formalized national strategy, through individual initiatives of distributors aimed at commercial efficiency, in a regulated tariff context. Mexico (6%) concentrates the largest absolute volume of meters installed in the region, under a centralized model executed by the Federal Electricity Commission (CFE), with an operational approach associated with the reduction of losses. Brazil (5.6%) combines low residential penetration with large-scale projects under execution and a regulatory process aimed at setting minimum guidelines at the federal level. In Colombia (3.9%), the regulatory framework was consolidated between 2018 and 2022 with national goals for 2030, although physical deployment is in the initial stages, led by distribution companies based on urban pilots. In Argentina (3.3%), progress corresponds mainly to pilot projects distributed territorially, while the NRA begins to structure a modernization program with a medium-term horizon. Ecuador (3.1%) has promoted localized interventions within the framework of energy efficiency plans, including recent initiatives in major cities with the participation of regional public distributors. Taken together, these cases illustrate intermediate scenarios where the progress of the deployment is conditioned by institutional, social or technical factors that limit its pace and scope.

In a third set of countries, smart metering is in a clearly preliminary phase, with penetration of less than 1% and progress focused on pilots or early stages of modernization. In Peru (1.3%), development is supported by limited initiatives supported by a mandatory regulatory framework, although practical implementation remains limited. Paraguay (0.5%) maintains a deployment limited to urban pilots without a national scaling plan. El Salvador (0.5%) has developed pilots authorized by the Regulatory Body with telemetering and loss reduction functionalities, without yet transitioning to a massive phase. Taken together, these cases show an initial stage where regulatory frameworks and demonstration experiences have not yet translated into significant advances in low voltage.

A fourth group of countries is still in the early stages of adopting AMI, albeit with clearly differentiated dynamics. Panama and the Dominican Republic have recently begun deployment processes: in Panama, adoption began in 2024–2025 with urban pilots and initial phases of telemetering supported by regulatory guidelines, while in the Dominican Republic an accelerated program started in 2024 is advancing that incorporates hundreds of thousands of smart meters aimed at reducing losses and modernizing the grid. Nicaragua, for its part, developed a technically successful pilot a decade ago, with significant reductions in losses in critical areas, but the initiative was not scaled up due to funding constraints and priorities focused on the basic expansion of the service. Bolivia and Venezuela have made very limited progress, without national smart metering programs and with specific or incipient efforts in a context of financial limitations, weak institutional frameworks and, in some cases, operational deterioration of electricity systems.

Fig. 1 graphically summarizes the regional comparison, where countries that have consolidated massive deployments, others that are advancing through partial or pilot strategies and a group that has just begun the modernization of its measurement fleet coexist. This diversity reflects different institutional trajectories, levels of technical capacity, and degrees of priority assigned to digitalization within each electricity system.

Fig. 1. Estimated penetration of LV smart meters by country in Latin America and the Caribbean (2024). Sources: ADELAT (2024b), IDB (2023), Grupo Mercados Energéticos, ICE and press releases.

The scale analysis of the distributors that participated in this study and responded to the survey shows that, within each country, there are also important differences in the degree of progress of the deployment. The case of Costa Rica stands out, where ICE has reached penetration levels above 50%, the result of a consistent national strategy, stable financing and institutional continuity. In more fragmented markets, different trajectories emerge: some companies have achieved advances of close to 20%, while others remain in incipient ranges of 2% or less, even operating under the same regulatory framework. Argentina is a clear example of this dispersion, with concessions exceeding double digits while others have barely begun adoption. In Central America, most distributors are between 1% and 5%, generally in pilot phases or early stages of deployment, and in Andean systems with less digital development there are still companies without effective implementation of AMI. This shows that, even when facing similar technological costs, the economic viability of deployment varies significantly between distributors, even within the same country, which makes it necessary to examine the strategic and regulatory factors that determine this difference.

DEPLOYMENT STRATEGIES

In Latin America, the deployment of MIL presents diverse approaches, reflecting differentiated priorities and non-homogeneous strategic frameworks. While some countries have formalized explicit national targets with defined deadlines and policy support, others are moving forward through strategies in the design stage, pilot validation or definitions that are still evolving. In certain contexts, deployment responds exclusively to individual initiatives of distribution companies, without a centralized orientation. These differences allow us to distinguish between levels of institutional commitment and political ambition around the digitalization of the distribution system, with concrete implications on the expected penetration, the allocation of responsibilities and the projected pace of implementation. Table 2 summarizes the main guidelines in the countries where the distributors participating in the study operate, including official goals, deadlines, strategic approaches, prioritized areas or segments, and current state of progress.

Costa Rica and Colombia lead the group of countries with clearly defined national penetration targets, anchored in robust regulatory strategies. Costa Rica seeks to reach 100% penetration of smart meters by 2028 under its National Strategy for Smart Grids (ENREI), while Colombia set a goal of 75% penetration by 2030 through mandatory regulation by the CREG. Both cases present detailed roadmaps and segmented prioritization criteria, as well as regulatory mechanisms for cost recovery. In particular, the Colombian case illustrates a sequential deployment approach, in which a mandatory initial phase reduces the technical and economic uncertainties of the system, enabling subsequent mass deployment conditioned on verifiable results of the cost-benefit analysis (CREG, 2025). For their part, Peru and Brazil have formulated ambitious plans still in the design or validation phase. Peru proposes a widespread adoption of smart meters in a 2025–2035 horizon, subject to the approval of Congress and OSINERGMIN. Brazil, on the other hand, is in the public consultation phase of a regulation that establishes mandatory short-term minimum targets, equivalent to 4 percent of consumer units, as a prelude to mass deployment conditioned on cost-benefit analysis. The proposal is aligned with a 10-year digitalisation horizon (Portaria Normativa MME No. 111/2025, of 18 June 2025) and considers as a long-term reference a deployment of around 40% of LV consumer units in that period

In the case of Ecuador, El Salvador, Guatemala, and Argentina, there are no defined national penetration targets or mandatory regulatory mandates. The deployment of AMI infrastructure in these countries is driven almost exclusively by corporate decisions by distributors, whether for operational modernization, loss control, or preparation to integrate distributed generation. Argentina is in a previous stage of technological evaluation, with pilots led by ENRE in the Metropolitan Area of Buenos Aires, but without a national roadmap. In El Salvador and Ecuador, actions have focused on limited pilots or specific segments such as high-consumption consumers and self-generators. Guatemala, for its part, has not reported significant progress at the institutional level.

Chile is a unique case in the region. Initially, it adopted a policy of massive and mandatory replacement of meters, protected by Law No. 21,076. However, the lack of social acceptance of the transfer of costs to consumers generated strong public controversy, which led the government to reverse the mandate in 2019 and make the deployment a voluntary process. Currently, the strategy is limited to default replenishments, new connections or individual requests, with no timeline or national goal in place. The Chilean case illustrates the risks of moving forward with metering modernization schemes without an effective communication strategy and without social consensus on the expected benefits of technological change, particularly when the replacement is not accompanied by new tariff options or economic signals visible to consumers.

Table 1. National Goals and Strategic Approaches for the Deployment of AMI

Country	National deployment goal	Official deadline	Strategy Approach	Priority area or segments	Regional Progress Status
Argentina	There is no formal national goal.	No defined term.	Technical assessment and pilot projects to prequalify technologies.	Urban areas of the AMBA.	The Study Committee was constituted and the source of funding was defined. Massive progress conditioned on the results of the pilot.
Brazil	The MME proposed a goal of installing additional smart meters in 4% of the consumer units of each distributor.	12 months maximum for the installation of 4% and the presentation of the CBA.	Forced deployment (4%) to break inertia, with mandatory scale-up if the CBA is positive.	Contiguous areas with high potential for reducing non-technical losses.	Regulatory phase in public consultation.
Chile	National target reverted to non-mandatory.	Original term of 7 years. Now without obligation.	Voluntary process and replacement due to failure.	Prioritize customers with GD or who request it voluntarily.	Massive deployment stalled due to voluntary regulation.
Colombia	Goal of 75% of consumers with AMI.	Until 2030. Phases of 18 and 60 months.	Phased and mandatory deployment, conditional on CBA.	High-consumption consumers and self-generators.	Regulatory framework advanced after the Constitutional Court ruling.
Costa Rica	National goal of 100% penetration.	80% by 2026 and 100% by 2028.	Phased mass deployment.	National penetration.	High progress. More than 50% of the meter fleet.
Ecuador	There is no formal national goal.	No defined term.	Mandatory bidirectional measurement for GD	Regulated consumers implementing GD.	Regulatory and systems adaptation phase after the 2023 standard.
El Salvador	There is no formal national goal.	No defined term.	An AMI pilot-based strategy to validate the technology before massive expansion.	Focus on loss reduction and demand management.	Pilot phase with regulatory reforms under analysis.
Guatemala	There is no formal national goal.	No defined term.	Incipient, voluntary and functional strategy, focused on enabling hourly rates (TOU) and prepaid options	High-consumption customers in Guatemala City.	Incipient progress in the pilot phase, without massive expansion.
Peru	Bill proposes national deployment.	The plan covers 2025–2035.	Phased deployment based on CBA.	High-consumption and GD customers.	In the regulatory planning phase.


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AMI SYSTEM TECHNICAL SPECIFICATIONS AND INFRASTRUCTURE PERFORMANCE

The analysis of national goals and penetration levels shows that the region is moving towards the modernization of its measurement systems, but the success of these processes depends not only on the scale of the deployment, but also on the technical soundness of the installed infrastructure. The adequate definition of functionalities, the selection of communication technologies according to the conditions of each network and the existence of standards and proven interoperability are critical factors to ensure that AMI systems respond to the operational and regulatory challenges of Latin America. This section examines these three structural elements, characterizing the type of functionalities incorporated by distributors, the communication technologies that support data transmission, and the mechanisms adopted to ensure interoperability and technical compliance in an environment with multiple manufacturers and architectures, recognizing that the full use of these capabilities depends on their articulation with compatible tariff schemes.

