RECLAIMING POWER

Innovation and Strategies for Non-Technical Loss Management in Latin America and the Caribbean

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EXECUTIVE SUMMARY

Non-technical losses (NTLs) represent one of the most persistent challenges to the financial sustainability and operational efficiency of utilities in Latin America and the Caribbean. Beyond the direct economic impact on revenue recovery, high levels of unbilled energy distort demand signals, compromise service quality and constitute a structural barrier to grid modernization. In a context of energy transition, where digitalization and operational flexibility are imperative, reducing these inefficiencies is no longer an isolated goal but a necessary condition for the viability of the distribution model.

Unlike technical losses, whose reduction faces diminishing returns dictated by physical laws and requires capital-intensive investments, NTLs respond to behavioral dynamics and management failures that offer a wider and more cost-effective margin for action. This study focuses its analysis on intentional losses, systematizing the strategies that allow companies to act on fraud and irregularity through tools under their direct control. The study proposes an operational taxonomy organized around three sequential intervention pillars:

1. Detection and Identification (Visibility): Focused on the use of energy balances and data analytics to target inspection resources, moving from random sweeps to information-based risk stratification.

2. Disincentive and Control (Containment): Focused on raising the opportunity cost of fraud by physically hardening the network (tamper protection, telemetering) and strengthening the capacity for control and sanctioning.

3. Regularization and Inclusion (Integration): Aimed at addressing the causes that originate irregularity, through mechanisms of commercial flexibility and inclusion that make it possible to pay for the service, particularly in contexts of vulnerability, and prevent recurrence.

The analysis of regional experience suggests that technology, while indispensable for modernizing management, is not in itself a definitive solution. The incorporation of smart metering or data analytics facilitates detection, but its effectiveness depends on the robustness of the processes that support it. In practice, the most consistent results are observed where loss control ceases to be a temporary campaign and becomes a permanent function of the operation. This requires not only discipline in the field to manage the human factor, but also rigorous work on the quality of commercial information, recognizing that no algorithm can compensate for poor-quality or outdated data.

Finally, the study suggests that strategies based exclusively on coercion face structural limits in contexts of social vulnerability. Efficient management requires distinguishing between opportunistic fraud and irregularity motivated by the need or lack of infrastructure. Consequently, the sustainability of interventions in informal settlements depends on the ability to articulate technical regularization with public policy instruments. This approach seeks to facilitate the integration of users willing to regularize their electricity service, understanding that energy recovery in these territories is inextricably linked to their urban and social integration.

PROLOGUE

Electricity losses are one of the most persistent structural challenges with the greatest financial impact on electricity systems in Latin America and the Caribbean. When they remain at high levels, they not only reflect operational inefficiencies in network management, but also deeper tensions in the sector's institutional architecture, linked to regulatory incentives, control capacities, territorial dynamics, legal frameworks, and social conditions. In particular, non-technical losses express the complexity of a phenomenon where fraud practices, weaknesses in law enforcement and business processes, and situations of informality or energy exclusion converge. For this reason, addressing it requires moving beyond purely operational perspectives and recognizing that it is a systemic problem that involves technical, legal, regulatory, economic and social dimensions.

In this context, this study provides a structured look at the management of non-technical losses in the region. Based on the compilation of practical experiences of distribution companies, the document proposes a taxonomy of measures and practices that allows ordering a field that is usually approached in a fragmented way. This systematization facilitates the comparison between strategies, identifies patterns of intervention and contributes to the formulation of more coherent policies and action plans. As part of this effort, measurement sheets designed for easy reading and wide dissemination are developed, which synthesize operational learning and allow for more direct appropriation by different actors in the sector. These fact sheets, together with the repository of experiences that support them, seek to become a living tool, capable of being continuously updated, incorporating new advances and accompanying the evolution of loss management strategies in the region. The study also highlights that many of the measures aimed at reducing non-technical losses, such as digital metering, the use of advanced data analytics or mechanisms for the early detection of irregularities, can be understood as systemic efficiency investments. These initiatives not only allow unbilled energy to be recovered, but also improve the overall management of the grid and reduce operating costs associated with reactive processes, generating benefits that can be transferred to all users of the system without necessarily implying increases in the tariff. At the same time, the evidence collected underlines that the management of non-technical losses must consider the diversity of social realities in which the networks operate, combining control tools with energy regularization and inclusion strategies.

Finally, this work reflects the value of collaboration between institutions with complementary roles in the development of the regional electricity sector. The cooperation between the Latin American Electric Power Distributors Association (ADELAT), the Centro de Soluciones de Energía Descentralizada Avanzada (SEDA), the Latin American and Caribbean Energy Organization (OLACDE) and the Inter-American Development Bank (IDB) has made it possible to articulate institutional and technical knowledge, operational experience and academic analysis to address a common challenge from a regional perspective. This joint effort demonstrates that the sustainable reduction of non-technical losses requires not only technological innovation and regulatory improvements, but also spaces for dialogue, collective learning and the construction of shared knowledge between companies, public institutions, international organizations and academia.

ACKNOWLEDGEMENTS

We thank all the organizations, companies, regulatory institutions and professionals who made the development of this study possible. Their willingness to collaborate, through interviews, response to surveys, attention to specific queries and the open exchange of information and experiences, has been fundamental in building a rigorous and representative vision of the management of non-technical losses in the region. We are especially grateful to ARIAE for facilitating the coordination and collaboration of the regulatory entities of the region. This work is, to a large extent, the result of this collective effort and the shared commitment to move towards more efficient, transparent and sustainable electricity systems.

We thank:

AETN
Afinia
ANEEL
ASEP
CEMIG
CENS
Centrosur
CNE (Chile)
CNEE (Guatemala)
CNEL Guayaquil
CNMC
CPFL Energia
CRE R.L.
CREE
CVC Energía
DELSUR
Edea
Edesa
Edenor
Edenorte Dominicana
Edesur
EDEQ
EDP
EEQ
EEGSA
Electro Dunas
Enel Brasil
Enel Chile
Enel Colombia
Energisa
ENERGUATE
ENSA
EPESF
EPEC S.A.U.
EPM
Equatorial
ERSE
ESSA
FENACOPEL
Grupo SAESA
ICE
Light
ONURE
OSINERGMIN
Pluz Energía
SECHEEP
SIE
SIGET
VMME

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INTRODUCTION AND OBJECTIVE OF THE DOCUMENT

MOTIVATION

Electricity losses in transmission and distribution are a central indicator of the performance of electricity systems, as they express the difference between the energy that is generated or purchased and the energy ultimately billed to customers. While some level of losses is inherent to the operation of the network, persistently high levels often reveal investment shortfalls and weaknesses in the technical and institutional functioning of the sector. In Latin America and the Caribbean, this phenomenon not only affects the financial viability of companies, but also limits their ability to maintain and expand infrastructure, deteriorates the quality of service, and amplifies social and environmental impacts associated with unbilled energy and, sometimes, overconsumption and higher emissions.

This study focuses on non-technical losses (NTLs) because they are, in general terms, the most manageable component through utility-led action. Unlike technical losses, which can be explained by physical phenomena, NTLs are associated with commercial, operational and institutional processes, and include everything from physical interventions (theft and fraud) to process failures (metering and billing errors) and financial aspects such as delinquency. In practice, and as regional evidence shows, addressing them transcends engineering: it involves understanding incentives, control capacities, organizational practices, regulatory conditions, and socio-territorial dynamics that shape the payment culture and systemic informality.

The starting point of this document is the Inter-American Development Bank (IDB) study "Economics of Electricity Losses in Latin America and the Caribbean", which provides an updated conceptual framework and underlines the multidimensional nature of the problem, where technical, financial, socio-economic, regulatory and political factors interact. According to the IDB study, Latin America and the Caribbean faces an endemic situation of electricity losses. In the last three decades, it is estimated that, on average, around 17% of the energy generated in the region has been lost, a level three times higher than that of OECD countries and above thresholds compatible with an efficient system. In 2019, losses exceeding a reference limit of 10% reached the order of 120 TWh, and the problem is pervasive across the region, as 22 of 26 countries analyzed exceed 10%. At the same time, the IDB underscores regional heterogeneity: although the average rates by subregion range from approximately 15.2% to 18.1%, countries with performance relatively close to reference levels (e.g., Peru) coexist with others that exhibit extremely high percentages, where losses can exceed 25% (e.g., Jamaica and Paraguay) and very critical cases associated with relevant absolute magnitudes (e.g., Venezuela and Honduras).

In this framework, this study proposes that the implementation of measures aimed at the reduction and management of non-technical losses can be understood as systemic efficiency investments, whose economic and operational benefits can be shared among the users of the electricity system. The reduction of NTLs not only decreases unbilled energy, but also lowers operating costs related to reactive inspections, service disconnections, equipment replacement, claims management, litigation, and customer compliance activities. Additionally, it impacts the perception of risk of both investors and customers. Thus, the incorporation of tools such as digital metering, advanced data analytics and early detection of irregularities opens the possibility of reducing structural costs of the distribution service, improving the accuracy of future demand forecasts, and contributing to the financial sustainability of the system with a positive impact on the final rate.

Based on this hypothesis, the document proposes to move from the regional diagnosis to an applied analysis, focused on the concrete experience of distribution companies in Latin America and the Caribbean. To this end, measures implemented in different regulatory, operational and socioeconomic contexts are systematized, organizing them into lines of action according to their logic of intervention and their contribution to the management of non-technical losses. This approach seeks to identify both implementation experiences and the conditions under which specific measures have proven effective, the capacities required, and coordination with the institutional environment of each country. In this way, the study aims to provide operational evidence and analysis criteria that guide the design, prioritization and evaluation of strategies to reduce NTLs, recognizing the diversity of existing realities in the region.

OBJECTIVE

The general objective of this work is to systematize the measures implemented by distribution companies in Latin America and the Caribbean to reduce non-technical losses, identifying, characterizing and organizing their experiences in order to build an operational repertoire of good practices, aimed at supporting decision-making and the design of contextualized strategies.

To this end, the following specific objectives are established:

1. To identify the main measures and approaches used by distribution companies in the region for the reduction and prevention of non-technical losses, based on secondary sources and primary evidence collected through interviews and surveys.

2. Characterize these measures according to their purpose, scope, enabling conditions, capacity requirements (technical, commercial, and organizational), and main implementation barriers, distinguishing contexts where their application is most effective.

3. Systematize the experiences in a common framework of analysis, classifying them into areas of action that allow their comparison and informed selection.

4. Extract transferable learnings and practical criteria for the design of integrated NTL management strategies, emphasizing combinations of measures, implementation sequences and minimum conditions for their sustainability over time.

SCOPE AND DELIMITATION

The scope of this document is limited to the operational and customer management of non-technical losses (NTLS s) in the context of distribution companies in Latin America and the Caribbean. Its purpose is to systematize the set of actions that can be designed and implemented under the direct control of the company itself to detect, reduce and prevent unbilled energy. Consistent with this practical approach, the analysis is structured as a repertoire of intervention tools, ranging from investment in metering infrastructure and data analytics, to the deployment of onsite control strategies and sustainable regularization mechanisms.

The study takes a distributor's agency-centric perspective. While acknowledging that the success of these strategies depends on enabling conditions—both internal (institutional health and governance) and external (public policies and macroeconomic frameworks)—this manual focuses on the operational levers through which utilities interact with users and the electricity system. In this way, it seeks to provide a functional guide on what measures exist, how they operate and what capacities they require to be effective in the various contexts of the region.

ConsequeNTLs y, the design of public policy, legal reforms, and regulatory discussion in the strict sense are outside the scope of the document. These elements are considered here as the contextual framework within which the company must optimize its decisions, but not as the central object of the analysis.

> Electricity losses in transmission and distribution are a key indicator of the performance of electrical systems

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ELECTRICAL LOSSES

DEFINING ELECTRICAL LOSSES

Electrical losses are fundamentally defined by the energy balance of the system: they correspond to the difference between the energy generated or purchased (input) and the energy actually sold to end users (output).

$$Losses_{Total} = Energy_{Injected} - Energy_{Billed}$$

These losses function as an indicator of the performance of the electricity system, as their levels reveal structural inefficiencies, lack of maintenance in the infrastructure or critical weaknesses in the processes of customer management and fraud control.

TECHNICAL AND NON-TECHNICAL LOSSES

It is useful to distinguish between the two broad categories of losses, as their nature and management differ substantially.