FUNCTIONALITIES

The deployment of advanced metering infrastructure involves not only the installation of a device, but the incorporation of a set of functionalities that determine the level of observability, control, and operational value that the system can offer. The functionalities reported by the surveyed distributors allow us to characterize the technological state of the region and place it in front of the international evolution of smart metering. This analysis is critical, as AMI system's ability to generate reliable data, enable remote operations, record events, and detect irregularities conditions both operational benefits and its contribution to network modernization.

The specialized literature distinguishes two stages in the international evolution of smart metering. The first wave, deployed between the mid-2000s and early 2010s, was primarily oriented towards operational efficiency and had as its central functionality remote reading as a substitute for manual reading, with limited communications and a reduced set of records. The second wave, driven since the 2020s, responds to the growing digitalisation of the electricity system and the integration of distributed resources. It is characterized by increased data granularity, robust two-way communications, remote software updating, strengthened cybersecurity capabilities, and functionalities aimed at operating on a more dynamic and decentralized network. Pioneering countries are already replacing first-generation equipment with devices that incorporate edge processing and support advanced active demand management schemes.

Fig. 2 summarizes the frequency with which the different functionalities are reported by the surveyed distribution companies, offering a first empirical approximation to the technological status of the regional AMI fleet. From this evidence, a clearly hybrid pattern is observed. The region is not belatedly entering the first wave based solely on telemetry, as most companies declare a broad functional set that includes, in a majority proportion, bidirectional recordings, reactive energy measurement, load curves and tamper detection. However, there is also no full adoption of the distinctive capabilities of the second wave, such as widespread operational remote control, active flexibility management, strict granularity oriented towards dynamic rates or architectures designed for the systematic integration of distributed resources. Overall, the observed deployment reflects the adoption of advanced functionalities, but with a marked emphasis on solving operational and commercial needs specific to the region, especially the reduction of non-technical losses. The result is a Latin American model of AMI that combines second-generation attributes with specific adaptations to the local context.

> Analysis of national targets and penetration levels shows that the region is moving towards modernizing its measurement systems

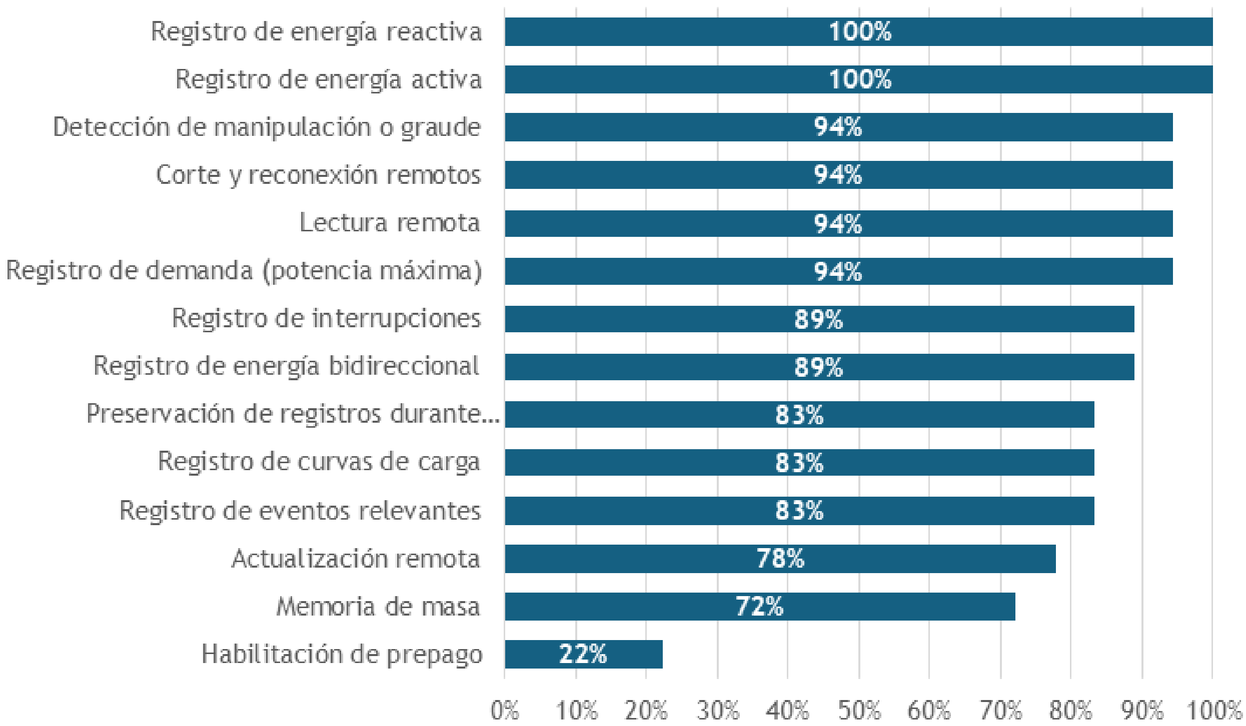

Fig. 2. Frequency of AMI functionalities reported by the surveyed distribution companies.

A distinctive aspect within the set of functionalities is the low presence of prepaid enablement. Unlike technical capabilities such as time recording, mass memory or tamper detection, which depend mainly on hardware and communications architecture, prepayment requires very specific regulatory, commercial and procedural conditions. Its implementation involves defining billing rules, charging mechanisms, disconnection and reconnection protocols, and safeguards for vulnerable customers. In the region, only a limited number of distributors declare this functionality, and always in markets where there is an explicit framework that regulates their operation. The evidence suggests that the absence of prepayment does not reflect a technological lag, but the lack of regulations that authorize its use and establish the necessary safeguards. This confirms that the expansion of functionalities aimed at advanced commercial management will depend less on technical capabilities and more on regulatory decisions on consumer engagement models.

COMMUNICATION TECHNOLOGIES

The ability of an AMI system to deliver the functionalities described in the previous section is directly dependent on the communications architecture that supports continuous, secure, and reliable data transmission. The operational value of timekeeping, events, tampering detection, or remote outage and reconnection is only realized when there is a proper communication interface between meters, hubs, and management platforms. In this context, characterizing the technologies used by distributors is essential to understand the real capabilities of the system and the limits imposed by the available infrastructure. The deployment in Latin America shows a strong dependence on communication solutions designed to adapt to heterogeneous networks and complex territories, which makes technology selection a strategic element of AMI development in the region.

Responses from companies show that the region uses virtually the entire spectrum of internationally available technologies, organized around neighborhood area networks (NANs) and wide area networks (WANs). PLC-based solutions predominate in NAN, especially in consolidated urban environments, along with RF Mesh networks and variants such as Wi-SUN in areas where the topology or quality of the network makes transmission by power line difficult. For WAN, utilities rely extensively on cellular networks in their different generations, from 2G and 3G to LTE and 5G, complemented in some cases with fiber optics or satellite links for remote areas. This diversity reflects both the technological maturity available in the market and the need to adapt the communication solution to very varied geographical, climatic and load density conditions in the region.

A distinctive feature of the regional deployment is that distributors do not converge towards a single dominant technology, but rather configure hybrid architectures that simultaneously combine PLC, radio frequency and cellular communications within the same network. This practice does not respond to experimentation, but to a structural need: no single technology offers sufficient performance in the face of the heterogeneity of Latin American networks, which include dense areas with electrical noise, extensive rural areas with low concentration of consumers, and sectors with complex topologies or relevant interferences. As a result, AMI systems in the region tend to be designed from the ground up with multiple technologies in parallel, balancing cost, robustness, and penetration, but also introducing greater demands on integration, communications network management, and operational standardization.

The challenges reported by the distributors confirm that the limitations do not come from technological availability, but from the operational conditions in which these solutions must operate. In PLC, the most recurrent problems are signal attenuation and electrical noise, sometimes exacerbated by the use of non-approved customer equipment that injects interference into the network. In radio frequency, the main difficulties are related to the need to deploy additional repeaters or concentrators to ensure penetration in environments with low density or adverse geography, together with sensitivity to interference. Cellular communications face penetration restrictions in rural areas, high operating costs, and dependence on the availability and quality of service of operators. Added to this are cross-cutting challenges, such as interoperability between technologies from different manufacturers, end-to-end time synchronization, cybersecurity and, in some countries, regulatory authorization for the use of free bands. These elements condition the performance of the system and explain why communication becomes one of the most critical components of AMI deployment in the region.

The technological diversity and operational challenges identified have direct implications for the future evolution of AMI systems in the region. The coexistence of multiple communication technologies, hybrid architectures, and disparate vendors requires more robust interoperability frameworks, formal homologation processes, and communication standards that ensure operational continuity throughout the system lifecycle. Without these elements, technical complexity translates into higher integration costs, difficulties in scalability and risks of technological fragmentation. Therefore, the performance of the communications system not only conditions the current operation of AMI, but also defines the starting point from which each country and distributor will be able to move towards second-generation functionalities, integration of distributed resources and more complete digital platforms, which motivates the analysis presented in the next section.

Table 2 summarizes the communication technologies used in AMI systems of the region, differentiating between neighborhood area networks and wide area networks. The table orders the main technological approaches and their operational conditions, showing that the design of communication architectures responds to territorial and network heterogeneity, and not to the existence of a dominant technology.

Table 2. Communication technologies used in AMI systems in Latin America and their main operational conditions.

Communication layer	Technology	Synthetic Technology Description	Predominant use in the region	Relevant operational constraints
NAN	PLC	Data transmission using the LV power grid as a means of communication	Consolidated urban areas with high network density	Sensitive to electrical noise, wiring quality and heterogeneity of connections
NAN	RF Mesh / Wi-SUN	Short- and medium-range wireless communication with mesh topology between meters	Environments with complex topologies or low power grid quality	Requires penetration planning and minimum node density
WAN	Cellular networks (2G–5G)	Use of public mobile infrastructure to transport data to central systems	Connectivity between hubs, HES and corporate platforms	Operator penetration dependency and recurring operating costs
WAN	Fiber Optics	High-capacity physical link for data transmission	Critical nodes and dense urban areas	Deployment limited by cost and territorial scope
WAN	Satellite	Communication via satellite links for data transmission	Extensive or hard-to-reach rural areas	Spot usage for costs and latency
NAN + WAN	Hybrid architectures	Combining multiple communication technologies in a single AMI network	Predominant configuration in heterogeneous networks	Increased integration complexity and interoperability

INTEROPERABILITY, STANDARDS AND COMPLIANCE TESTING

Interoperability is a fundamental functionality to be considered in the planning of the implementation of any AMI system, allowing hubs and management platforms to operate under a common architecture regardless of the manufacturer. At the international level, this principle is recognized as a condition to avoid closed solutions and ensure the scalability of the system. In the case of Latin America, the results of this study show that this dimension is still at an early stage: proprietary or partially open architectures predominate, and only in a few cases is there a regulatory framework that establishes unified standards of measurement and communication. The resulting picture is heterogeneous and presents disparate levels of effective standardization between countries and distributors.