Technical losses

Technical losses are those inherent to the electromagnetic and thermodynamic phenomena that occur in the physical elements of the electrical system during its operation. These losses are mainly caused by the dissipation of energy in the form of heat due to the resistance of conductive materials (ohmic losses or Joule Effect), as well as by specific phenomena such as the corona effect, which at high voltage levels can ionize the surrounding air, and losses in the core of transformers, a product of eddy currents and magnetic hysteresis.

Its magnitude is a direct function of the physical characteristics of the network—such as topology, length of feeders, conductor gauge, and voltage levels—and depends primarily on the load being carried. While it is possible to reduce them through investments in infrastructure (improvement of conductors, insulators and topology) or by optimizing the operation of the system (management of voltage profiles and current levels), due to the physical laws that govern them, they cannot be fully eliminated.

Non-technical losses

Unlike technical losses, which obey immutable physical laws, NTLS s are an empirical and "residual" quantity. They are defined as the fraction of total losses that has no electromagnetic explanation:

$$Losses_{(Non\ Technical)} = Losses_{Total} - Losses_{Technical}$$

Since their causes are not physical in nature, these losses stem from human, commercial and institutional processes. While a certain level of losses is inherent to the operation, NTLS s are theoretically preventable through management, technology, and oversight. Its management transcends engineering, entering the field of economic, political and social conflict by involving the culture of payment and access to basic services.

TYPOLOGY AND CLASSIFICATION OF NON-TECHNICAL LOSSES

Non-technical losses are a heterogeneous phenomenon that groups together situations of different nature, causes and treatment mechanisms. These losses can originate both in internal operational weaknesses of the distribution companies and in deliberate behavior of users, as well as in structural contexts of informality and precarious access to the service. In order to delimit the scope of this study, this section proposes a typology that distinguishes between unintentional non-technical losses, intentional non-technical losses and situations of systemic informality. Although all of them have an impact on the overall level of losses, the subsequent analysis focuses mainly on intentional non-technical losses, since these are the losses over which distribution companies have the greatest direct control through management and operation tools.

Unintentional non-technical losses

Unintentional non-technical losses correspond to energy that is effectively supplied and consumed, but that is not correctly recorded or billed by the distribution company, without there being any deliberate fraud on the part of the user. These losses originate mainly from internal operational weaknesses, management failures or limitations of the metering, billing and commercial administration systems.

This category includes, in the first place, metering errors, associated with faulty, obsolete, poorly installed or meters past their useful life, which under-record the actual consumption. Failures in billing processes are also considered, such as incorrect readings, inadequate consumption estimates or regulatory limitations that prevent charging unread energy in certain periods. Added to this are customer management problems, such as active customers who do not appear correctly in the systems, poorly registered contracts, existing but not billable supplies, or collective consumption, such as public lighting, whose metering is incomplete.

Taken together, these losses reflect structural inefficiencies of the company and not illicit user behavior. It is important to note that, in many cases, the persistence of these inefficiencies can have deep roots in corporate governance problems, misaligned internal incentive schemes, or lack of accountability mechanisms.

However, in order to narrow the scope and ensure an integrated systematization of operational practices, this study does not address institutional reform or internal governance issues. This methodological choice focuses the analysis exclusively on the management tools that distributors deploy to the market and the network to combat intentional non-technical losses, thus allowing for a deeper understanding of fraud control, prevention and regularization strategies.

Intentional non-technical losses

Intentional non-technical losses correspond to energy consumption that is not recorded or paid for as a result of deliberate actions aimed at evading formal metering and billing mechanisms. Unlike unintentional losses, in these cases there is a conscious decision to breach the conditions of service, although this decision can manifest itself in very diverse social, economic and regulatory contexts. From the perspective of the electricity system, these losses represent a direct impact on the financial sustainability of distribution and on equity between users.

According to the experience collected, intentional non-technical losses are manifested through practices with different levels of processing and degree of integration into the commercial system. In the most immediate and opportunistic cases, unregistered consumption usually presents itself as unauthorized reconnections after a formal suspension of supply, where the user restores the service directly. These are visible behaviors, of low technical complexity and high recurrence. On a different level are the fraud practices associated with the manipulation of the metering process, in which the user remains contractually bound to the company, but deliberately intervenes in the meter or its environment with the aim of underreporting consumption and reducing payment. These practices can range from easily detectable interventions to more selective or intermittent schemes, designed to maintain appareNTLs y normal consumption profiles.

Finally, in the scenarios with the greatest energy impact, consumption is carried out through illegal direct connections to the distribution network, without an authorized metering point or contractual relationship, configuring situations of energy theft on a larger scale, which usually involve entire homes or groups of users. Added to this panorama is an additional dimension that complicates detection and control: operational collusion. This aspect is not an isolated technical modality, but an enabling factor where irregular activity involves the participation – active or omitted – of personnel linked to the operation, who facilitate the intervention, falsify records or avoid the reporting of anomalies in violation of the distributor's internal protocols.

Non-technical losses therefore present a marked heterogeneity in terms of magnitude, sophistication and social context, which prevents them from being addressed through single or standardized solutions. While some situations can be effectively resolved through control, detection and deterrence measures, others require broader strategies of regularization, network redesign or social intervention. Precisely because of this diversity, this study focuses its analysis on intentional non-technical losses, examining the tools available for distribution companies to reduce incentives for non-compliance, strengthen their control capacities and promote sustainable solutions over time.

Systemic informality and gray areas

There are situations of irregular consumption that do not fully fit into the classic distinction between intentional and unintentional non-technical losses. These gray areas are associated with informal settlements, users without property titles, precarious inherited access, or historically tolerated consumption, where connection to the electricity service occurs outside of formal metering and billing schemes. In these contexts, unregistered consumption is part of structural dynamics of exclusion and precariousness, and its persistence is often linked to the absence of adequate infrastructure, legal loopholes, or historical decisions of institutional tolerance.

Unlike deliberate fraud, in these situations the irregularity does not always respond to an explicit intention to evade payment, but to material, legal or administrative restrictions that prevent regularization. In many cases, users lack basic conditions to join the commercial system, such as proof of ownership, personal documentation or access to formal procedures, even when there is a willingness to pay for the service. The application of purely punitive or technical control strategies is often ineffective or counterproductive, as it does not address the root causes of the problem and can reinforce dynamics of conflict or recurrence.

Aware of this reality, several distributors have begun to develop specific approaches for these territories, differentiated from traditional loss control strategies. These initiatives include adapted technical tools, flexible commercial schemes and the creation of specialised areas or teams with a more social and inclusive approach, aimed at the progressive regularization of supply. This study addresses these experiences as part of the analysis of non-technical losses, recognizing that the sustainable reduction of systemic informality requires combining technical solutions with policies of inclusion, territorial management and adaptation of business models, rather than a response focused exclusively on sanctions.

RELEVANCE OF ELECTRICAL LOSSES

The management of electrical losses is an imperative that transcends the financial balance of the company, compromising the operational sustainability and social equity of the service. From an economic perspective, unbilled energy represents a non-recoverable cost and an inefficiency that, under modern regulatory schemes, results in severe financial penalties. However, the impact is systemic: high levels of loss degrade the quality of supply by causing overloads and voltage drops, exponentially increase public safety risks from fires and electrocution, and generate a profound distributive distortion, where the cost of inefficiency ends up being transferred to the tariffs paid by compliant users, eroding the legitimacy of the payment system and culture.

To address this challenge, utilities must deploy differentiated strategies depending on the nature of the loss. On the one hand, reducing technical losses requires investments in efficient infrastructure and operational optimization of the network. On the other hand, the mitigation of unintentional non-technical losses involves strengthening corporate governance, improving business processes and internal control mechanisms. Finally, combating intentional non-technical losses requires a different approach, based on precise detection tools, disincentive strategies and on-the-ground inspection actions. It is precisely in this last area, where technology intersects with fraud management, where the analysis and good practices systematised in this study are concentrated.

FOCUS OF THE DOCUMENT

The present study focuses its analysis on intentional non-technical losses. Unlike technical losses, limited by physical laws, and unintentional losses, caused by internal administrative inefficiencies, this segment responds to deliberate actions by third parties aimed at evading metering and billing mechanisms. Because they follow behavioral dynamics rather than thermodynamic constraints, NTLS s require operational and commercial solutions that offer a wider margin of action. ConsequeNTLs y, the document delves into the deployment of management mechanisms that do not depend on the physical expansion of the grid, but on applied intelligence: from the analysis of consumption data and optimized inspection campaigns, to the implementation of emerging technologies that, beyond energy recovery, modernize customer interaction and add value to the operation of the smart grid.

Although this phenomenon is influenced by regulatory, legal and social factors that exceed the scope of control of distributors, they have their own effective tools to act on its persistence. In particular, companies can identify where losses are concentrated, reduce incentives for non-compliance and, in certain contexts, offer regularization mechanisms that allow users to be integrated into the formal system. In this framework, this study limits its scope to the analysis of these utility-led actions, concentrating mainly on intentional non-technical losses and, in a complementary way, on situations of systemic informality or gray areas.

03

METHODOLOGY FOR GATHERING INFORMATION

The study was developed from a mixed methodological approach, combining quantitative and qualitative tools with the aim of identifying, classifying and analyzing the practices used by distribution companies for the management of non-technical losses. The methodological design was aimed not only at surveying the existence of certain measures, but also at systematically examining their implementation conditions, the challenges associated with their operation, their observed performance, and the lessons learned from their application in real contexts. The methodological structure used is summarized in Fig. 1.

Fig. 1. Methodological approach of the study.

The first stage of the study consisted of the application of a structured questionnaire to the participating distribution companies, with the aim of systematically surveying the tools and measures implemented for the management of non-technical losses. The questionnaire was designed based on a preliminary classification of areas of intervention, which included technological and innovation, regulatory and institutional, economic and commercial, community and social dimensions, as well as evaluation and monitoring mechanisms. On the basis of these categories, companies were asked to identify and describe the measures they had implemented in each of these areas. A total of 38 responses to the questionnaire were received, of which 24 met the criteria of consistency and completeness defined for the analysis, allowing the identification of an initial set of 191 reported measures that constituted the initial basis for the subsequent stages of the study. The companies participating in the study are shown in Table 1.

Table 1. Electricity distribution companies participating in the study.

Country	Distribution company	Initial Questionnaire	Interview	Follow-up Questionnaire
Argentina	Edea	●	●	●
	Edesa	●	●	●
	Edenor	●	●	●
	Edesur	●	●	●
	EPEC S.A.U.	●	●	
	EPESF	●	●	●
	SECHEEP	●	●	
Brazil	CEMIG	●		
	CPFL Energia	●		
	EDP	●	●	●
	Enel Brasil	●	●	
	Energisa	●	●	
	Equatorial	●	●	●
	Light	●		
Bolivia	CRE R.L.	●	●	●
Chile	Enel Chile	●	●	
	FENACOPEL	●	●	●
	Grupo SAESA	●	●	●
Colombia	Afinia	●		
	CENS	●	●	●
	EDEQ	●	●	
	Enel Colombia	●	●	
	EPM	●	●	
	ESSA	●	●	●
Costa Rica	ICE	●	●	●
Ecuador	Centrosur	●	●	
	CNEL Guayaquil	●		
	EEQ	●	●	●
El Salvador	DELSUR	●	●	●
Guatemala	EEGSA	●	●	●
	ENERGUATE	●		
Panama	ENSA	●	●	●
Peru	CVC Energía	●	●	●
	Electro Dunas	●	●	●
	Pluz Energía	●	●	
Dominican Republic	Edenorte Dominicana	●		
Uruguay	UTE	●	●	●
Total		37	30	20

The second stage of the study was aimed at qualitatively deepening concrete implementation experiences, with the purpose of understanding the operational nuances, learning, difficulties and contextual factors that influence the performance of the different measures identified. Based on the answers obtained in the questionnaire from the previous stage, a pattern of semi-structured interviews was designed and a total of 30 interviews were conducted with distribution companies, mainly aimed at those responsible for the areas of non-technical losses. The interviews were carried out individually or in groups, depending on the internal organization of each company, and lasted approximately between 40 and 60 minutes, being carried out remotely. This stage allowed the collection of qualitative information that could not be observed through standardized instruments, including operational challenges, success conditions, local adaptations and lessons learned from the implementation of the measures in different territorial and institutional contexts. The instruments used were specifically designed for this study and made it possible to ensure the coherence and comparability of the information collected between companies.

The third stage consisted of the development of a taxonomy of non-technical loss management measures, built from the information collected in the initial questionnaire and further explored through interviews. This taxonomy organizes the identified tools according to their nature, scope of application and logic of intervention, distinguishing between measures aimed at identifying losses, discouraging irregular behaviors and facilitating user regularization processes. Beyond its descriptive role, the taxonomy is one of the study's main methodological contributions, since it structures the subsequent analysis and orders the set of measures examined throughout the document, serving as a conceptual and operational framework for the discussion of results.

The fourth stage consisted of the systematic processing of the qualitative evidence collected in the interviews, which were previously transcribed to allow their textual analysis. The material was organized and coded through thematic analysis, which allowed structuring the findings into comparable categories, contrasting implementation and performance patterns, and identifying relevant convergences and differences between distributors according to their operational contexts, capacities, and local conditions. The results of this analysis constitute the empirical basis of the study and are presented in the following sections, where the main practices reported, their design variants and the lessons associated with their application are synthesized.

In the fifth stage, a second questionnaire was applied to the participating companies with a mainly quantitative approach. This instrument had a double objective: on the one hand, to survey the evolution of non-technical losses over the last five years and, on the other, to identify the degree of implementation of the measures described in the previous sections. The information collected made it possible to build comparable indicators, derive statistical results and identify patterns between the characteristics of the distribution companies, the adoption of different management tools and the observed evolution of non-technical losses.

Finally, in the sixth stage, a consultation phase was carried out with regulatory bodies in Ibero-America. This stage aimed to contrast the operational vision of the distributors with the current institutional framework and the loss control policies defined by the authority. The information collected helped validate the regulatory dimension of the taxonomy and ensured that the recommendations of the study were consistent with the local regulatory contexts of the region. The participating regulatory bodies are presented in Table 2.

Table 2. Regulatory bodies participating in the study.

Country	Regulatory Entity	Interview/Questionnaire
Argentina		
Bolivia	AETN	●
Brazil	ANEEL	●
Chile	CNE	●
Spain	CNMC	●
Colombia		
Costa Rica		
Cuba	ONURE	●
Ecuador		
El Salvador	SIGET	●
Guatemala	CNEE	●
Honduras	CREE	●
Panama	ASEP	●
Paraguay	VMME	●
Peru	OSINERGMIN	●
Dominican Republic	SIE	●
Portugal	ERSE	●
Uruguay		

“

The study was developed using a mixed methodological approach

04

ELECTRICITY LOSSES IN COUNTRIES IN THE REGION

The management of non-technical losses in electricity distribution systems is strongly conditioned by the regulatory, institutional and operational framework in force in each country. While utilities face common problems associated with energy theft, irregular connections, and failures in metering and billing systems, the tools available, economic incentives, and enforcement powers to address these situations vary significaNTLs y across jurisdictions.

The comparative review of the national experiences included in this study allows us to identify common patterns, structural differences and diverse regulatory trajectories in the management of non-technical losses (NTLS s) in electricity distribution systems in Latin America and the Caribbean. Although the countries analyzed present heterogeneous institutional, socioeconomic and market realities, the cross-sectional analysis shows that NTLS s constitute a persistent and multidimensional challenge, whose management combines, to varying degrees, tariff instruments, regulatory mechanisms, entrepreneurial capacities and social intervention strategies.

Tariff recognition and economic signals

One of the main pillars of differentiation between countries is the role of tariff recognition of losses as an economic signal to guide business management. In systems with developed economic regulation and explicit tariff frameworks—such as Brazil, Chile, Colombia, Peru, and Mexico—there are formal methodologies that define levels of losses recognized in tariffs, generally differentiating between technical and non-technical losses, and reviewed periodically (between annual and quadrennial, depending on the country). Brazil represents the most sophisticated case in the region, using an econometric benchmarking scheme that compares distributors with similar socioeconomic characteristics to define individual targets for non-technical losses, integrated into the tariff trajectory. In this model, the economic signal is clear: companies that exceed the regulatory level incur economic losses, while those that exceed it positively retain profits, without resorting to direct administrative sanctions. Chile and Peru, on the other hand, operate with efficient model company schemes, where the recognition of losses is defined ex ante and incorporated as a parameter of the tariff calculation, without explicit goals or direct penalties for deviations, which shifts the incentive towards a more indirect signal.

In contrast, countries such as Paraguay, Bolivia and, to a lesser extent, Ecuador (until the recent regulatory modernization) show schemes where tariff recognition of losses is non-existent, partially or weakly linked to the real management of companies. In these contexts, losses are mainly addressed as a problem of planning or internal management of state-owned enterprises, without an explicit translation into economic tariff incentives. Comparative experience suggests that, in the absence of these signals, the sustained reduction of NTLS s depends strongly on political decisions, extraordinary investment programs or specific managerial capacities, with less stable results over time.

Goals, plans and use of non-tariff instruments

A second relevant pillar is the use of loss reduction plans and explicit goals, whether regulatory, corporate or public policy. The Dominican Republic, Honduras, Ecuador and Paraguay stand out for the existence of national or sectoral loss reduction plans, which establish quantified objectives and defined time horizons. In these cases, the goals play a role of strategic orientation and follow-up, even if they are not always associated with direct economic incentives or formal sanctions.

Evidence shows that these plans are most effective when they are integrated with clear operational and budgetary instruments (as happened in Ecuador with PlanREP) and less effective when they function solely as programmatic statements. In countries where targets are not linked to tariffs or accountability mechanisms, their impact tends to be diluted in the face of financial, institutional or political constraints.

By comparison, regulators in countries outside the region, such as Portugal and Spain, use implicit targets embedded in service quality and efficiency frameworks, with periodic reviews and cost-efficient methodologies that internalize losses within firms' expected performance. Although these contexts cannot be directly extrapolated, they illustrate the importance of integrating loss management into a coherent and stable regulatory framework, rather than addressing them as an isolated problem.

Transparency, reporting and quality of information

A cross-cutting feature in the countries studied is the centrality of the energy balance as a basic tool for measuring losses, both technical and non-technical. However, there are significant differences in the quality, frequency, and regulatory use of this information. In Brazil, Colombia, Ecuador, Chile and Peru, distributors are required to periodically report their loss levels to the regulator, and such information is used for tariff, comparison and monitoring purposes. In these cases, the data is usually public, at least in aggregate form, which enables comparative analyses and generates reputational pressure.

In other countries, such as Bolivia or Paraguay, loss information exists and is reported, but its use is predominaNTLs y analytical or internal planning, without systematic regulatory audits or direct tariff effects. This difference is not minor: comparative experience shows that publicity, traceability and consistency of data are necessary conditions to move towards more sophisticated schemes of incentives, control and institutional learning.

The cases of Spain and Portugal reinforce this conclusion: in both countries, loss reporting systems are highly standardized, audited and publicly available, allowing the regulator not only to supervise, but also to adjust methodologies and parameters with a solid evidence base.

Enforcement powers and inter-agency coordination

In all the countries analysed, non-technical losses associated with electricity fraud are classified as administrative offences or criminal offences. However, the degree of effective coordination between distributors, regulators, prosecutors' offices and security forces varies considerably. The Dominican Republic and Brazil stand out for having more explicit institutional arrangements, where the criminal prosecution of fraud actively involves specialized prosecutors' offices and formal protocols of joint action.

In other countries, coercive capacity exists in the legal framework, but its application is more fragmented, dependent on the initiative of companies or limited by security conditions, slow prosecution or lack of resources. In these contexts, the evidence collected in interviews suggests that coercive control, by itself, generates transitory effects and can even deepen social conflicts if it is not accompanied by regularization and inclusion strategies.

Social inclusion, informality and sustainability of the reduction

A cross-cutting finding of the study is that NTLS s associated with contexts of informality and socioeconomic vulnerability cannot be approached exclusively from the logic of control. In countries as diverse as Uruguay, Argentina, Ecuador, Brazil and Chile, distribution companies agree that sustainable regularization requires combining technical, commercial and social instruments.

The most effective practices include social tariffs, payment flexibility schemes, differentiated debt management, community support, and coordination with broader public policies on housing, urban planning, and social protection. In these cases, the reduction of NTLS s is not conceived as an isolated objective, but as part of an energy inclusion strategy that seeks to transform irregular consumption into formal and sustainable supply.

This approach contrasts with experiences where utility-led action is limited to cuts and sanctions, without accompanying instruments, which tends to reproduce cycles of illegal reconnection and recurrent loss. Comparison with countries such as Cuba, where universal access and strong state presence reduce the space for irregularity, shows that electricity informality is, to a large extent, a reflection of broader structural inequalities.

Overall, the comparative analysis shows that there is a set of recurrent principles associated with more robust experiences: (i) clear economic signals, preferably integrated into the tariff regime; (ii) reliable, public and audited information; (iii) effective inter-institutional coordination for fraud control; and (iv) inclusion strategies that address the structural causes of irregularity.

Countries that manage to articulate these elements in a coherent manner show more stable trajectories of NTLS reduction. Conversely, when any of these components are absent—for example, economic incentives, data quality, or social tools—progress tends to be partial, fragile, or dependent on extraordinary efforts. This comparative learning is a key input to guide recommendations and frameworks of good practices that can be adapted to different national contexts.

In order to contextualize the business experiences systematized in this study, this section describes, for each country analyzed, the main elements of the regulatory scheme applicable to non-technical losses, based on the information provided directly by the regulatory and supervisory entities through forms and interviews. The characterization focuses on the mechanisms for tariff recognition of losses, the regulatory instruments and incentives associated with their reduction, the reporting and transparency requirements, and the powers granted to distribution companies for the detection, control and recovery of unregistered energy.

This comparative analysis allows us to identify common patterns, structural differences and degrees of regulatory maturity, providing an indispensable framework for the interpretation of the good business practices presented in the following sections.

ARGENTINA

Argentina has a vertically disintegrated electricity sector, with competitive generation and wholesale marketing, regulated transmission and distribution as a natural monopoly concessioned by area. The operation of the wholesale market is in charge of CAMMESA, while regulation and supervision are exercised in a dual manner: at the national level for distributors under federal jurisdiction through ENRE, and at the provincial level for the rest of the distributors, through provincial regulatory entities. Due to this coexistence of different regulatory frameworks, tariff review mechanisms and loss recognition can differ significaNTLs y depending on the jurisdiction. The ownership of the distributors is mixed, with private operators and electric cooperatives predominating, with some provincial companies with state capital.

For distributors under national jurisdiction, the treatment of tariff losses is defined within the framework of the Integrated Tariff Revisions (RTI) and their transitory updates. For their part, in the case of provincial companies, tariff recognition mechanisms may respond to specific regulatory frameworks defined by each province. In the RTI scheme, the regulator sets levels of recognized losses (technical and non-technical) consistent with an efficient company, which are incorporated into the calculation of the distributor's regulated revenues. Losses above the recognized level are not transferable to the tariff and constitute an economic cost for the company, generating an implicit incentive to reduce them. The RTI establishes medium-term parameters (typically five-year), while subsequent adjustments and revisions can be made through tariff transition or recomposition mechanisms, especially relevant in the recent macroeconomic context. In practice, the tariff instability of recent years has partially weakened the long-term economic signal, although the principle of limited recognition of losses is maintained in the regulations.

In addition to tariff recognition, the Argentine framework contemplates complementary instruments. At the federal level, ENRE requires distributors to submit investment and operational improvement plans, which include loss reduction actions (network renewal, supply standardization, metering improvement). Historically, programs have been implemented to normalize neighborhoods and informal settlements, aimed at transforming irregular connections into formal supplies, with the support of public financing. Although there are no explicit and homogeneous loss reduction goals at the national level applicable to all distributors, there are indirect economic incentives and, in certain cases, regulatory penalties associated with non-compliance with service and quality obligations.

Distributors must periodically report their energy balances (purchased energy vs. billed energy) to the regulator and CAMMESA. This information is used for tariff, control and comparative purposes, and is part of the technical and economic audit processes. At the national level, the ENRE publishes aggregated information on the performance of the distributors, including loss indicators, although the degree of detail and updating may vary. At the provincial level, the publicity of information depends on each regulatory entity, generating heterogeneity in transparency and comparability.