At the international level, the most widespread standard for smart metering is the IEC 62056 family, based on the DLMS-COSEM specification, which defines a common language for structured data exchange and forms the basis of national profiles such as the Brazilian ABNT NBR 16968 standard. In Latin America, several distributors operate under these frameworks, while others use ANSI standards, appropriate for conventional metering, but with limited capabilities for interoperability in multi-vendor architectures. Even when an open standard such as DLMS-COSEM is adopted, its practical implementation varies between manufacturers, resulting in incompatibilities that require specific adjustments, certifications, or developments. Evidence shows that the existence of a standard does not guarantee full interoperability and that its success depends on both the quality of the implementation and consistency between providers.

In the absence of widely adopted formal guidelines, Latin American utilities manage interoperability primarily through internal homologation processes, laboratory testing, and controlled pilots that validate compatibility between meters, hubs, data management systems, and communication technologies before authorizing mass deployments. While this approach allows for case-by-case incompatibilities to be resolved, it involves high costs, lengthy integration times, and sometimes significant dependency on the dominant vendor. This is in contrast to the practices of more advanced markets, where interoperability is ensured through formal certifications and standardized test schemes.

The survey results show common barriers that hinder progress towards effective interoperability. These include the persistence of proprietary protocols, regulatory restrictions that limit the adoption of certain standards, heterogeneous implementations of the same protocol, and the absence of independent laboratories or national certification schemes. These conditions restrict the full use of the functionalities enabled by the meters and raise the costs of integration. Overall, the region faces the need to move towards unified technical guidelines and formal certification mechanisms that allow sustaining scalable, secure, and technologically open AMI deployments, for example through the national coordination of integration and validation tests, the establishment of reference laboratories, or the development of independent sectoral certification schemes.

05

AMI INTEGRATION WITH CORPORATE SYSTEMS

The ability of an AMI system to generate value depends not only on its technical functionalities and communications infrastructure, but also on its integration with the distributor's corporate systems and the analytical use made of the data. This section examines both aspects: first, the degree of integration of AMI with operational and commercial platforms; and second, the use cases that show how the information collected is transformed into concrete improvements in operation, planning and commercial management. This characterizes the level of digital maturity observed in the distributors participating in the study.

INTEGRATION WITH CORPORATE PLATFORMS

An AMI's ability to generate value depends on its integration with the corporate platforms that distributors use to operate, plan, and manage their customers. While the previous sections characterized the technical capabilities of the meter and communications infrastructure that enable data to be captured and transmitted, this section addresses the next critical step: how that data is incorporated into the business, operational, and analytical systems of the enterprise. Integration determines whether metering information translates into timely operational decisions, more accurate business processes, and advanced network management tools. As such, it is a central indicator of the level of digital maturity achieved in AMI deployments in the region.

The responses from the distributors show a mixed picture in terms of the scope and depth of the integration. In most cases, AMI infrastructure connects to billing and business systems first, allowing reading to be automated, improving data quality, and reducing rework. In a more limited group of companies, integration with operational platforms such as SCADA, OMS or ADMS is observed, which enables uses related to fault location, LV network supervision and interruption management. Other distributors are still in preliminary stages, operating pilots with manual or semi-automatic file exchange, or planning the incorporation of an MDM as an integrating core. Taken together, these results reflect different levels of digital maturity and different institutional and technological starting points within the region.

As for the mechanisms used to integrate AMI with corporate systems, architectures based on APIs, web services and business integration buses predominate, which allow automating information flows between MDM, business systems and operating platforms. In some cases, standards such as Multispeak or CIM are used, while in others the integration depends on specific connectors provided by the manufacturer of the HES or commercial system. Where deployments are still pilot or incipient, information transfer is done through manually or semi-automatically exchanged files, which limits the frequency and depth of operational use of data. These results suggest that the region is moving towards more modular and service-based schemes, although solutions of different scale and technical maturity still coexist.

Finally, several vendors report plans to deepen integration as their AMI deployments mature. These initiatives include the phased incorporation of MDMs as central data repositories, the systematic linking with operational platforms to enable advanced functionalities such as automatic fault location or flexibility management, and the development of more unified architectures through standardized APIs or integration buses. However, significant gaps remain: some companies do not yet have fully operational AMI infrastructure, others rely on proprietary solutions that make integration difficult, and several face institutional or budgetary constraints to modernize their legacy systems. The resulting panorama shows a region in transition, where corporate AMI integration is advancing, but still unevenly and with significant spaces to standardize practices and consolidate an interoperable digital architecture.

In summary, the degree of integration achieved directly conditions the analytical and operational potential of AMI. Where data flows in a structured way into business systems, operations, and asset management platforms, more complex use cases are enabled that transcend reading and billing. Conversely, when integration is partial or manual, the value of smart metering is restricted to core operational benefits. This lays the foundation for the next section, which examines how utilities in the region are beginning to use AMI data for advanced analytics, loss detection, operational optimization, and quality of service improvement.

ADVANCED AMI-BASED ANALYTICS

The adoption of analytics based on AMI data in Latin America is at an early stage, although with significant advances in a limited set of distributors. Among those who have developed use cases, a focus on operational and commercial efficiency predominates: detection and segmentation of non-technical losses, validation of consumption, energy balances, demand forecasting and optimization of reading, billing and collection processes. The results in this area already show quantifiable benefits: cases have been reported where the evolution of analytical tools to combat commercial losses allowed the detection rate to increase by about 50% compared to traditional methods, increasing the effectiveness of field inspections (true positive) by more than 18 percentage points. At the same time, a significant proportion of companies do not yet have analytical capabilities on AMI data, either because their deployments are in the pilot phase, because they do not have an integrated MDM or because the infrastructure does not yet generate data at sufficient scale. The regional picture therefore reflects a heterogeneous level of adoption, but consistent with the region's structural priorities in terms of losses, measurement accuracy and trade efficiency.

Beyond these initial uses, a number of utilities have begun to explore operational applications that take advantage of the increased observability provided by smart meters. Among the cases reported are the early detection of voltage deviations, the analysis of transformer loadability, the correlation of events with customer complaints, and the use of alarms and load curves to prioritize maintenance. In some systems, progress is being made towards integration with OMS and ADMS platforms to support fault localization and enable FLISR schemes, although these cases remain in partial or pilot stages. In addition, AMI infrastructure opens the opportunity to develop demand management programs that allow distributors to have resources of operational flexibility, expanding the scope of these uses beyond the monitoring and control of the network.

Despite these advances, relevant gaps persist that condition the consolidation of advanced analytics in the region. The lack of full integration between AMI and corporate systems limits process automation and systematic data application. In several cases, the quality and completeness of information is insufficient to enable predictive models or complex operational analytics, and reliance on proprietary solutions restricts access to and processing of data in standardized formats. In addition, many vendors do not yet have analytics architectures or teams dedicated to developing AMI-based use cases. The body of evidence suggests that the expansion of analytics will advance as data infrastructure is consolidated, levels of integration are expanded, and institutional capacity is strengthened to fully exploit the potential of this technology in grid and electric service management.

06

DATA GOVERNANCE, CYBERSECURITY AND CONSUMER ENGAGEMENT

While the previous sections characterized the technical capabilities of AMI system and its integration with corporate platforms to enable new operational and analytical uses, the adoption of smart metering also poses challenges of data governance, cybersecurity, and end-consumer relations. These aspects determine not only the institutional viability of the deployment, but also its social legitimacy and consumer confidence in the handling of sensitive information. The section examines how distributors in the region are addressing consumer access to their data, cybersecurity practices applied to metering infrastructure, and regulatory frameworks governing privacy and use of information generated by AMI. This scenario also opens an opportunity to progressively incorporate artificial intelligence tools into AMI data analysis, as a mechanism to expand and scale use cases.

CONSUMER ACCESS TO INFORMATION

Timely and transparent access to consumption information is one of the core attributes of modern AMI systems, allowing consumers to understand their usage patterns, better manage their demand, and participate more actively in electric service. At an international level, this component is an essential part of data governance and the digital relationship between distributor and customer. In Latin America, the results of the study show partial progress: although several distributors have enabled digital interfaces to report consumption and time curves, the availability and depth of these mechanisms varies significantly and does not yet constitute a fully consolidated standard in the region.

The experiences collected exhibit two levels of maturity. A first group of distributors has web portals and mobile applications that allow them to consult consumption almost in real time, view load curves, review billing history and, in some cases, access specific modules for customers with AMI. These solutions are usually supported by commercial platforms or MDM modules that are already integrated. A second group provides more basic information, generally linked to monthly consumption used in billing, or is in the design phase of access channels. In several cases, the enablement of more advanced mechanisms depends both on the degree of AMI deployment and on the existence of regulatory guidelines that define obligations to deliver data to the end consumer.

Despite these advances, gaps persist that limit fully functional and standardized access. These include the absence of common formats for data delivery, limited interoperability with third-party applications, the lack of unified interfaces for viewing cost or operational event information, and the still reduced deployment of connected smart meters. These conditions restrict the potential for active consumer engagement and anticipate additional cybersecurity and privacy challenges, which are addressed in the following sections.

AMI CYBERSECURITY

The expansion of client access to consumption data and the increasing digitalization of metering systems mean that cybersecurity requirements play a central role in the operation of smart grids. Unlike traditional systems, AMI infrastructure introduces millions of distributed entry points that must be securely integrated with corporate platforms and network operating systems. The results of the survey show that, although the region is making progress in this area, there is significant variability in the degree of adoption of formal policies, certifications, and data protection practices applied to AMI ecosystem.