Distributors have the power to inspect facilities, detect irregularities, suspend supply in cases of fraud and recover unbilled energy in accordance with contractual and regulatory frameworks. Energy theft is typified in criminal regulations, which enables criminal reporting and prosecution in serious cases, usually in coordination with security forces and judicial authorities. In practice, the application of criminal sanctions has been limited, privileging administrative and commercial mechanisms. To balance control with social protection, social tariffs, targeted subsidy schemes and regularization programs have been developed in vulnerable areas, recognizing that a part of the non-technical losses have a structural socioeconomic origin.

From a regulatory perspective, the main challenges to reduce non-technical losses in Argentina include: (i) restoring stable and predictable tariff signals that reinforce efficiency incentives; (ii) standardize regulatory criteria between national and provincial jurisdictions to improve comparability; (iii) accelerate metering modernization (telemetering and data analysis) in critical areas; and (iv) deepening electricity regularization and inclusion programs, coordinating distributors, local governments, and social policies. The Argentine experience shows that the sustainable reduction of NTLS s requires a combination of economic, regulatory, technological and social instruments, rather than a single isolated measure.

BOLIVIA

In Bolivia, as reported by the regulatory entity consulted, the level of losses recognized in the tariffs is determined by a tariff study commissioned by the distribution companies, which is reviewed every four years. The available inputs do not detail an additional mechanism for intra-period adjustment, nor an explicit disaggregation between technical and non-technical losses within the tariff recognition.

In addition to tariff recognition, the regulation contemplates sanctions associated with infractions linked to irregular consumption. In particular, Electricity Law No. 1604 establishes consumer infractions (arbitrary connection, alteration of measuring instruments, clandestine consumption and refusal of access to inspections), and provides for the application of fines calculated based on energy (kWh) multiplied by the corresponding average tariff, without prejudice to other liabilities.

Regarding reporting and transparency, the response received indicates that distributors should not report, audit, or certify their loss levels to the regulator within the framework of this form, and that such information is not considered public (as indicated by the entity). Therefore, the evidence available for this study does not allow us to describe systematic regulatory uses (comparative, corrective or sanctioning) based on periodic reports of losses.

Finally, the strengthening of prevention information campaigns aimed at alerting the population to people who offer "services" to carry out infractions or manipulate consumption is highlighted as a relevant measure. This emphasis is consistent with recent public messages disseminated by companies in the sector in Bolivia, which warn about the illicit nature of energy theft and its consequences.

BRAZIL

Brazil has one of the most sophisticated regulatory frameworks in the region for the management of non-technical losses in electricity distribution. The level of losses recognized in terms of tariffs is defined in the Periodic Tariff Review (RTP) processes of each distributor, which are carried out every four or five years depending on the duration of the concession cycle. Technical losses are determined from a regulatory engineering model, while non-technical losses are established through a comparative benchmarking approach between distributors operating in areas with similar socioeconomic characteristics.

To this end, ANEEL uses an econometric model that identifies socioeconomic variables that explain non-technical losses, building a ranking of complexity of the concession areas. Each distribution company is compared to potential peers, and the regulatory target for non-technical losses is defined as the lowest value resulting from a weighted average between its own historical losses and those of its benchmarks. This target corresponds to the level that the company must reach at the end of the tariff cycle, and translates into an annual reduction trajectory, which determines the level of non-technical losses recognized in each tariff year of the regulatory period.

The main incentive instrument is economic: the tariff recognition of losses may differ from the level actually incurred by the company. If the distributor manages to perform better than the regulatory level, it obtains an economic gain; if he does not reach the goal, he faces an economic loss. There are no direct sanctions or fines for non-compliance with the goals, nor additional explicit rewards, beyond this economic signal. The plans to combat losses presented by companies during tariff reviews do not directly influence the definition of regulatory levels.

A relevant element of recent evolution is Decree No. 12,068/2024, which establishes that distribution concessions that will be extended in the coming years, and that face severe operational restrictions, must present non-technical loss reduction plans, the performance of which will have an impact on tariff recognition. The specific regulation of this mechanism will be the subject of public discussion during 2026, which could strengthen the link between operational planning and regulatory signals.

In terms of information and oversight, Brazilian distributors must report their loss levels to ANEEL on a monthly basis. These data are used to feed the econometric model, make comparisons between companies, define regulatory goals and monitor sectoral performance. All this information is public, and is disseminated through official regulatory reports and documents, fulfilling a comparative and transparency role rather than sanctioning.

Finally, one of the main challenges to strengthen the reduction of non-technical losses is to move towards greater inter-institutional coordination. It is identified as necessary to coordinate more closely with ANEEL, the sectoral Ministry, the distribution companies, the police forces, the judiciary and the state and municipal governments. Likewise, the need for an integrated public policy to combat losses is raised, which combines control actions in the face of a cross-cutting problem with measures to reduce the cost of energy focused on vulnerable areas, allowing the problem to be addressed from a structural logic and not only tariff.

CHILE

In Chile, the level of electricity losses recognized in tariffs is determined within the framework of the four-year process of fixing the Distribution Value Added (VAD), which is based on the design of an efficient model company. For this model company, the investments and the costs of operation, maintenance and administration necessary to provide the distribution service are defined, considering the restrictions of the operation of real companies. In this context, the characteristics of the networks defined for the model company allow the technical losses of the system to be determined, while the non-technical losses are estimated in a complementary way, mainly considering energy theft as a relevant variable. In the last tariff process, the level of theft was estimated using an econometric model that incorporated, among its explanatory variables, the historical theft reported by the distribution companies and the Gross Domestic Product (GDP). The level of losses recognized is reviewed and updated every four years, with each new VAD setting process.

In addition to tariff recognition, the Chilean regulatory framework includes specific regulatory instruments that guide the management of non-technical losses. In particular, the Regulations of the General Law of Electrical Services, contained in Supreme Decree No. 327 of 1997, establish explicit provisions regarding irregular connections. Article 157 of said regulation states that, when the Superintendence of Electricity and Fuels (SEC) confirms the existence of an alteration of the facilities or metering equipment, the distribution company is empowered to charge for the unregistered energy (CNR) and, when appropriate, initiate the relevant legal actions, operating these mechanisms as deterrent instruments against this type of conduct.

In terms of transparency and reporting, distribution companies report their loss levels as an input for modeling the VAD determination process. This information is used for methodological and comparative purposes, without direct corrective or sanctioning effects on real companies. The background information associated with the tariff studies is public and is available on the institutional website of the National Energy Commission, in the section corresponding to the Value Added of Distribution.

Regarding the role of distributors and enforcement authority, the Regulations of the General Law of Electric Services establish that, upon detection of non-technical losses confirmed by the SEC, companies can proceed to collect unregistered energy and initiate legal actions. In addition, Article 147 of the same regulation provides that, in the event of non-payment, the distribution company may cut off the electricity supply, once 45 days have elapsed since the expiration of the first unpaid account and prior notice to the user at least 5 days in advance, incorporating procedural safeguards aimed at protecting the user.

Finally, loss reduction in distribution systems can be strengthened through a combination of regulatory and technological measures. Among the actions highlighted are the identification and replacement of assets with technical losses higher than expected parameters; the development and integration of databases that allow characterizing and monitoring non-technical losses; deepening the digitalization of networks, including smart metering, real-time monitoring, and advanced analytical tools; and the maintenance of economic signals in tariff processes that encourage the reduction of losses. In addition, the relevance of public policies aimed at reducing the socioeconomic incentives associated with generating non-technical losses is recognized, as well as dissuasive and educational measures that promote regulatory compliance and responsible use of energy.

COLOMBIA

In Colombia, the level of electrical losses recognized in distribution tariffs is defined differeNTLs y by voltage level, in accordance with the provisions of the General Annex of Resolution CREG 015 of 2018 . For systems with nominal voltage greater than or equal to 57.5 kV and less than 220 kV, the recognized losses are calculated monthly through energy balances for each Regional Transmission System (STR), using information managed by the Liquidator and Account Administrator (LAC) of the electricity market. However, this mechanism does not yet apply to all distributors, because some have not met the necessary technical requirements; In such cases, losses continue to be estimated using hourly load flows based on historical information, with a progressive migration towards the energy balance scheme. For systems with a voltage between 1 and 57.5 kV, the recognized losses are determined from load flow studies carried out by the grid operators and reviewed by the regulator, remaining constant throughout the tariff period. For systems with a voltage of less than 1 kV, in addition to a methodology similar to the systems just described, a non-technical loss component is explicitly recognized, calculated based on variables of the commercializing market, such as kilometers of rural networks and energy sold in special areas characterized by high levels of losses, low levels of collection or informal conditions.

In addition, the current methodology incorporates a mechanism for the recognition of additional non-technical losses associated with the level of investment executed by the distributor in the previous year, with the aim of encouraging investments aimed at reducing losses. This mechanism allows, in the first year of the tariff period, to recognize up to all the losses recorded in systems with a voltage of up to 1 kV at the beginning of the period, subsequeNTLs y establishing a linear path of reduction over a ten-year horizon, until converging towards levels considered efficient. Access to this scheme is conditional on compliance with regulatory requirements and is explicitly regulated in Resolution CREG 015 of 2018.

As a complementary regulatory instrument, the CREG introduced the Loss Reduction Plan, to which distributors that had losses in their systems with a voltage level lower than 1 kV higher than those recognized at the beginning of the tariff period could apply. Companies that accessed this mechanism had to submit a plan that included an annualized loss reduction path for a ten-year horizon, the cost of the plan, and the Total Loss Ratio (TPI) at the beginning of the period. Likewise, the regulator defined maximum amounts to be remunerated, intended for specific investments for the reduction of non-technical losses (such as meters for user legalization, metering equipment at entry points by voltage level, feeder meters in transformers and centralized metering systems) using an efficiency model based on neural networks trained with data from companies considered efficient. It should be noted that, during the first five years of application of this scheme, there was no positive correlation between the receipt of these incentives and the effective reduction of the loss indicator.

In terms of transparency and reporting, the Total Loss Index (TPI) is a regulatory obligation only for distributors that applied to the Loss Reduction Plan. This index is calculated by the Market Administrator (XM S.A. E.S.P.) based on the information on trade borders managed by the ASIC and the records of the Unified Information System (SUI), under the supervision of the Superintendence of Residential Public Services (SSPD). The information is mainly used to evaluate the annual fulfillment of the goals defined in the reduction path and determine the continuity, suspension or cancellation of the incentives. The data used for this monitoring are not public on an individual basis; however, the CREG has published aggregate analyses and sectoral diagnoses that allow observing the evolution of losses at the national level, such as draft resolution CREG 701 090 of 2025 .

Regarding the role of distributors and enforcement authority, they have the power to inspect facilities, suspend or terminate contracts in the event of fraud, recover unbilled consumption (generally up to five months backwards, extendable if fraud is proven) and criminally report the crime of fraude de fluidos (energy theft) to the prosecutor's office, with police support when deemed necessary. In this context, the SSPD has established specific technical-legal procedures that guarantee the right of the user to challenge the energy recovery processes, including the review of minutes, technical tests and calculations, with the possibility of a claim before the Superintendence itself. CurreNTLs y, the CREG is updating the user protection regime, in force since Resolution CREG 108 of 1997.

Finally, it is identified that the strengthening of loss reduction in Colombia requires advancing in the massification of advanced metering infrastructure (AMI), harmonizing regulatory developments with the current legal framework; evaluate alternative incentive schemes, including the remuneration of additional assets for loss management, the use of data analytics and artificial intelligence, macro metering and symmetric incentive mechanisms; and continue to ensure a tariff design that reflects efficient costs and preserves the financial sustainability of the service. In addition, the need to improve social targeting criteria is identified, migrating from strata-based schemes to more precise vulnerability approaches, and to strengthen social management and focused control programs in areas with higher volumes of unbilled energy.

COSTA RICA

In Costa Rica, the regulation of the electricity service corresponds to the Public Services Regulatory Authority (ARESEP), in an institutional context characterized by a high participation of public and social economy companies. The provision of electricity distribution service is mainly carried out by the Costa Rican Electricity Institute (ICE), including the National Power and Light Company (CNFL), together with rural electrification cooperatives and municipal companies. This model has made it possible to achieve high levels of universal coverage and access, configuring an environment where loss management is closely linked to security of supply and social responsibility objectives.

From a regulatory point of view, the marketing and treatment of losses are governed by the technical standard "Supervision of the electricity supply in low and medium voltage" (AR-NT-SUCOM, updated as of October 2024). This regulation grants clear lines and explicit powers to distribution companies. Among its provisions are the prohibition of tampering with measuring equipment (Art. 20), the authorization of entry to buildings for inspections (Art. 30), and the guidelines against damages, illicit use, resale of energy and suspension of service. Likewise, the regulations expressly prohibit companies from providing electricity service totally or partially free of charge (Art. 33).

With respect to tariff recognition, Costa Rican regulation does not explicitly distinguish between technical and non-technical losses, but operates under a scheme of global recognition of losses with a maximum limit. This cap is calculated based on the average value of electrical losses for the entire distribution industry during the two years prior to the year of fixation. In this way, if a company registers losses below the ceiling, its real value is recognized; however, if its losses exceed the historical industry average, the surplus is not transferable to the tariff and constitutes a direct financial loss for the distributor. This mechanism acts as a strong economic incentive (and an indirect sanctioning measure) for the reduction of losses, also highlighting that this cap does not include adjustment factors for socioeconomic, demographic or crime variables present in the different concession areas.

With regard to the treatment of fraud, when illicit use is detected (whether by inspection, maintenance or reporting), the regulations support a standardized procedure. This includes the collection of evidence, the metering normalization and the determination of the unbilled energy by analyzing variations in the historical consumption pattern (comparing consumption before and after the irregularity). The collection is managed through internal processes that, depending on the amount, can be taken to court.

To ensure transparency and monitoring of these indicators, companies are required to report their loss levels annually to ARESEP as part of tariff studies, in addition to submitting their available energy and sales balances monthly. This information is public and is hosted on the ARESEP Open Data portal, evidencing, as an example, that the total losses of the ICE have remained in a stable range between 7.5% and 8.3% during the period 2019-2024.

Finally, at the level of business management, the ICE Group complements these regulatory requirements with its Corporate Energy Loss Management Policy. This policy establishes an integrated approach that combines technical actions (improvement of networks, macro-metering), commercial (control of irregular consumption) and social actions. In this way, it is recognized that informal and insecure connections must be addressed not only from punitive inspection, but with criteria of safety, inclusion and sustainability, prioritizing the regularization of supply.

CUBA

The Cuban electricity system operates under a fully state-owned and vertically integrated model, in which the generation, transmission, distribution and retail of electricity are the responsibility of the State, mainly through the Electricity Union (UNE) and its subordinate companies. There is no competitive electricity market or functional separation between activities, and the planning of the sector responds to centralized criteria defined by the Ministry of Energy and Mines. In this context, electricity tariffs are administratively regulated and play an explicit social role, with extensive cross-subsidies and fiscal transfers aimed at guaranteeing universal access to the service.

In Cuba there is no explicit tariff recognition scheme for electricity losses, neither technical nor non-technical, comparable to the models used in regulated market systems. The losses are part of the overall operating balance of the electricity system and their cost is absorbed by the State as part of the general financing of the sector. Tariffs are not adjusted for firms' loss performance, nor are they used as an economic signal to incentivise reduction. The tariff review responds mainly to public policy decisions and fiscal availability, rather than to periodic processes of efficient cost review.

The management of electrical losses is fundamentally addressed as a technical-operational and social discipline problem, rather than as a regulatory-economic challenge. The energy authorities establish internal loss reduction plans, mainly aimed at improving metering, modernising networks and controlling illegal consumption. No formal regulatory goals with differentiated economic consequences for companies are identified, since they do not operate under a regime of autonomous financial incentives.

However, the Cuban regulatory framework contemplates administrative and criminal sanctions for energy theft and the manipulation of electrical installations, which are applied by state bodies in coordination with the judicial system. These sanctions serve a deterrent function, although their effectiveness depends to a large extent on operational inspection capacities and the socio-economic context.

State-owned electricity companies prepare energy balances and internal loss reports, which are used by the sectoral authorities for planning, diagnosis and operational control purposes. However, this information is not published in a systematic or disaggregated manner, and its use is predominaNTLs y internal. There is no independent regulatory audit system or mechanisms for comparison between companies, given the monopolistic and state nature of the sector. The loss information is integrated into general sectoral reports and technical diagnoses, without direct tariff or sanctioning effects associated with their level.

The Cuban State has broad enforcement authority in the face of non-technical losses. Theft of electricity and illegal connections are classified as serious offences, subject to administrative and criminal sanctions. The electricity companies, in coordination with security bodies and local authorities, can proceed to cut off the supply, remove irregular connections and apply fines. The prosecution of electricity fraud is integrated into a broad state control scheme, where inter-institutional coordination is guaranteed by the centralized design of the system itself.

From a comparative perspective, the Cuban experience shows that a high degree of state control and heavily subsidized tariffs does not in itself eliminate the existence of non-technical losses, especially in contexts of prolonged economic restriction. Reducing losses is critically dependent on the capacity to invest in infrastructure, the availability of reliable metering technology and the stability of supply. The absence of explicit economic incentives and transparency mechanisms limits the use of losses as a performance management tool, although the model allows for direct and coordinated enforcement action. In this sense, Cuba is a reference case for analyzing the limits of purely administrative approaches to the management of non-technical losses, in contrast to regulatory schemes based on economic incentives and tariff signals.

EQUADOR

In Ecuador, the public electricity service operates under a mostly state-owned and regulated scheme. Distribution is carried out by regional publicly owned companies, mainly the National Electricity Corporation (CNEL EP), which serves about 48% of regulated customers, and municipal or regional companies (Quito, Centrosur, Ambato, Riobamba, Loja, among others). Marketing to end customers is carried out under a single national tariff sheet, with the exception of a small number of large consumers authorized to contract under unregulated conditions. The system has a high concentration of small consumers, complemented by targeted subsidy policies, such as the Dignity Tariff, aimed at vulnerable households.

Rate loss recognition is based on a partial recognition approach. The regulation defines a maximum level of recognized losses, which is incorporated into the tariff calculation by means of voltage level loss factors. Losses that exceed this threshold are not transferred to the tariff and must be absorbed by the distributor, generating an economic signal aimed at efficiency. This recognized level has been gradually reduced in line with national efficiency targets, curreNTLs y aligned with the domestic target of reaching 10.5% total losses by 2025. The updating of the distribution tariff parameters, including recognized losses, is carried out periodically, with annual reviews based on the information reported by the companies. The regulator (ARCERNNR) has stated that it is also developing specific technical regulations for the definition of admissible losses, which will allow differentiating objectives by type of service area; the foregoing considering that there is curreNTLs y no official regulation in force in this matter published.

In addition to tariff recognition, the Ecuadorian framework contemplates complementary instruments for loss management. Of note are the official goals established in sectoral plans, the loss reduction plans at the business level, and the possibility of financing specific investments via tariffs, such as network modernization, advanced metering, customer standardization, and strengthening of business processes. The periodic publication of statistics on losses by company also introduces a reputational incentive, which is relevant in the context of public companies subject to political and social control.

Distributors are required to report their energy balances to the regulator on a monthly basis, disaggregating technical and non-technical losses. This information is audited, used for tariff, comparative and corrective purposes, and is widely available to the public through statistical reports on the electricity sector, constituting a central input for regulatory oversight and policy formulation.

In relation to the powers against non-technical losses, distribution companies can inspect facilities, suspend irregular supplies, recover unbilled energy and apply administrative charges, in accordance with current regulations. The theft of electricity is classified as a criminal offense, which enables the complaint to the Prosecutor's Office and coordination with the National Police. These actions are complemented by regularization and inclusion programs, aimed at informal settlements and vulnerable users, seeking to balance fraud control with the protection of access to the service and the security of the facilities.

In this way, strengthening loss reduction in Ecuador requires consolidating specific technical regulations, advancing in a more efficiency-oriented tariff methodology, accelerating the execution of investment projects, deepening the deployment of smart metering, and reinforcing the social and community approach in areas of high vulnerability. Accumulated experience shows that an integrated strategy, combining economic signals, public investment, institutional control, and social policies, has allowed for substantive progress, although challenges remain in converging towards levels of losses comparable to the most efficient systems in the region.

EL SALVADOR

In El Salvador, the level of electricity losses recognized in the tariff is defined through the methodology for the calculation of Distribution and Marketing charges, which constitutes the integrated tariff study that sets the reference charges for a period of five years. This methodology contemplates the preparation of a specific study of energy losses in medium and low voltage distribution networks, from which the losses to be recognized for tariff purposes are determined. In this framework, 100% of technical losses and up to 50% of justified non-technical losses are recognized, with the rest of the latter remaining as risk that is not transferable to tariffs. The implementation and updating process is executed by the distribution companies and reviewed by the General Superintendence of Electricity and Telecommunications (SIGET), and is based on energy purchase and sales balances, along with the consolidation and modeling of commercial and network information to estimate losses through power flows. The resulting percentages are translated into factors that feed the tariff component associated with losses, transferring its efficiency to the end user throughout the five-year period.

Beyond tariff recognition, the Salvadoran regulatory framework includes specific regulatory instruments for the management of non-technical losses, highlighting the Procedure for Irregular Conditions (Agreement 283-E-2011), which regulates the detection, inspection, documentation, verification of metering equipment, calculation and recovery of unregistered energy, as well as the treatment of disputes. In addition, the tariff methodology itself introduces a cost-effectiveness criterion, establishing that the component associated with theft or fraud is only recognized when its elimination is not economically justifiable, which acts as an implicit incentive to prioritize efficient measures. At the operational level, activities such as inspections, meter readings and suspension of service are part of the usual control processes.

In terms of transparency and reporting, distributors report to SIGET every six months electricity statistics that include technical and non-technical losses, which are mainly for statistical purposes and do not modify the levels of losses recognized in the tariff during the five-year period. This information is publicly accessible through the SIGET statistical bulletin. In parallel, global losses can be certified by the regulator when they are required for tax reporting to the Ministry of Finance. In cases of irregular conditions, SIGET maintains powers to verify calculations of unrecorded energy recovery, using the information for corrective and technical purposes.

Regarding the role of distributors, they have regulated enforcement authority to face non-technical losses, including inspections, suspension or disconnection of supply in extreme cases, demand for guarantees and reconnection collection, all under the Terms and Conditions to the End User approved by SIGET, which limits business discretion. There is coordination with institutions such as the police, municipalities and community organizations, especially in contexts where control and security measures promoted by the central government are implemented. The balance between user control and protection is guaranteed through regulatory supervision of the actions of distributors and the existence of formal complaint channels, both with companies and through SIGET's User Service Centers (CAU).

Finally, opportunities are identified to strengthen the current scheme, including the evolution towards performance instruments with verifiable goals and incentives, the promotion of the deployment of advanced metering and predictive analytics, the reinforcement of inter-institutional coordination and the deterrent capacity in the face of serious or repeat cases, and the integration of a social approach that combines control with regularization, inclusion and adapted payment mechanisms to reduce losses without disproportionately affecting vulnerable users.

SPAIN

Spain operates a liberalised electricity system, with a separation between distribution (regulated activity, under a natural monopoly regime by area) and commercialisation (competitive activity). Distribution is remunerated via tolls and regulated remuneration, while marketers acquire energy on the market and supply consumers under competitive conditions, with a regulated price supply segment (PVPC) also coexisting for certain consumers. In this framework, electrical losses are managed as part of the energy metering, settlement and allocation processes, with standardized rules and regulatory oversight. This process is regulated by the Unified Regulation of Metering Points of the Electricity System (Royal Decree 1110/2007), which establishes the operation of the metering system and the Electricity Metering Information System (SIMEL).

According to the CNMC, the procedure for covering losses is mainly implemented through marketers, who must "increase" ex ante the energy acquired for delivery at a network point using standard loss coefficients, differentiated by voltage level, hourly period, calendar, among others. SubsequeNTLs y, in the metering settlement, the imputed losses are adjusted to reflect the actual losses, applying an adjustment coefficient that allows demand and generation to be equalized. ConsequeNTLs y, the standard coefficients are periodically adjusted to maintain their alignment with the reality of the system and ensure consistency between ex ante imputation and ex post closures.