Among the distributors with the greatest advances are standards aligned with international standards such as ISO/IEC 27001 for information security management and ISO/IEC 27019 for industrial systems in the energy sector. These practices are complemented by specific technical requirements, such as end-to-end encryption (including 128-bit AES schemes), strong authentication, network segmentation, and penetration testing during meter and MDMS/HES system approval processes. In several countries, regulation is beginning to explicitly require these practices, with cases where ISO 27001 certification will be mandatory for all distributors in the coming years.

However, the results also show that a significant part of companies are in the early stages of adoption. In these cases, efforts are focused on general institutional security guidelines, basic network hardening measures, and controls on credential management, without yet having specific frameworks oriented to AMI. The observed heterogeneity reflects both regulatory differences and gaps in technical and investment capacities. Overall, the findings show that progress in access to information and analytics based on AMI must be accompanied by a systematic strengthening of cybersecurity practices to safeguard critical infrastructure and protect consumer data.

PRIVACY AND DATA PROCESSING

The incorporation of advanced measurement capabilities and the increasing availability of granular consumption data increase the relevance of the privacy frameworks that regulate the processing of this information. In contrast to the international consolidation of specific principles for energy data, the results of the study show that in Latin America the applicable regulation comes, in most cases, from general personal data protection laws rather than from sectoral regulations dedicated to AMI. This generates a fragmented panorama, where the safeguarding of information depends both on the national legal framework and on the internal practices of each distributor.

Countries with more developed data protection legislation apply their principles to the scope of AMI: consumer consent, limitation of use to authorized purposes, anonymization for operational analytics, and security obligations for data controllers. In some cases, sectoral regulations complement these requirements, as is the case in Chile with the provisions on Measurement, Monitoring and Control Systems, or in Colombia, where the regulation of smart metering explicitly refers to habeas data laws. However, a significant proportion of distributors indicate that there is no specific regulation on energy data privacy or that they are unaware of applicable guidelines, which shows institutional gaps around the management of sensitive information generated by AMI systems.

The heterogeneity observed suggests the need to move towards clear frameworks that define consumer rights, processing obligations and safeguarding criteria for consumption data, in coherence with the principles of transparency and security that accompany the deployment of smart grids. As these frameworks continue to develop, effective information protection depends largely on internal practices, corporate policies, and access controls implemented by each distributor, reinforcing the importance of strengthening institutional capacities and ensuring consistency between privacy, cybersecurity, and end-consumer data access regulations.

Timely and transparent access to consumer information is one of the key attributes of modern AMI systems

07

ECONOMIC MODELS, FINANCING AND COST RECOVERY

The adoption of advanced metering infrastructure does not depend solely on its technical sophistication or the operational capabilities it enables. Its viability and sustainability are determined, to an equal or greater extent, by the financing models, the economic criteria applied by the distributors and the regulatory mechanisms that allow the cost recovery. This section examines how companies in the region structure meter ownership and financing, what methodologies they employ to assess the economic desirability of deployment, and the extent to which national regulatory frameworks recognize or incentivize these investments.

OWNERSHIP AND FINANCING SCHEMES

The analysis of metering infrastructure in Latin America reveals a deep structural transition in ownership models, driven more by technological necessity than by regulatory definitions. Historically, in much of the region, a scheme where the electromechanical meter was owned by the end consumer, who paid for the device at the time of connection, predominated. However, the nature of AMI—from an isolated asset to an integrated network sensor that requires centralized data management, cybersecurity, and constant technological renewal—is forcing a shift toward schemes where ownership and responsibility for the investment rests with the distributor. However, the simple allocation of ownership is insufficient if it is not accompanied by a modernization in the criteria for the recognition of assets.

Based on the information collected from the companies associated with ADELAT, it is possible to identify three major typologies that group financing strategies in the region, differentiated by the degree of sophistication with which the regulation addresses the digital nature of these investments.

The ownership model of the distributor with regulated recognition is more financially sustainable and corresponds to those markets where regulation has evolved to explicitly recognize the smart meter as a network asset, owned by the DSO and whose remuneration is guaranteed in the tariff. In Brazil, this approach has been clearly proposed in the framework of Public Consultation 198/2025 (opened in September and still ongoing), which aims to incorporate meters into the Regulatory Remuneration Base (BRR). However, even in this advanced scenario, critical challenges persist such as the need to adapt regulatory useful lives, because unlike electromechanical assets amortizable for 30 years, AMI components (communication modules, software) have much shorter technological obsolescence cycles. Therefore, sustainable financing in this model requires moving towards accelerated depreciation mechanisms that align capital recovery with the real useful life of the technology, avoiding the financial risk of keeping assets that are no longer operational on the books.

A similar logic is observed in Costa Rica's vertically integrated public service model. There, the property is owned by the state-owned electricity company, and the financing is structured through a combination of equity capital and leverage with multilateral banks, highlighting the use of IDB loans for modernization. By operating under a service-at-cost model without short-term market pressure, financing can be aligned with long-term sovereign or corporate debt instruments, facilitating the amortization of the technology. The lesson of this group is that ownership of the distributor works, as long as the regulation accepts that the costs of licensing, cybersecurity and telecommunications are essential investments and not operational "inefficiencies".

A second group of countries is going through a regulatory transition phase, migrating from a regime where the customer bought the meter to one where the law assigns responsibility to the distributor, generating unresolved financial frictions. Chile and, to a lesser extent, Colombia, illustrate this tension. The legislation has shifted the investment obligation to the company, but it faces the problem of "stranded assets": how to finance the new smart meters without having finished depreciating or recovering the value of conventional meters that will be retired early. Without an explicit regulatory mechanism to recover the residual value of the retired equipment, distributors are forced to finance the modernization with their own capital and high risk, limiting deployment to pilots. In these markets, the ownership is already owned by the distributor, but there is a lack of regulatory financial engineering that allows replacing the meter fleet without destroying book value for the DSO or generating unsustainable tariff shocks for the consumer.

Property of the distributor without explicit acknowledgement. There is a third group of countries where the distributor maintains ownership of the de facto deployed AMI equipment, but faces critical financing barriers due to the absence of price signals. As reported by ADELAT associates, this is the predominant scenario in Argentina, Peru and Guatemala, where investments are made exclusively with the company's operating cash flow, motivated by specific urgencies such as the reduction of non-technical losses or the attention to large consumers, but without a "pass-through" mechanism" to the regulated tariff. The structural barrier in these cases is the lack of recognition of the "intangibility" of the investment. As there are no regulatory categories in these countries to capitalize on software or recognize efficient OPEX technology, distributors cannot scale projects beyond niches of high profitability due to energy recovery. The experience of this group confirms that assigning ownership to the distributor without modernizing the catalog of regulatory accounts condemns AMI to be a niche technology and not a universal infrastructure.

This regional disparity shows that, although the technical trend pushes towards the ownership of the distributor, the speed of deployment depends on the existence of a tariff vehicle (such as the RAB or the TOTEX) that reduces the risk of technological investment.

BUSINESS CASE AND EVALUATION CRITERIA

While the technical consensus points to smart metering as the backbone of the energy transition, the local economic equation to justify its cost (business case) is much more complex to close than in developed economies. The region operates under a heterogeneous financial logic, where the investment engine varies according to the urgencies of each concession. Based on the information provided by ADELAT associates, it is possible to distinguish two orientations in the way in which distributors build their business cases for AMI, marked by the difference in their main value drivers.

The first group uses a loss recovery approach, predominant in Argentina, Peru, Guatemala and specific areas of Brazil. According to distributors in these markets, the traditional Cost-Benefit Analysis (CBA) only yields positive results when applied to areas with high rates of fraud or energy theft. In this sense, investment in AMI is almost exclusively justified by its ability to reduce Non-Technical Losses (NTLs) and recover revenue, and the smart meter is seen as a "revenue control" tool rather than an operational modernization tool. The consequence of this model is a fragmented deployment: the technology reaches troubled neighbourhoods or large industrial consumers, but there are no incentives to expand to the mass residential customer with good payment behaviour, where the return on loss recovery is zero.

The second group corresponds to the operational efficiency approach, predominant in Chile and in the more mature distribution areas of Brazil and Colombia. There, business cases incorporate a broader matrix of operational savings (OPEX), such as eliminating manual reading, reducing field shut-off and reconnection costs, and reducing customer complaints. However, this model faces a structural barrier typical of Latin American economies: the relatively low cost of labor. Unlike Europe or the United States, where eliminating manual reading generates a gigantic saving that the meter pays, in Latin America that savings are lower. For this reason, even in countries like Chile, the business case is tight and often requires a long-term view that current rates do not always encourage.

The cross-cutting conclusion is that traditional financial evaluation models, restricted to the company's cash flow (utility cost test), are insufficient to promote universal deployment in the region. In this sense, recent experiences in the region show an evolution from internal financial evaluations to schemes where CBA is required at the regulatory level, gradually applied by phases, segments, and network typologies, and used as a deployment prioritization tool and not as a binary authorization condition (CREG, 2025). If AMI is only installed where it is profitable for the company (theft areas or large customers), an energy digital divide will deepen. To overcome this stagnation, it is imperative to move towards a social and systemic Cost-Benefit Analysis (CBA). This approach must be flexible enough to capture the particularities of each distributor, considering differences in the topology of the network, consumption patterns and specific opportunities for improvement in performance, resilience and postponement of investments, so that the prioritization of implementation responds to technical and social criteria, and not only to short-term private profitability. The regulatory evaluation must also monetize those benefits that technology brings to society but that today are invisible on the distributor's balance sheet. First, it is necessary to incorporate improvements in resilience and quality of service. AMI's ability to automatically locate faults reduces outage rates. If regulation values this non-supplied energy at the cost of failure of the economy (VoLL), AMI project multiplies its social profitability. Second, the systemic benefits avoided must be quantified. The management of demand and hourly prices make it possible to flatten the load curve, postponing millionaire investments in network reinforcements and generation. If the NRA allows the distributor to capture a fraction of that deferred capital savings, deployment becomes viable.