In addition to the recognition through standard coefficients and their adjustment, the existence of economic incentives of the bonus/malus type aimed at network operators to reduce loss levels is reported, which is also regulated by Royal Decree 1110/2007. In addition, when distributors are detected with losses greater than what is reasonable, the CNMC carries out a technical inspection aimed at ensuring that the losses are as close as possible to the technical losses, establishing that non-technical losses, when detected, are not allowed. It is also stated that, in previous periods in which the levels of NTLS s were higher, companies were allowed to appropriate a percentage of the value of the fraud detected, as a specific incentive mechanism (today not described as in force, but as a precedent).

In terms of transparency and monitoring, it is indicated that it uses the national system of measures SIMEL, managed by the system operator, which receives measurements from secondary concentrators and allows the CNMC to estimate loss levels for three main purposes: (i) the calculation of standard loss coefficients; (ii) the calculation of incentives to reduce losses; and (iii) the detection of anomalous losses that trigger inspection activity. In this scheme, metering information functions as a basis for economic regulation and for corrective performance supervision.

In the event of detection of NTLS s, distributors are authorized to suspend the supply until regularization, re-invoice the unpaid energy, and initiate legal proceedings for electricity fraud, in addition to the obligation to inform the competent administrations and the affected parties of situations of fraud or other anomalies. With regard to the balance with the protection of vulnerable users, the CNMC highlights explicit instruments: electricity social bonus (regulated discount on bills, in 2025 between 42.5% and 57.5% depending on vulnerability, applicable to consumers covered by the PVPC and who meet requirements), thermal social bonus (complementary annual aid associated with the electricity bonus) and restrictions on supply cut-off by extending deadlines and impossibility of cutting off for severely vulnerable people at risk of exclusion social (with co-financing of social services) and other cases; Additionally, the extension of prohibitions on cuts in basic supplies to vulnerable consumers until December 31, 2025 is indicated.

Thus, the changes necessary to strengthen loss reduction would already be implemented and agents would have incentives to act in line with the interests of the system. In particular, the recent implementation of quarter-hourly metering is noteworthy, which, together with telemetry, would improve the control of non-technical losses. It is also noted that a regulation has been proposed to the competent ministry to improve the treatment of electricity fraud and provide greater legal certainty in detection and processing procedures.

GUATEMALA

In Guatemala, the level of electricity losses recognized in the tariff is defined within the framework of the process of setting the Distribution Value Added (VAD), which is carried out on a five-year basis, as established by the General Electricity Law and its Regulations. In this process, the National Electric Energy Commission (CNEE) determines the efficient costs of a model company, including a recognized level of losses that is part of the tariff calculation. In accordance with current regulations and the information gathered in the interview, the recognition of losses is based on technical and economic criteria associated with the efficient operation of the networks, without the regulator automatically recognizing the total losses effectively incurred by the companies. Losses above the recognized level must be absorbed by the distributor, configuring an economic signal oriented to efficiency. The available information does not allow us to identify an explicit and public disaggregation between technical and non-technical losses within the tariff recognition, beyond their incorporation via parameters in the design of the model company.

In addition to tariff recognition, the Guatemalan regulatory framework includes regulatory and operational instruments that guide the management of non-technical losses. Among them are the Technical Standards for Distribution Service, which regulate the conditions of connection, metering, inspection, suspension of supply and obligations of users and distribution companies. The information reviewed shows that reducing losses is a permanent priority for the regulator and companies, particularly in areas with a high incidence of fraud, and that actions are focused on early detection, standardization of supplies and strengthening of metering and control systems. In the public regulation analyzed, no explicit numerical regulatory goals for reducing losses imposed by the CNEE are identified, nor are there formal schemes of additional incentives other than tariff recognition and the economic signal associated with unrecognized losses.

In terms of reporting and use of information, as established by the General Electricity Law and its Regulations, distributors must periodically report to the CNEE operational and commercial information relevant to tariff and inspection processes, including information associated with energy balances. This information is mainly used for regulatory and supervisory purposes, in particular for the determination of tariffs and the evaluation of the performance of companies in relation to efficiency assumptions. Some of the tariff and regulatory background is publicly accessible, although detailed information on losses at the company level is mainly used in internal regulatory processes and is not necessarily systematically disclosed in public comparative reports.

With respect to the role of distributors and enforcement authority, the Guatemalan legal framework empowers companies to inspect facilities, suspend supply in cases of illegal connections or manipulation of metering equipment, and charge for unregistered energy, in accordance with the procedures established in technical and contractual regulations. The theft of electricity is typified in national legislation (Decree 8-2023), which enables criminal complaints in cases of fraud. In addition, in areas of high social conflict, companies tend to coordinate their actions with local authorities and security forces, seeking to balance the effectiveness of control with the safety of personnel and continuity of service. Likewise, the importance of advancing in processes of regularization and formalization of supply in informal settlements is recognized, as a complement to strictly punitive measures.

Thus, strengthening the reduction of non-technical losses in Guatemala requires deepening the modernization of metering systems, improving the quality and traceability of commercial information, and strengthening inter-institutional coordination to confront electricity fraud as a cross-cutting phenomenon, complementing these actions with measures focused on areas of greater social vulnerability. The experience gathered suggests that the combination of economic signals via tariff, clear operational powers for distributors and regularization strategies constitutes a central pillar to advance in the sustainable reduction of non-technical losses, while maintaining user protection and service stability.

HONDURAS

The Honduran electricity sector operates under a state-dominated wholesale market scheme, where the National Electric Power Company (ENEE) maintains a central role in transmission and distribution, while generation is carried out through a combination of public and private assets. In recent years, the country has promoted reforms aimed at improving the financial sustainability of the system, including the functional separation of activities within ENEE and the strengthening of the regulatory role of the Electric Energy Regulatory Commission (CREE). Electrical distribution faces relevant structural challenges, with high levels of total losses, where non-technical losses constitute a significant component. In the period 2024-2025, total losses (technical and non-technical) have been recorded of around 35-36%, according to sector reports and specialized press.

As reported by the CREE, the level of electricity losses recognized in the tariff is defined within the framework of the tariff review processes (Electricity Distribution Service Regulations), using the energy balance of the distribution system as the main input. Recognized losses are established as a regulated parameter that is part of the tariff calculation, differentiating between technical and non-technical losses at a methodological level, although in practice recognition is usually carried out in aggregate form. The review of these parameters is carried out on a regular basis, associated with tariff processes that include the updating of efficient costs, allowing the level of losses recognized to be adjusted according to the evolution observed and the sectoral policies in force.

In addition to tariff recognition, the Honduran regulatory framework includes control instruments, goals, and indirect incentives to guide the reduction of losses, particularly in the context of the recovery and sustainability policies of the electricity subsector. The CREE has incorporated into the regulations performance indicators linked to losses within the regulatory monitoring of the distributor, and there are explicit commitments by the State to reduce them. However, the experience reported indicates that direct economic incentives are curreNTLs y limited and that the effectiveness of these instruments depends to a large extent on the operational and financial capacity of the distribution company to carry out sustained control, investment and regularization actions.

Companies in the subsector are required to periodically report operational and commercial information to the CREE, including data on purchased energy, billed energy, and loss levels. This information is used for the purposes of supervision, corrective analysis and support for tariff processes. The regulator may also require additional information, carry out technical verifications or request audits when relevant inconsistencies are identified. Aggregated loss data are part of sectoral reports and official documents, contributing to transparency and public monitoring of the system's performance, although the availability of detailed disaggregation remains a challenge.

The Honduran legal framework criminalizes the theft and fraud of electricity in accordance with the Penal Code and applicable sectoral regulations. Distribution companies have the power to inspect supplies, suspend service in the event of irregularities, rebill unmetered energy and report the facts to the competent authorities. The criminal prosecution of electricity fraud involves coordination with the Public Prosecutor's Office and other security agencies, although the experience reported shows practical limitations in the effective and sustained application of these powers, especially in areas of high social and territorial vulnerability.

Thus, the sustainable reduction of non-technical losses in Honduras requires simultaneous progress on several fronts: (i) strengthening the mechanism for calculating and recognizing losses, improving the disaggregation and traceability between technical and non-technical losses; (ii) strengthen metering, information and commercial control systems; (iii) provide the regulatory framework with clearer economic signals that align the distributor's management with explicit loss reduction objectives; and (iv) deepen inter-institutional coordination to address electricity fraud in conjunction with social and territorial policies. The Honduran experience shows that, in contexts of structurally high losses, regulatory instruments must be complemented with operational capacities, sustained investment, and inclusion approaches that allow transitory reductions to be transformed into lasting improvements in the system's performance.

MEXICO

Mexico operates an electricity system with a predominance of the State and with the public transmission and distribution service under State conduction . In this context, distribution and basic supply are mainly provided through the Federal Electricity Commission (CFE), while the wholesale market is coordinated by CENACE and maintains private participation in generation within the limits and conditions defined by current regulations.

The tariff recognition of losses (including technical and non-technical losses) is part of the Regulated Tariffs scheme and the methodologies to be issued by the regulatory authority. In particular, the Electricity Sector Law (DOF 18-03-2025) establishes that the CNE must issue, through general administrative provisions, the methodologies to determine the calculation and adjustment of the Regulated Transmission and Distribution Tariffs (among other components). The Law also specifies that the Regulated Tariffs for transmission and distribution must allow efficient costs to be recovered and a reasonable return, including technical and non-technical losses in accordance with the standard determined by the CNE. In addition, the Law provides that the CNE must apply these methodologies for the calculation and adjustment of Regulated Tariffs (and the final tariffs of the basic supply), and that it must publish the calculation reports used, reinforcing the principle of regulatory traceability.

With respect to the periodicity of review/update, neither the Law nor the Regulations establish in these articles a rigid cycle (e.g., annual or five-year). Rather, the regulatory framework refers the operational definition to the methodologies and administrative provisions issued by the CNE (i.e., periodicity is endogenous to the methodological design of "calculation and adjustment"). The Regulations of the Electricity Sector Law (DOF 03-10-2025) reinforce this approach by stating that electricity tariffs must consider the recognition of costs and that the CNE, in coordination with the Secretariat, must establish the methodologies for the determination of tariffs and the regulatory accounting guidelines; and it also requires the publication of relevant information on the process, including calculation reports.

In addition to the tariff component, Mexico uses sectoral policy and management instruments that have an impact on losses: sectoral plans and network modernization programs (including metering, instrument transformers, telemetering/monitoring, and connection replacement), along with public monitoring of aggregate indicators. In practice, the recent emphasis has been on operational and technological actions (e.g., metering and infrastructure modernization) to reduce both technical and non-technical losses.

Regarding reporting and transparency, loss information is published in aggregate form in official sectoral planning/monitoring documents and also through institutional/business reports. In particular, SENER has disseminated recent national results of losses and their evolution, which enables comparative uses and public monitoring.

In relation to powers in the event of non-technical losses, the federal criminal framework classifies the use or exploitation of electrical energy without the right as conduct equivalent to theft (Federal Penal Code, art. 368, section II), enabling criminal prosecution when appropriate. Operationally, the distributor can carry out inspection, detection and regularization actions, and coordinate with competent authorities in cases that escalate to the criminal sphere, trying to reconcile the control of illicit acts with continuity of service and attention to vulnerable users (in a system with a high proportion of residential users).

Finally, from a regulatory and institutional strengthening perspective, the challenges are associated with: (i) deepening the modernization of networks and metering to sustain loss reduction, (ii) improving inter-institutional coordination to effectively combat theft/fraud, and (iii) maintaining economic and management signals that allow for the consolidation of reduction trajectories, especially in territories with a higher incidence of non-technical losses.

PANAMA

In Panama, the recognition of the level of electricity losses in tariffs is part of the Tariff Regime of the Public Distribution and Marketing Service, regulated in Title IV of the Distribution and Marketing Regulation (RDC) and in the Methodology for Calculating the Maximum Allowed Income (IMP). Within this framework, the regulator estimates efficient losses by means of efficiency equations, applied to historical data and characteristics of each distribution network – such as energy injected, number of customers and maximum demand – using regressions or other statistical methods whose parameters are set by resolution of ASEP in each tariff period. The resulting value is incorporated directly into the structure of the IMP and, therefore, into the tariff formula.

In addition, the Panamanian regulatory scheme contemplates an additional recognition of non-technical losses considered unmanageable by the distributor, particularly those associated with red zones or invasions. For example, in the tariff period July 2022–June 2026, the methodology included an additional recognition for estimated non-technical losses in these territories, which is expressed as an absolute percentage that is added to the efficient losses and translates into an additional income within the IMP, accompanied by the regulatory expectation that the company will execute loss reduction plans. The tariff period in Panama lasts for four years, during which the recognized parameters remain in force.