Finally, evaluation criteria should abandon the idea of a "national average cost"; The regulation should allow evaluations by clusters or zone typologies, recognizing that the costs and benefits are not homogeneous. On the other hand, the amortization horizons must be adjusted. Evaluating digital assets with the useful life of physical assets (30 years) is a financial mistake; The models must recognize technological replacement cycles of 10 to 15 years, or even less depending on technological evolution, for the communication and computing components, ensuring that the tariff covers the real sustainability of the network's intelligence.

08

BARRIERS TO SCALING UP AND ENABLING CONDITIONS

The advancement of advanced metering infrastructure in Latin America has made it possible to accumulate relevant learnings in technical, operational, and economic terms. However, the deployment faces an "implementation paradox": while there is an almost unanimous technical and political consensus on its indispensable role as a nervous system of the energy transition, the operational reality reveals a fragmented execution. The move from limited deployments or pilots to mass adoption continues to be conditioned by a set of structural barriers that transcend technological availability.

Even when there are success stories and favorable business cases in specific segments, scaling faces regulatory, economic, technological, operational, and social constraints that reflect a systemic incompatibility between the disruptive nature of digital technology and institutional frameworks designed under paradigms of the last century, and which must be addressed in a comprehensive manner. This section synthesizes these barriers and collects lessons from experience with AMI vendors and solutions, in order to identify the enabling conditions necessary to transition to larger-scale deployments.

REGULATORY AND ECONOMIC BARRIERS

The main obstacle to AMI scaling is usually located in the regulatory and financial architecture that determines how the cost is (or is not) remunerated and, therefore, how "bankable" the deployment is. In much of the region, there is still a lack of an explicit regulatory framework that defines specific obligations, incentives, and remuneration mechanisms for smart metering; consequently, deployments tend to depend on internal business cases and pilots, rather than massive programs with revenue predictability and clear phased rollout rules. However, evidence also suggests that these barriers tend to be attenuated when the deployment of AMI is articulated with tariff modernization processes, which allow a more granular allocation of costs and benefits among consumers and reinforce the economic coherence of the regulatory model.

An important part of the regulation in the region has been built on the logic of an efficient model company, designed to standardize costs of relatively static physical assets with a long useful life; however, AMI challenges that logic, as it behaves like a digital investment with faster innovation cycles. This difference is not merely conceptual: it determines which costs are considered "prudent", what recovery periods are assumed and what risks are transferred to the distributor.

A critical point that is often underestimated is the CAPEX/OPEX asymmetry. Although the meter may be recognized as a network asset, the value of AMI is fully realized when an operational cost-intensive ecosystem (software, cloud, telecommunications) is financed and operated that enables network "intelligence." When regulation privileges CAPEX and treats these OPEX components as "inefficiencies," the business case is weakened precisely where transformational capabilities are generated: operational automation, loss analytics, consumption segmentation, and enabling new services.

Moreover, even with asset recognition, tariff schemes do not always capture the systemic benefits attributable to AMI (loss reduction, operational efficiency, advanced demand management). The result is a gap between the social/sectoral value of the investment and its financial recoverability, which reduces the appetite for scale, especially when deployment must compete with other investment priorities.

Added to this set of tensions is an accounting friction that affects the speed of modernization: non-amortized assets. Mass replacement of legacy meters may involve retiring equipment that still has book value; without a recovery mechanism or clear regulatory treatment, modernization results in immediate destruction of value for the distributor, even when the long-term benefits are positive.

Finally, the region faces an additional macroeconomic barrier: exchange rate risk and the difficulty of accessing financing in volatile economies, which amplify the mismatch between hard currency investments and local currency tariffs, affecting the bankability of deployment and raising the decision threshold for massive programs.

TECHNOLOGICAL AND INFRASTRUCTURE BARRIERS

In technological terms, the main lesson is that the limitations do not lie only in the meter, but in the ecosystem that surrounds it: communications, interoperability, integration with corporate systems and data governance. When any of these links is weakened, the reliability of the data is reduced and, consequently, the operational value of AMI decreases, affecting the willingness to scale.

Connectivity is a particularly sensitive challenge in Latin America. Distributors report difficulties in communications stability, especially in PLC networks exposed to electrical noise and in rural areas where cellular penetration is limited; and, when radio frequency is used, meter densities may be required that are not always achieved and sensitivities to physical obstacles appear. These constraints not only make the solution more expensive, they also introduce uncertainty about the system's homogeneous performance in heterogeneous environments.

Added to the above is a last-mile gap that forces, in certain territories, to deploy expensive private networks. At the same time, the progressive shutdown of 2G/3G networks introduces a risk of accelerated obsolescence not controlled by the electricity sector, which forces the design of architectures and purchasing strategies with a vision of the technological life cycle, and not only with initial cost criteria.

Interoperability is another decisive barrier. The coexistence of multiple measurement and communication technologies increases operational complexity and demands continuous integration processes. Even with open standards, variations in their implementation generate incompatibilities that require additional approvals, extensive testing and specific adjustments; all of which raise costs, extend lead times, and add performance risk during escalation.

At the same time, the lack of mandatory standards and local certification increases the risk of technological lock-in and hinders multi-vendor integration. This doesn't just affect the initial deployment: it conditions the future ability to evolve the platform, integrate new use cases, and sustain consistent data management over the long term.

Finally, cybersecurity emerges as a new generation barrier. AMI expands the attack surface and requires sustained investments in defense (e.g., SOC and encryption); When regulation does not clearly define who finances these capabilities or how they are recognized, a double effect is generated: greater systemic risk and economic brake on scaling.

OPERATIONAL AND IMPLEMENTATION BARRIERS

Operational and vendor management barriers also have a significant impact on the ability to scale AMI. Distributors identify extended equipment manufacturing and delivery timelines that make scheduling difficult and can affect compliance with regulated plans or corporate goals. In large-scale programs, this variable defines the actual pace of deployment, as well as territorial sequencing and the ability to capture benefits in the expected time.

Added to this is the dependence on international technical support, which in some cases introduces delays in the resolution of problems and limits the ability to respond to operational contingencies. This dependence becomes more critical as the installed fleet increases, because incidents cease to be exceptional and become part of the daily operation; Without sufficient local capacities, recovery time can deteriorate the internal perception of system reliability.

In a complementary way, scaling requires a sustained strengthening of internal capabilities: administration of AMI platforms, database operation, monitoring, cybersecurity and IT infrastructure management. This dimension is key because AMI does not generate value only by remote reading, but by the institutional ability to convert data into decisions and automations, which demands additional investments and continuous training, as well as the efficient management of the logistical challenge associated with the physical replacement of equipment on a large scale, in a productive, optimized and reliable way.

The available experiences also underscore the relevance of a procurement and contracting strategy aligned with the program's risk. Planning coordinated purchases and ensuring contractual conditions that mitigate compatibility, performance, and after-sales risks becomes an enabling factor so that scaling is not trapped in integration cost overruns or support gaps.

SOCIAL AND CULTURAL BARRIERS

AMI scaling requires a "social license" that isn't always guaranteed. In contexts where installation is voluntary or there is mistrust about the impact of tariffs, adoption can be significantly delayed due to misinformation, misperceptions or fears associated with privacy, even going to court. As a result, communication and transparency cease to be complementary activities and become structural components of the programme.

In rural or hard-to-reach areas, the social dimension is combined with logistical complexity: the installation may require greater efforts of community coordination, technical support and differentiated relationship strategies. In these environments, end-consumer acceptance becomes a central determinant for mass deployment, even when technical and economic analyses are favorable.

A particularly critical chapter in the region is physical security and fraud in territories with high social vulnerability and critical levels of non-technical losses. In these contexts, the meter can be perceived as a threat to informal economies, increasing the risk of vandalism, equipment theft and violence against personnel, with operating and security costs that strain any assumption of standard efficiency. This factor not only makes deployment more expensive: it also conditions the territorial prioritization, installation protocols and the maintenance budget of the AMI fleet.

These barriers tend to reinforce each other. Imperfect connectivity or weak interoperability increase costs and deadlines, which aggravates the problem of tariff recovery and bankability; in turn, the lack of regulatory clarity on digital OPEX and cybersecurity reduces the ability to sustain the ecosystem that makes AMI valuable; and, in environments of low trust or high territorial conflict, deployment becomes more expensive and slower, just when programming and operational continuity are essential to capture benefits.

ENABLING CONDITIONS

Overcoming these barriers requires advancing in a set of enabling conditions that allow sustaining larger-scale deployments and, above all, capturing the value of AMI as a critical digital infrastructure. First, regulatory frameworks are required to evolve from the recognition of the meter as a physical asset to the recognition of AMI ecosystem as an enabler of efficiency, resilience, and modernization of the service. This involves establishing explicit and predictable rules that ensure cost recovery throughout the lifecycle, including OPEX-intensive components (software, cloud, and telecommunications), and defining clear treatments for replaced assets with remaining book value. Likewise, the regulatory evaluation must monetize the social benefits that are currently "invisible" on the distributor's balance sheet, for example, improvements in resilience and quality of service, and systemic benefits avoided by demand management, allowing the company to capture a fraction of that value when its materialization is verified.

Second, the technological frictions that make scaling more expensive must be reduced. To this end, it is a priority to establish mandatory technical standards, national interoperability profiles, and formal certification and conformity testing mechanisms that reduce the costs of multi-vendor integration and mitigate technological lock-in. At the same time, coordinated communications planning, including strategies for "last mile" and technology obsolescence (e.g., 2G/3G transition), should be treated as a program prerequisite, with early agreements with operators and/or private network deployments where necessary, to ensure penetration and data quality. In parallel, cybersecurity must be assumed as a design and operation requirement, with minimal demands and cost recognition, given that AMI expands the attack surface and is increasingly integrated into IT/OT environments.

Third, scaling should be managed as an operational programme and not as a sum of projects. This means strengthening internal capabilities (data management, AMI platforms, integration, analytics and cybersecurity), strengthening the purchasing and contracting strategy with verifiable service level agreements (SLAs) and version/firmware governance, and anticipating mass logistics (installation, quality control, replenishment and support). Finally, it is essential to consolidate a strategy for relating to consumers that strengthens trust, transparency and perception of value, addressing privacy concerns and avoiding resistance that may translate into delays or litigation; and, in territories with high vulnerability and non-technical losses, incorporate specific physical security and personnel protection measures, adjusting deployment sequences and sustainment costs to local realities. Table 3 summarizes the barriers and their respective enabling conditions.

Table 3. Summary of barriers to scaling up and enabling conditions.

Group	Barrier	Qualifying condition
Regulatory and economic	Absence of an explicit regulatory framework (obligations, incentives and remuneration mechanisms) that allows for the transition from pilots to mass programmes	AMI regulatory roadmap (goals, phased rollout, governance, minimum performance obligations) and cost recovery mechanism (recognition on a regulatory basis/allowed income or equivalent scheme).
	"Model enterprise" approach that standardizes static physical assets and shifts risks to the distributor versus digital investments	Adjust efficiency criteria for digital investments: benchmarks by results, KPIs and recognition of costs associated with technological evolution.
	CAPEX/OPEX Asymmetry: The value of AMI depends on software, cloud, and telecom	Adopt total cost logic and/or TOTEX schemes; create regulatory categories to capitalize on software or recognize technology OPEX.
	Tariff schemes do not capture systemic benefits of AMI (loss reduction, operational efficiency, demand management)	Methodologies for monetizing and sharing benefits: part of the value is transferred to consumers and part is retained as an incentive for performance.
	Non-amortized assets	Implement regulatory treatment for early retirement assets (accelerated amortization, transition fund, regulatory deferral, or equivalent mechanism) and rules to avoid tariff shocks.
	Exchange rate risk and difficulty in accessing financing	Hedging/mitigation mechanisms (partial indexation, recognition of technology cost variations, multilateral financing/blended finance).
Technology and infrastructure	Last mile gap	Communications master plan (by territorial typology), prioritising hybrid solutions and agreements with telcos
	Switching off 2G/3G networks: uncontrolled risk of obsolescence	Incorporate technology lifecycle criteria into specifications and procurement and a planned transition strategy.
	Complex interoperability: multiple technologies and standards generate incompatibilities, approvals and cost overruns.	Establish interoperability profiles, conformance testing, and a "compatibility catalog"
	Absence of mandatory standards and local certification	National/sectoral standardisation and certification schemes that reduce interoperability risks and costs.
	Risk of technological captivity (vendor lock-in)	Multi-vendor strategy with data portability requirements, open APIs, exit clauses and continuity; preferring open standards verified by certification.
	Cybersecurity	Minimum requirements (encryption, authentication, segmentation, hardening, penetration testing), and explicit recognition of security costs
	Internal capabilities gap (AMI platforms, databases, monitoring, cybersecurity, IT)	Create PMO/AMI Transformation Office and capability plan (profiles, training, platform operation, analytics, cybersecurity); Define KPIs and data quality from the start.
Social and cultural	Lack of "social license": distrust and misinformation	Relationship strategy: proactive communication (tangible benefits), privacy protocols, service channels and early dispute management; Segment messages by type of consumer/ territory.
	Rural or hard-to-reach areas	Differentiated deployments (rural/peri-urban/urban), with local partners, adapted schedules, reinforced logistics and a "first benefits" approach (use cases that the consumer perceives early).
	Physical security and fraud in territories with high vulnerability and non-technical losses	Comprehensive security plan: installation protocols, coordination with authorities/community, anti-fraud measures, personnel protection, replacement and explicit maintenance costs in the design of the program.

09

INTERNATIONAL REGULATORY APPROACHES

International experience shows that the most sustained advances in advanced metering infrastructure do not depend only on technological availability, but also on the coherence and clarity of the regulatory framework that guides its deployment. Countries that have achieved significant penetration have combined explicit goal definitions, robust functional standards, and cost-recovery mechanisms that align distributor incentives with public policy priorities. At the same time, different jurisdictions have adopted divergent approaches according to their structural challenges, from national mandate strategies to models based on economic analysis or market incentives. Understanding this diversity of approaches allows us to identify the institutional, technical, and economic conditions that favor the adoption of AMI, and provides concrete elements for Latin American regulators to define realistic goals and implementation schemes compatible with the modernization of their distribution networks.

TYPES OF REGULATORY MODELS AND DESIGN LOGIC

Mandated rollout models with mass deployment

The accelerated adoption of advanced metering infrastructure has been made possible, in several countries, thanks to regulatory frameworks that establish mandatory penetration goals, defined deadlines, and minimum functional standards applicable to all consumers of the system. Under this logic, public policy assumes a leading role and reduces the discretion of distribution companies by setting an implementation schedule and ensuring the tariff recovery of the associated investments. The result is a uniform deployment process, with high levels of standardization and a speed of execution difficult to achieve through voluntary or gradual strategies. Under this logic, the European Union's experience shows how a massive deployment can be sustained and scaled up when it is supported by a progressively developed regulatory framework, which reduces regulatory and operational uncertainty by clarifying objectives, minimum requirements and interoperability. An initial milestone was the Third Energy Package, in particular Directive 2009/72/EC, which linked ex-ante assessment to a long-term policy target of 80% penetration of consumers by 2020, and required Member States to develop and sustain their CBAs on that basis. When the outcome was positive, they should translate it into national implementation plans and timetables. Subsequently, Recommendation 2012/148/EU contributed to harmonising the CBA methodology and consolidating functional requirements, as well as guidelines on security and data protection, reinforcing the standardisation conditions necessary for uniform deployment. In parallel, the Commission promoted technical harmonisation through standardisation mandates to ensure interoperability and mitigate vendor lock-in risks. With the Clean Energy Package, especially Directive (EU) 2019/944, critical aspects for large-scale implementation were reinforced, including the functioning of the retail market, consumer rights, cybersecurity and data governance. Finally, measurement for billing purposes is supported by the legal metrology framework (e.g. Directive 2014/32/EU – MID), providing certainty on technical conformity and placing requirements on the market.

The experiences of Italy and Spain are representative of this approach in its most structured and centralized form. Italy was a pioneer with the Telegestore program, developed by Enel between 2001 and 2011, which replaced around 32 million meters in the world's first mass deployment. The plan had explicit regulatory support and allowed distributors to recover investment costs through approved tariff components. From a regulatory point of view, the Italian regulation allowed distributors to voluntarily initiate deployment, after adhering and submitting a detailed plan to the regulator. The framework established binding targets and precise timelines, defined in volumes of meters to be installed and execution timelines; the recognition of costs in the tariff and incentives were conditional on compliance with these commitments (output-based), and sanctions were provided for significant non-compliance. The regulatory framework also incorporated strengthened requirements in terms of cybersecurity, interoperability and greater granularity of data. Spain followed a similar strategy through Order IET/290/2012, which established the mandatory replacement of all meters under 15 kW by 2018, reaching nearly 28 million installations. The Regulator Body defined the tariff recognition parameters and oversaw the execution through annual compliance milestones.

Another relevant trajectory is that of the Nordic countries, which advanced early by imposing remote reading and hourly measurement obligations for all consumers, integrating AMI within a broad vision of digitization of the system. Sweden completed its first national deployment in 2009 and launched a second generation from 2020, with greater demands on functionality, quality of service and the ability to integrate with distributed resources. Finland followed a similar path with a regulatory obligation that required reaching more than 80 percent penetration in 2014, accompanied by advanced standards for event reporting and automatic notifications.

In Asia, Japan is another emblematic case of state mandate. Following the 2011 energy crisis, advanced metering was integrated into the electricity sector modernization strategy and established as a requirement for the full liberalization of the retail market. Regional utilities, such as TEPCO, were instructed to execute massive deployments, with plans that included more than 80 million installations and a goal of complete penetration by 2024. In France, the Linky program, led by Enedis, was structured through a core mandate with a goal of installing 35 million meters in five years, financed through a regulated deferred recovery mechanism and a higher-than-standard remuneration rate: 7.25% for Linky assets, with an additional incentive of +300 bps for assets placed in service between 2015 and 2021, vs. an onshore standard WACC of 5.0% real before tax.

Despite its effectiveness in accelerating deployment, this type of strategy presents significant challenges to replication. It requires strong regulatory institutions, political stability, and a tariff environment capable of absorbing massive investments without affecting the affordability of the service. In contexts with fiscal constraints or with financially weakened distribution companies, a universal mandate can generate tensions between regulatory deadlines and the actual capacity to execute. In addition, the imposition of a single schedule reduces the flexibility to adapt technologies, standards or operating models to local conditions, which can lead to cost overruns or early obsolescence of equipment. These limitations have led several jurisdictions to prefer approaches based on cost-benefit analysis and phased deployments, which allow the relevance of the investment to be assessed before adopting universal penetration commitments.

Models based on cost-benefit and phased rollout

The adoption of advanced metering infrastructure has also followed more prudent trajectories, in which regulatory authorization depends on verifiable results in terms of cost and benefit. In this approach, deployment is not conceived as a universal mandate from the beginning, but as a process conditioned by the technical, economic and operational performance observed in pilots or initial stages. The regulation thus introduces periodic review mechanisms, scope limits and explicit criteria for social profitability, allowing investments to adjust to the pace of learning and technological maturation. This model is especially used in jurisdictions with high sensitivity to transition costs or with institutional frameworks that prioritize ex ante regulatory impact assessment.

Germany is one of the most representative examples. Its Law on the Digitalisation of the Energy Transition (2016) established that the installation of smart meters would only be mandatory if a technical certification and an economic assessment confirmed the suitability of the deployment. The strategy first focused on large consumers, customers with distributed generation and critical segments for the management of the system, with a deliberately gradual advance. Ireland adopted a similar approach, starting with regional-scale pilots and independent cost-benefit assessments before authorizing their national deployment. This process culminated in 2017 with the approval of the phased replacement of 2.4 million meters, executed between 2019 and 2024, with strict requirements for interoperability and secure communication.

The UK followed a comparable logic during the first stage of its smart metering program. Although an ambitious national goal was defined, the initial rollout was governed by a transition phase dominated by pilots, interoperability testing, and the creation of a centralized data entity (DCC) before mass deployment was authorized. This sequential approach responded to the need to reduce technology integration risks in a highly competitive retail market and to ensure that final costs to the consumer reflected tangible benefits, such as energy efficiency and participation in demand response programs.