In addition to tariff recognition, the Panamanian regulatory framework includes additional instruments that guide loss management. These include implicit regulatory goals derived from the loss parameter set by ASEP in each tariff review, the possibility of requiring specific investment plans aimed at reducing losses (sectorization, advanced metering, regularization of customers, among others), and the non-recognition of excessive losses in tariffs, which operates as a natural economic incentive to improve performance.

In terms of transparency and reporting, distributors are obliged to report monthly information to ASEP on energy purchased, sold, own consumption and losses, as well as to submit technical reports and justify significant variations in their indicators when required by the regulator. This information is used for comparative, corrective and sanctioning purposes, allowing the evaluation of relative performance between companies, identifying critical areas, supporting tariff processes and feeding instances of public consultation. A relevant part of this background is publicly accessible and is available in the monthly indicators and in the documents associated with the tariff processes published by ASEP.

With respect to the role of distributors and enforcement authority, in the event of the detection of non-technical losses – such as theft, manipulation of meters or illegal connections – companies can suspend the service, regularize the supply through the installation of meters or formal connections when the user proves rights over the property, collect the unbilled energy and report the facts, since the theft of energy is classified as a crime. In areas authorized by ASEP, the implementation of prepaid meters is also allowed in accordance with current regulations. These actions can be coordinated with the National Police and the Public Prosecutor's Office, particularly in mass operations or judicial cases.

The need to balance control with social sensitivity is recognized, promoting the regularization of settlements by the competent institutions, the use of prepaid tariffs for qualifying customers, energy education campaigns, and the installation of smart meters and protected equipment to reduce estimates and fraud. From the regulator's perspective, strengthening loss reduction involves the definition of explicit and growing targets, greater deployment of smart grids, binding monitoring of investments and theft control programs, and structured inter-institutional coordination, including security, justice, social development, and housing, especially aimed at the regularization of red zones and settlements. identified as one of the main sources of non-technical losses.

PARAGUAY

The Paraguayan electricity sector is characterized by a vertically integrated state structure, in which the National Electricity Administration (ANDE) exclusively exercises the functions of generation, transmission, distribution and retail. There is no competitive electricity market or functional separation between activities, and the planning, operation and definition of tariffs respond to centralized State guidelines. In this context, ANDE acts simultaneously as system operator and provider of the public electricity service, under the supervision of the Vice Ministry of Mines and Energy (VMME).

According to the information reported, in Paraguay there is no explicit and differentiated recognition of electricity losses in the tariff, nor a formal mechanism that defines recognized levels of technical or non-technical losses. Electricity tariffs are set at the national level through administrative resolutions, considering general criteria of system costs, but without incorporating specific methodologies of model company, benchmarking or regulatory goals associated with losses. ConsequeNTLs y, losses, including non-technical losses, are absorbed as part of ANDE's overall economic result, without direct tariff signals that encourage their reduction. The tariff review does not respond to a fixed periodicity nor is it linked to systematic evaluations of performance in terms of losses.

The management of electricity losses in Paraguay is mainly approached from an operational and administrative logic, rather than a regulatory one. As reported, there are no formal regulatory goals or loss reduction plans with explicit economic consequences. The actions to deal with non-technical losses are implemented as part of ANDE's internal programs, aimed at detecting irregularities, standardizing supplies and improving business processes. These initiatives depend fundamentally on budget availability and the priorities defined by the state-owned company, without being integrated into a scheme of incentives or regulatory penalties.

ANDE carries out internal energy balances that allow estimating the total losses of the system, including those associated with distribution. However, as there is no regulator constituted, there is no formal obligation to periodically report losses for sanctioning or comparative purposes, nor a specific external audit system to validate these indicators. Loss information is used primarily for internal diagnostic and operational planning purposes, and its publication is limited and aggregated. In this sense, the regulatory use of loss information is limited, and it is not used as a systematic input for the definition of tariffs or for the evaluation of institutional performance.

The Paraguayan legal framework classifies the theft of electricity as a punishable offense, granting ANDE powers to detect illegal connections, suspend the supply and apply administrative sanctions. In addition, cases of fraud may be referred to the judicial system in accordance with the criminal legislation in force. However, it is indicated that inter-institutional coordination with other State entities (prosecutor's office, police, municipalities) is limited and is mainly activated in a reactive manner in specific situations, rather than through permanent protocols of joint action. This conditions the effectiveness of the prosecution of electricity fraud, especially in contexts of persistent informality.

In this way, strengthening the reduction of non-technical losses in Paraguay requires moving towards a more structured approach, which transcends the internal operational management of the state-owned company. Among the challenges identified are the need to improve mechanisms for controlling and monitoring losses, strengthening inter-institutional coordination for the prosecution of fraud, and advancing in awareness and prevention campaigns aimed at the population. The Paraguayan experience shows that, in the absence of explicit economic signals, regulatory incentives or accountability schemes associated with losses, the sustained reduction of non-technical losses depends to a large extent on administrative decisions and the operational capacity of the company, which limits the stability and predictability of results over time.

PERU

In Peru, the level of electricity losses recognized in the tariffs is defined within the framework of the calculation of the Distribution Value Added (VAD), in accordance with the provisions of Article 143 of the Regulations of the Electricity Concessions Law (RLCE). This framework recognizes standard physical (technical) losses and trading (non-technical) losses. Efficient technical losses are determined based on the optimization of the electrical installations of an efficient model company, considering networks technically and economically adapted to the demand served by the real company and compliance with technical quality standards (including maximum voltage drop tolerance). As for non-technical losses, the RLCE establishes that they cannot exceed 50% of physical losses; Its level is set for each company based on the studies presented by the concessionaires and the historical levels used in previous regulations. Standard losses are determined and updated each regulatory period, with a periodicity of four years.

In addition to tariff recognition, the Peruvian regulatory scheme seeks to generate economic incentives to reduce costs, including costs associated with losses. In practice, a percentage of efficient losses is recognized in the tariff, so that if the distributor registers losses lower than those recognized, it obtains additional income, operating this design as an explicit incentive to efficiency. In addition, in certain cases, projects aimed at technological innovation and/or energy efficiency with a focus on reducing losses are recognized in the tariff. At the same time, energy theft can be sanctioned as a criminal offense under the Penal Code, constituting a legal endorsement of loss management by concessionaire companies.

In terms of transparency and reporting, distribution companies report their loss levels to the regulator on a monthly basis. This information is mainly used for regulatory process validation and for comparison between companies. The data is publicly accessible and updated quarterly; the loss levels of the main companies are published, among other means, in the quarterly bulletin “El Informativo”, where they are presented in a systematic and comparable way.

Regarding the role of distributors and enforcement authority, the Electricity Concessions Law (LCE) empowers concessionaires to immediately cut off the service, without prior notice or intervention by authorities, when energy is consumed without authorization or the conditions of supply are violated. In cases of illicit use, in addition to the collection of cutting costs and energy consumed, the persons involved may be reported to the criminal courts. Regarding institutional coordination, before carrying out an intervention, the concessionaire must notify the user in accordance with the DGE Standard “Reimbursements and Recoveries of Electrical Energy”; If the notification is difficult, a police or notarial verification is carried out. Osinergmin, for its part, has a specific procedure for monitoring the refund and recovery processes carried out by the distributors, verifying their correct application.

Finally, strengthening loss reduction requires promoting targeted investments in this area. In particular, Osinergmin has promoted technical specifications and technological standards for AMI, proposed for approval by the Ministry of Energy and Mines, recognizing advanced metering as a key instrument for reducing losses through more accurate and timely energy balances.

PORTUGAL

The Portuguese electricity sector operates under a liberalised market model, with functional and legal separation between generation, transmission, distribution and marketing. The distribution network is operated by regulated concessionaires, while marketing is carried out under a competitive regime. The Entidade Reguladora dos Serviços Energéticos (ERSE) is responsible for economic regulation, tariff definition and supervision of the performance of grid operators, in coordination with the system operator and other sectoral authorities.

According to the information reported by the ERSE, electricity losses are recognized in the tariffs by means of standard loss coefficients, differentiated by voltage level and applied ex ante to the calculation of the energy supplied. These coefficients reflect the expected efficient losses of the system and are directly integrated into the tariff structure. The level of losses recognized is reviewed periodically within the framework of regulatory processes, adjusting according to the evolution of the system and the available empirical information. This scheme allows losses to be internalized within the calculation of regulated costs, avoiding their discretionary transfer to consumers.

In addition to tariff recognition, the Portuguese regulatory framework contemplates economic incentive mechanisms aimed at reducing losses. In particular, bonus/malus incentive schemes are applied, through which the network operator can benefit economically if it achieves loss levels below the reference values established by the regulator, or be penalised if its performance is worse than expected. This approach seeks to align the operator's incentives with the general interest of the system, promoting active and efficient management of losses, including non-technical losses.

Grid companies are required to report detailed information on energy supplied, measured energy, and losses to the regulator and system operator. These data feed into national metering and settlement systems, and are used by the ERSE for purposes of supervision, tariff calculation and implementation of incentive mechanisms. Loss information is continuously monitored and published in an aggregated manner, allowing for comparative analysis and regulatory transparency. Likewise, the ERSE has the power to carry out technical audits and require additional information when relevant deviations are detected.

In the case of non-technical losses associated with fraud or manipulation of metering equipment, distribution companies have the power to suspend supply, regularize installations and rebill unmetered energy in accordance with current regulations. These procedures are clearly defined and have legal support. When appropriate, cases may be referred to judicial bodies. Institutional coordination occurs mainly between the network companies, the regulator and the competent authorities in matters of supervision and justice, within a standardized procedural framework.

Finally, it is recognized that the current regulatory framework provides adequate economic signals and sufficient tools to promote the reduction of electrical losses, including non-technical losses. The emphasis is placed on the correct calibration of loss coefficients and economic incentives, as well as on the quality of metering and reporting systems. In this context, the need for additional structural changes is not identified, considering that the current instruments make it possible to effectively align business management with the objectives of system efficiency and consumer protection.

DOMINICAN REPUBLIC

In the Dominican Republic, the level of electricity losses recognized in the tariff is determined within the framework of the Technical Tariff process for regulated users, in accordance with the methodology established by the Superintendence of Electricity (SIE). The tariff study is built from a base year, corresponding to the last closed calendar year, and considers a retrospective analysis of operating variables, where the energy and power balance of the base year constitutes the main input for the estimation of losses. The methodology contemplates a tariff review and periodic study cycles, in which the parameters recognized in the tariff are updated.

In addition to tariff recognition, loss management is guided by complementary regulatory and control instruments. These include performance goals and indicators, integrated into operational plans and reduction commitments with monitoring by the regulator, such as the Integrated Loss Reduction Plan 2022–2028. Likewise, the SIE exercises powers of inspection and administrative action, being able to request information, carry out inspections and demand corrective actions in accordance with the General Electricity Law No. 125-01 and its Implementing Regulations. In addition, there is a specific methodology for the indicators measurement of the National Electricity Pact, within which the way of calculating the loss indicator is defined.

In terms of transparency and reporting, distribution companies are required to periodically report to the SIE operational and commercial background that allows determining and monitoring the levels of total losses. This information is used for regulatory and supervisory purposes, mainly for corrective monitoring, validation of the coherence between actual performance and the assumptions recognized in the tariff, and support for administrative and regulatory processes, including tariff evaluations and, when appropriate, sanctioning actions. The SIE may also require technical or commercial verifications or specific audits in the event of relevant inconsistencies. Loss indicators and other sectoral background information are published on an aggregate and periodic basis by both the SIE and the Ministry of Energy and Mines.

Regarding the role of distributors and enforcement authority, the Dominican legal framework classifies the detection and prosecution of non-technical losses as a criminal action of a public nature, qualifying them as Electricity Fraud or Attempted Electricity Fraud, in accordance with the General Electricity Law No. 125-01 and the Code of Criminal Procedure. The competent authorities for the lifting of the Electricity Fraud Act are the Deputy Attorney General's Office for the Electricity System (PGASE) and the SIE, acting joiNTLs y at the request of the distribution companies or the interested party. In 2024, the SIE approved a Regulation on the verification of supplies and connections, which delimits the competences of the intervening authorities, assigning the PGASE the main role of criminal prosecution and the SIE the technical support of the process. In this context, distribution companies have the obligation to cooperate with the information requests formulated by the PGASE within the framework of judicial investigations.