While this type of strategy reduces financial risks and allows the deployment to be adapted to the maturity of the technology, it also has limitations that have been evident in practice. Relying on ex-ante economic assessments can significantly delay the start of deployment, especially when the benefits of AMI are systemic and difficult to capture in traditional analytics. Sequential approval processes also generate territorial heterogeneity and prolong the period in which old and new systems coexist, raising operational costs and technological complexity. These difficulties explain why a number of jurisdictions have evolved towards more flexible frameworks and explicit economic incentives, which seek to accelerate deployment without necessarily resorting to universal mandates.

Hybrid models and economic incentives

The expansion of advanced metering infrastructure has also followed strategies that combine regulatory flexibility with clear economic signals. In this approach, the authority does not impose a universal mandate from the outset, but designs remuneration and incentive mechanisms that make the installation of smart meters economically advantageous for both distribution companies and marketers and, ultimately, for consumers. The most common instruments include tariff schemes that recognize the cost of investment, TOTEX mechanisms that level decisions between capital expenditure and operating expenses, mandatory data platforms that multiply use cases, and demand response programs that allow operational benefits to be captured. This logic facilitates phased deployment, promotes innovation, and reduces regulatory risks associated with irreversible decisions.

The United States provides representative examples of this model. In Texas, the Public Utilities Commission approved a framework since the mid-2000s that authorized the early tariff recovery of AMI investments and established a specific surcharge to finance the deployment. This design made it possible to install millions of meters in a few years without the need for an explicit mandate. In addition, the creation of the Smart Meter Texas platform facilitated access to hourly data and enabled innovative retail products. New York took a distinct but equally hybrid approach through the Reforming the Energy Vision initiative. There, AMI was integrated as an enabler of a flexibility market and a distribution platform operator model, combining performance incentives, results-based regulation and AMI investments approved on a case-by-case basis according to their contribution to public policy objectives.

In other countries, this approach has been consolidated through regulatory reforms attentive to economic efficiency. Australia exemplifies this with the reform led by the AEMC, which evolved from a free choice scheme led by retailers to a model with replacement goals, clear tariff recovery and coordinated processes between distributors and marketers. Ontario, Canada, also pursued an incentive-driven strategy: the provincial regulatory boby integrated AMI into a performance-based regulation framework, approved multi-year investments with efficiency criteria, and articulated smart metering with mandatory hourly rate programs. In both cases, the combination of full lifecycle incentives, open access to data, and transparent regulatory targets allowed for progress without imposing a universal timetable from the start.

Despite its flexibility and ability to stimulate innovation, this type of strategy presents challenges that have arisen in its implementation. The absence of an explicit mandate can translate into uneven speeds of deployment between companies, generating territorial heterogeneity and a prolonged transition between technologies. The effectiveness of the model also depends on the quality of the incentive design: if the tariff or performance mechanisms are not aligned with the systemic benefits of AMI, adoption may slow down or be concentrated in more profitable segments. For these reasons, several jurisdictions have complemented these schemes with minimum installation goals or mandatory functional requirements, converging towards more structured models when the digitalization of the network becomes essential to integrate distributed resources and improve operational management.

Models oriented to operational efficiency

Advanced measurement has also been adopted as a tool to address persistent operational inefficiencies in distribution networks characterized by high levels of losses, delinquency, reading difficulties and limitations in customers management. In this approach, AMI is primarily conceived as a tool to improve the quality of the business process, recover revenue, and have granular information to locate and reduce non-technical losses. Regulation typically prioritizes specific segments considered critical and, in many cases, defines geographic or functional targeting criteria before moving on to broader deployments. This model has been common in countries where operational challenges condition the financial sustainability of the distributor and where the benefits of AMI can be realized in a direct and quantifiable way.

India offers one of the most illustrative cases. The Revamped Distribution Sector Scheme, launched in 2021, set mandatory smart meter installation goals with integrated prepaid for around 250 million consumers. The funding combines federal grants with state and operational contributions, conditional on verifiable reductions in losses and improvements in collections. At the same time, priority installation is promoted in dense urban areas and areas with losses of more than 15 percent, with mandatory functionalities such as remote cutting, handling alarms and real-time load monitoring. This strategy has made it possible to move quickly in states where billing and collection had structural deficits.

In Latin America, Brazil stands out for using

AMI in a focused way in segments of high risk, such as areas with high losses or hard-to-reach customers. Several distributors have implemented pilot projects or partial deployments with advanced functionalities for tamper detection, prepayment integration and real-time monitoring of LV transformers. In several countries in the region, including Central America and the Southern Cone, companies have used similar schemes, prioritizing complex urban areas or registries with high rates of irregularity. While these deployments have not been universal or framed by national mandates, they have led to significant improvements in metering, invoicing, and loss control.

While this approach allows for rapid and measurable benefits, it has significant limitations. Its focused nature can perpetuate differences between areas served with advanced technologies and others that continue to operate with traditional systems, making it difficult to plan the network in a comprehensive way. Prioritizing immediate benefits over long-term capabilities can also restrict the evolution towards more advanced uses of AMI, such as distributed resource integration or flexible demand response. Finally, reliance on direct operating returns may delay expansion into segments where profits are systemic and less visible on balance sheets. These restrictions explain why, even in countries that began their digitalization with a focus on operational efficiency, the discussion has tended to evolve towards broader models, with gradual goals and economic evaluation criteria that allow for a transition to universal deployments.

Table 4 summarizes these four approaches, bringing together their main characteristics, representative countries, advantages, and limitations as a reference for policy design in the region.

Table 4. International typologies of regulatory models for the deployment of advanced metering infrastructure.

Type of regulatory model	Representative countries	Central features of the approach	Key benefits	Limitations or risks
State mandate with massive deployment	Italy, Spain, Sweden, Finland, Japan, France	Mandatory penetration goals; defined deadlines; uniform functional standards; guaranteed fare recovery; Centralized deployment	High installation speed; functional standardization; universal penetration; Immediate systemic impact	It requires strong institutions; high initial cost; less local flexibility; risk of obsolescence if technology is fixed too early
CBA and gradual approach	Germany, United Kingdom (first phase), Ireland	Authorization conditional on cost-benefit analysis; previous pilots; deployment by segments; Sequential regulatory review	Reduces financial risk; allows testing before scaling; Greater technological adaptation	Significant delays; heterogeneous results; prolonged coexistence of technologies; systemic benefits undervalued by traditional analysis
Hybrid models and economic incentives	Texas, New York, Ontario, Post-Reformation Australia	Clear tariff recognition; TOTEX incentives; economic signals for investment; data platforms; Performance regulation	It fosters innovation; flexible pace; alignment of incentives; favors competition and new services	Uneven speed between companies; underinvestment risk if incentives are not well calibrated; requires institutional maturity and active markets
Models oriented to operational efficiency	India (RDSS), Brazil in critical areas, several Latin American countries	Focus on losses, delinquencies and failures in the retail cycle; deployment by zones; Advanced control, remote cutting and tamper detection functionalities	Rapid capture of operational benefits; improvement of cash flows; reduction of losses; Better control in critical segments	It does not generate universal penetration; risk of technological fragmentation; limited authorization of advanced uses; Difficult transition to AMI 2.0

AMI FUNCTIONALITIES AND INTERNATIONAL TRENDS

First wave of smart metering: core functionalities and initial deployments

Early deployments of advanced metering infrastructure focused on a limited set of essential functionalities aimed at improving metering, billing, and basic operational monitoring. In this stage, commonly referred to as the first generation, regulators mainly required automatic remote reading, the availability of hourly or fifteen-minute data, the possibility of remote disconnection and reconnection, and the detection of interruptions using last-breath signals. These capabilities have reduced operational costs associated with manual reading, improved billing accuracy, and provided more timely information on network failures.

The timing of this first wave varied by region. In Europe, the initial deployments took place between the mid-2000s and the middle of the following decade, favoured by a process of regulatory harmonisation that, as noted in the previous section, progressively consolidated objectives, minimum functional requirements and interoperability conditions, reducing uncertainty for large-scale investments. In this context, the EU directives not only guided the adoption of basic functionalities, but also reinforced a logic of long-term planning and standardization, facilitating national programs with greater levels of uniformity and economies of scale. In the United States, the first wave accelerated after federal stimulus programs between 2009 and 2015, which allowed many companies to replace their meter fleet with devices that met these basic requirements. Japan made similar progress from 2012, gradually integrating remote reading and remote cutting as mandatory capabilities, while countries such as Australia and Canada advanced in a more heterogeneous way and with more extended schedules. Although the technologies deployed at this stage were a significant improvement over traditional electromechanical meters, their ability to enable advanced uses, such as distributed resource integration or flexible demand management, was limited.

Second wave (AMI 2.0): Interoperability, advanced granularity and advanced cybersecurity

The second wave of smart metering, commonly referred to as AMI 2.0, arises as distribution networks incorporate distributed resources, new consumption patterns, and increased demands on cybersecurity and data management. Unlike the first generation, focused on remote reading and basic automation of the business cycle, this new stage requires advanced functionalities that allow a more dynamic interaction between the consumer, the grid and the energy markets. Common regulatory requirements include higher time granularity (typically between five and fifteen minutes), local processing capabilities or edge computing, ports or interfaces that facilitate interaction with smart home technologies, more detailed bidirectional metering, and strengthened authentication, encryption, and secure data management mechanisms.

In the European case, the transition to AMI 2.0 is interpreted as a coherent evolution of the framework already described above. Once high levels of penetration have been reached with the first wave, the regulatory focus shifts from the mere replacement of the fleet to the updating of the minimum functional standard required by the new context of electrification and decentralization. In this way, countries that completed massive deployments, such as Italy and Spain, enter cycles of technological renewal in which regulatory requirements prioritize interoperability, greater data granularity and stricter data security and governance requirements, with the aim of enabling use cases associated with flexibility, integration of DER and advanced consumer services. and to reduce the risks of technological fragmentation and premature obsolescence.

In line with this shift in regulatory focus, several countries have formalized advanced requirements for their new technological replacement and upgrade cycles. Italy started this transition in 2017 with the introduction of its second generation of meters, which incorporated stricter interoperability standards and functionalities aimed at enabling flexibility services. Sweden moved in the same direction from 2020, stating that new meters should include local outputs, increased data storage capacities, and quality of service indicators. France integrated similar requirements into the deployment of updated versions of Linky program equipment, while Japan has been strengthening its technical standards since 2020 to enable the mass integration of distributed generation, home storage, and more automated grid operation. In other jurisdictions, such as Australia and several U.S. states, regulators have begun to incorporate these attributes into certification or approval criteria for new smart metering projects.

The move towards AMI 2.0 responds to a structural need: the first generation of meters allows for improved operational efficiency, but does not provide the capabilities required to manage networks with high penetration of distributed resources or with advanced dynamic pricing schemes. As a result, countries that began their deployments a decade ago are entering a modernization cycle that not only replaces old equipment, but redefines the minimum functional standard that will be needed in the next phase of energy transition. For countries that have not yet massed smart metering, this evolution offers an opportunity to directly adopt second-generation specifications, avoiding intermediate stages that could lead to early obsolescence or additional upgrade costs.

Required functionalities according to uses prioritized by each country or region

The evolution of smart metering has shown that there is no single trajectory or set of functionalities that is optimal for all jurisdictions. Each country has prioritized the development of AMI capabilities according to its technical, economic, and operational challenges, resulting in different functional profiles even though the underlying technology is comparable. In some cases, the emphasis has been on strengthening the efficiency of the business cycle and reducing non-technical losses, while in others the priority has been to enable greater flexibility in demand or facilitate the integration of distributed resources and electric vehicles. There are also countries that have oriented smart metering towards improving resilience and quality of service, with a special focus on the early detection of critical events and automated grid management.

When the regulatory priority is loss reduction and operational efficiency, the most relevant functionalities are usually tamper detection, remote cutting and reconnection, real-time monitoring of load variations and alarms of anomalous behavior. These attributes strengthen the integrity of the business system and improve the financial sustainability of distributors. In jurisdictions looking to migrate to dynamic pricing and flexibility programs, or recognizing the need to move beyond monomic pricing schemes to fully capture the economic value of smart metering, the main capabilities are related to granular metering, low-latency two-way communications, and data platforms that allow consumers and aggregators to actively participate in the market. To facilitate the integration of distributed generation and electric vehicles, regulators have prioritized the availability of detailed information on bidirectional flows, local interfaces for home management systems, and functions that allow the evaluation of voltage and power conditions at the connection point. Finally, when energy policy emphasizes resilience and quality of service, event logging capabilities, automatic outage notifications, and analytics capabilities at the edge of the grid become more relevant.

These differences show that Latin America can be directly incorporated into the second wave of advanced measurement without the need to mechanically replicate the initial deployments of other regions. The selective adoption of AMI 2.0's own functionalities, aligned with the priorities of each country and with the maturity of their electricity systems, makes it possible to avoid investments in technologies that would become obsolete in the short term and to maximise the social return of digitalisation. The key is to define minimum standards that are consistent with the intended use of smart metering, leaving room for regulation to evolve gradually as the penetration of distributed resources, the electrification of transport, and new consumption dynamics transform the operation of distribution networks.

INTERNATIONAL GOOD PRACTICES AND LESSONS FOR LATIN AMERICA

A review of international experience contrasted with the heterogeneous operational reality of Latin America leads to a fundamental conclusion: technology is universal, but regulation must be contextual. While the driving force behind AMI deployment in the

European Union was the energy efficiency and decarbonization directive, and in the United States the management of peak demand predominated to defer investments in generation, in Latin America the drivers are multiple, as concessions coexist where the priority is the recovery of financial sustainability through the control of non-technical losses. with others where accelerated penetration of DER threatens the physical stability of the network. Consequently, the success of the rollout depends on the sophistication with which the NRA designs the incentive architecture. Below, some differentiated regulatory strategies and structural recommendations for the regional context are outlined.

Incentive architecture based on market priority

In those jurisdictions where the viability of the distributor is compromised by critical levels of fraud, theft and delinquency, applying "theoretical efficient company" regulatory models may be incompatible with an optimized AMI deployment. As ADELAT has argued in its analysis of regulatory challenges, it is imperative to move towards remuneration schemes based on the recognition of real costs, which capture the effective operating conditions instead of imposing ideal parameters (ADELAT, 2023).

In this sense, regulation can be based on a cost-benefit analysis of the system to evaluate and prioritize investments. In this framework, the intensive investments by zones and their eventual recognition in the tariff can be analysed by considering the aggregate benefits for the system as a whole (the reduction of technical and non-technical losses, the increase in revenue collection, the deferral of investments in the network and the improvements in the quality and continuity of supply) against the associated tariff impact. Such an approach allows investment decisions and cost recovery mechanisms to be justified in a transparent and proportionate manner, with verifiable assessments and regular reviews.

Technically, this approach calls for a paradigm shift in the meter specification from a commercial logger to acting as a network security sensor. Thus, regulation can prioritize granular energy balance functionalities at the distribution transformer level, algorithmic detection of physical or logical manipulations (tampering), and the ability to cut off and immediate remote reconnection. The deployment strategy, therefore, cannot be dispersed or at the customer's demand, but massive and geographical ("area sweep"), shielding complete circuits to guarantee the closure of the energy balance.

On the other hand, in markets such as Brazil, Chile or Costa Rica, where distributed photovoltaic generation and electric mobility are beginning to stress LV grids with bidirectional flows and localized peaks in demand, the regulatory challenge is managing complexity. Here, the remuneration model can move towards valuing flexibility and network services. Following the logic of the RIIO framework in the UK or New York's Reforming the Energy Vision (REV), regulation can recognize AMI as the "sensory backbone" of the DSO. From this perspective, smart metering investment is justified not by the savings in manual reading, but by its ability to avoid much larger capital investments in traditional grid reinforcements. This approach requires the NRA to reward the distributor for optimizing the use of existing infrastructure through data.

To operationalize this model, the implementation of dynamic rates or nodal prices is required. Regulation should favor Time-of-Use (ToU) schemes or critical prices that reflect the scarcity or abundance of energy in real time. This also requires that AMI infrastructure has the capacity to process and transmit data at intervals of 15 minutes or less. Only in this way can the distributor send efficient economic signals for consumers (or their automated systems) to shift their consumption or inject stored energy, turning the meter into the financial settlement tool of a distributed flexibility market.

Regulation for AMI 2.0

One of the most serious strategic risks for emerging economies is the adoption of mature, but functionally obsolete, technologies. If Latin American regulators define technical requirements based on standards from the past decade — the logic of which was the daily reading for monthly billing — they could condemn power systems to technological irrelevance before assets are amortized. It is therefore necessary for regional regulation to move rapidly ("leapfrog") towards AMI 2.0 standards.

This is important, on the one hand, because of latency and visibility. Managing solar intermittency and EV charging requires real-time visibility. Grid operators cannot stabilize voltage or manage congestion with data from the previous day; require telemetry with granularity of seconds or minutes. Regulation may therefore require bandwidths and latencies on the communication channels that support this traffic density.

Second, because of the "edge computing" architecture. Regulation should encourage meters that not only transmit raw data to the cloud, but have local computing capacity to run fault detection algorithms, product quality analysis, and on-site load disaggregation. This would not only reduce data transmission costs, but improve cybersecurity and privacy by minimizing the exposure of consumer information.

Finally, by the regulation of the local consumer interface. Following the example of the Italian regulations, it is important that the meter has a direct communication interface to the interior of the home (HAN), independent of the distributor's network. This would allow the consumer to receive consumption information or alerts in real time, enabling home automation without depending on the internet connection or the utility's cloud.

Regulatory Engineering: Recommendations for Latin America

To advance these strategies, four pillars of regulatory reform are proposed designed to mitigate region-specific risks and accelerate efficient deployment.

Phased deployment by value segments: International experience shows that universal and immediate deployment mandates often fail due to supply chain tensions and social resistance. A step-by-step approach by value segments is recommended. The regulation can establish initial mandatory phases for consumers where the economic benefit is indisputable: large consumers in low voltage, prosumers with distributed generation and areas with critical losses. This strategy allows the technology to be validated, operational processes to be adjusted and an early positive cash flow to be generated to finance the subsequent stages of residential scale-up. However, this progressivity must be part of an explicit trajectory towards total deployment over a period of years or decades, avoiding the prolonged coexistence of conventional systems and AMI, which increases operating costs and complicates management. Penetration targets should be explicit, multi-year and subject to review, avoiding the rigidity that leads to non-compliance. Likewise, when smart tariffs are enabled, they should be applied on a non-discriminatory basis between customers in the same network area.

Adoption of a TOTEX approach: It is important to reduce the regulatory bias that favors CAPEX over OPEX, and evolve towards Total Expenditure (TOTEX) models, where the company is compensated for achieving service objectives regardless of whether the solution is physical or digital. Specifically, it is crucial that regulators allow recognition in the tariff associated with the AMI's brain: software licenses (MDM, HES), SaaS platforms, and cybersecurity services. As long as regulation continues to treat these costs as operational inefficiencies, utilities will have incentives to underinvest in system intelligence, compromising its long-term security and functionality.

Cost-Benefit Analysis with a comprehensive approach: Traditional project evaluation methodologies, focused exclusively on reducing the company's internal costs, are insufficient to justify AMI in many contexts in the region. Regulators should be guided by social cost-benefit analyses that incorporate positive externalities. This involves assigning tangible value to resilience, improved service quality, public safety, and decarbonization. In addition, by quantifying the systemic savings in generation and transmission derived from energy efficiency and demand response enabled by AMI, the business case will be more robust and socially justify the investment.

Technological neutrality and open standards: Finally, to protect consumer interest and market efficiency in the long term, regulation must be neutral in terms of communication technology, but strict regarding interoperability. The adoption of open standards at the application layer should be a requirement for market entry. This avoids vendor lock-in by manufacturers, ensures that today's investments are compatible with tomorrow's innovations, and fosters healthy price competition in equipment tenders, reducing the final cost passed on to the tariff.

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One of the most serious strategic risks for emerging economies is the adoption of mature technologies

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