Thus, strengthening the reduction of non-technical losses in the Dominican Republic requires simultaneous progress in strengthening the mechanism for calculating and monitoring losses (with emphasis on the disaggregation between technical and non-technical losses, the homogenization of criteria between companies and the generation of verifiable and comparable estimates over time). as well as in the improvement of the quality, consistency and traceability of metering, billing and collection data, incorporating cross-validations and selective audits based on the energy balance as a methodological pillar. Added to this is the need to provide the regulatory framework with clearer signals, through the incorporation of incentives and, eventually, effective sanctioning mechanisms that align business management with loss reduction objectives, overcoming an approach focused mainly on programmatic commitments and administrative monitoring. It also highlights the importance of deepening inter-institutional cooperation, in particular between the Superintendence of Electricity (SIE), the Deputy Attorney General's Office for the Electricity System (PGASE) and the distribution companies, through clear protocols for the exchange of information that facilitate the detection, investigation and prosecution of electricity fraud, considering that the Dominican experience shows that, in the absence of economic and coercive signals SufficieNTLs y structured, the management of non-technical losses tends to rely to a large extent on the institutional will and management capacities of the actors, which limits the sustainability of the progress achieved.

URUGUAY

Uruguay has an electricity system where distribution and retail is strongly concentrated in UTE (public company), while the operation of the wholesale market is articulated through the sectoral institutionality defined by the electricity reform (including the Electricity Market Administration, ADME) and the regulatory supervision of URSEA in matters within its competence.

The law that structures the URSEA specifies as a regulatory objective the "application of tariffs that take into account the evolution of costs and other technical criteria" (without prejudice to the tariff policy guidelines of the Executive Branch). For purposes of control and technical consistency, the framework also contemplates the use of technical standards and procedures associated with metering and billing, which are particularly relevant to non-technical loss management (e.g., metering rules, meter control, and reconnection). In practice, the recognition of tariff costs (including components associated with energy purchase/supply, operation and management of the network and customers) is reviewed in the tariff adjustment processes defined by the authority. Likewise, URSEA's control architecture includes powers to request information from operators to fulfill their duties and sanction non-compliance with information requirements or hindering their control work.

Beyond tariff treatment, the institutional framework enables administrative sanctions for non-compliance associated with the provision of the service, safety/quality, and, crucially for NTLS , contraventions of standards and technical procedures for metering and billing, control and use of meters and reconnection. In addition, the experience in regularization/inclusion implemented by UTE stands out, such as voluntary regularization programs (without penalty if the client maintains regularity for a period) and payment facilities (for example, financing in installments).

In the fight against NTLS s, typical instruments include inspection of facilities, regularization of supplies, actions on metering/billing and, where appropriate, suspension/reconnection procedures in accordance with technical regulations and user protections. The URSEA law expressly recognizes the scope of metering, billing and reconnection as a regulable/controllable matter, which constitutes the regulatory support for practices consisting of control of NTLS s.

To make progress in reducing NTLS s, the Uruguayan case suggests strengthening (i) the systematic use of metering/telemetry and analytical tools for early detection, (ii) regularization mechanisms with a social and territorial focus (avoiding falling only into sanctions), and (iii) minimum public traceability of indicators that allows comparative monitoring (without compromising sensitive data), relying on the powers of information requirement and technical control already contemplated in the framework institutional.

As a synthesis of this international review, Table 3 presents the summary of the regulatory context related to NTLS s in each of the countries under study.

> The management of PNTs in electricity distribution systems is determined by each country

05

CLASSIFICATION OF NON-TECHNICAL LOSS MANAGEMENT MEASURES

The information collection showed that distributors have a heterogeneous arsenal of tools to address unregistered consumption, which vary significaNTLs y in terms of cost, technological complexity and approach. However, these tools do not operate in isolation; In practice, their effectiveness depends on how they are articulated within an integrated strategy.

In order to systematize the comparative experience and facilitate the reader's navigation, the study has developed a taxonomy that organizes these measures into three pillars of intervention. This classification is not arbitrary, but responds to the sequential logic necessary to manage a loss: first visibility is required, then control capacity and, finally, sustainability mechanisms.

Fig. 2 contextually illustrates this framework of analysis, where each pillar groups together measures that share a common operational objective and a distinctive functional nature:

- Pillar 1: Intelligence and Detection (Visibility). It groups those measures whose main attribute is the processing of information to identify and locate anomalies. Its function is not to stop fraud per se, but to efficieNTLs y direct operational resources to where it occurs. This includes everything from energy balances to advanced data analytics.
- Pillar 2: Control and Disincentive (Containment). It brings together physical and coercive measures to discourage network disruptions. Their distinctive characteristic is that they seek to increase the cost and difficulty of committing fraud, either through technological barriers (hardening, smart metering) or through on-site inspection (inspections and management of the human factor).
- Pillar 3: Regularization and Sustainability (Integration). It includes initiatives aimed at transforming the irregular user into a formal customer. Unlike the previous ones, these measures address the economic and social barriers to access, seeking commercial and community solutions that make payment for the service over time viable.

> “The information gathering revealed that distributors possess a heterogeneous arsenal of tools

The following chapters break down each of these pillars, analyzing in detail the specific tools that compose them, their implementation requirements and the evidence of their application in the companies consulted.

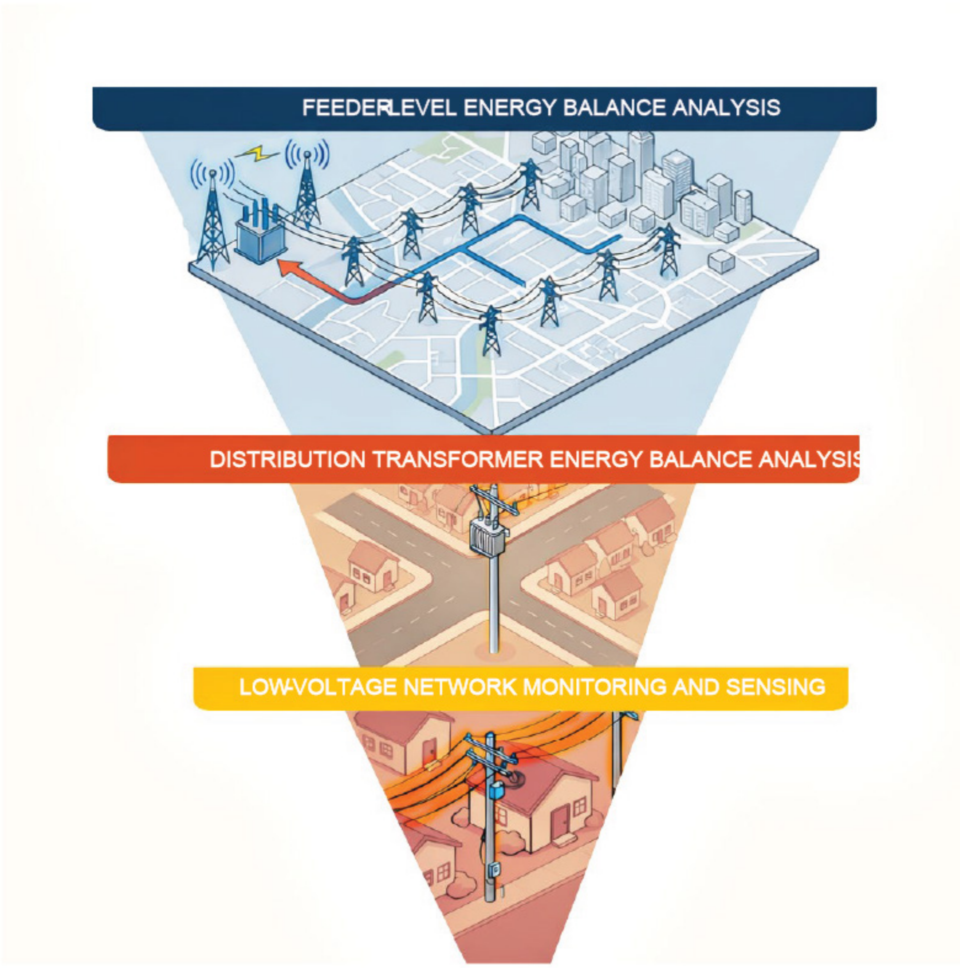
Fig. 2. Taxonomy of NTLS management measures according to their pillars of intervention: detection, control and social inclusion.

06

PILLAR 1: DETECTION AND IDENTIFICATION OF LOSSES

Non-technical losses are characterized by their heterogeneity, spatial variability and dynamics over time. Unlike technical losses, they are not evenly distributed across the network or respond to stable load patterns. In this context, loss detection and identification is the first link in any business strategy for reducing non-technical losses. Without precise information on where, how and to what extent the losses occur, subsequent inspection, sanction, investment or regularization actions tend to be inefficient. Thus, the objective is to reduce uncertainty about the origin and magnitude of losses, allowing resources to be focused where the impact is greatest.

Screening strategies have evolved significaNTLs y over the past few decades. Traditionally, they relied on random inspections and complaints, with high operating costs and limited levels of effectiveness. Progressively, these approaches have been complemented by analytical and technological tools that allow us to move from reactive detection to predictive and focused detection. This evolution has made it possible to concentrate inspection efforts in areas with a greater probability of non-technical losses, reducing the need for massive operations and increasing the effectiveness of field interventions.



In operational terms, detection and identification measures can be understood as a process of progressive narrowing of the search area, which advances from aggregate levels of the system to increasingly specific levels. This process usually starts at the substation and feeders, continues at the level of transformers and low-voltage circuits, and culminates in the identification of specific customers or connections, supported by metering information, energy balances and, in more advanced stages, end-user telemetry. This logic of gradually increasing resolution makes it possible to systematically reduce the inspection radius, improve the efficiency of field actions and lay the foundations for subsequent more precise and effective interventions.

6.1. NETWORK-LEVEL LOSS ANALYSIS AND SEGMENTATION

Energy balances are one of the central tools for detecting and locating non-technical losses. Applied to different levels of the network, they allow progress from aggregate analyses to increasingly limited territorial areas. In this framework, the balances at the feeder level and at the distribution transformer level represent two successive steps within the same segmentation logic, differing mainly by the spatial resolution and the degree of focusing they enable.

6.1.1. Feeder-level balances

The energy balances in substations and feeders are supported by metering and telemetry systems installed at the outlet of the substations, typically at the head of the medium voltage feeders. These devices measure electrical variables such as current, voltage and energy, allowing the quantification of the flows entering each circuit and comparing them with the energy recorded downstream, usually from aggregated billing information, without yet identifying individual users or connections. This frontier measurement constitutes the starting point for the analysis of non-technical losses within a logic of progressive segmentation of the network, since it provides a first estimate of the level of losses and allows an initial delimitation of the area of analysis. In practice, this first segmentation plays a key role in guiding subsequent analyses, by making it possible to identify which feeders justify descending to higher resolution levels, such as carrying out energy balances at the transformer level, as well as focusing inspection campaigns on broad sectors of the network, optimizing the use of technical and investment resources.

Although the general concept of energy balance at the feeder level is relatively homogeneous, the interviews show some relevant nuances in its practical implementation among distributors. In its most traditional form, companies such as SECHEEP or Electro Dunas rely on physical metering at the head of the feeders, using these circuits as aggregate units of analysis to obtain a first signal about the level of losses. Other distributors, such as CVC Energía or Centrosur, have made progress by incorporating greater analytical depth, either through additional metering at intermediate points in the network or through an explicit differentiation between macro balances, associated with the primary feeder, and micro balances, which descend to more localized levels of the network. In this context, a relevant nuance is the decision to increase the resolution of the balance by descending to the level of the distribution transformer, as a response to the inherent limitations of the feeder to delimit areas with high internal heterogeneity, which naturally gives way to the next layer of analysis.

6.1.2. Distribution transformer-level balances

Energy balances in distribution transformers constitute a next level of resolution within the process of segmentation of non-technical losses, by comparing the energy deliv-

ered by a transformer with the sum of the energy billed to the customers connected to it. This allows the analysis to be limited to a smaller territorial scope than that enabled by the balance at the feeder level, although it implies greater requirements for investment, installation and maintenance of metering equipment. In practice, while transformer-level balancing does not yet identify the individual customer with non-technical losses, it significaNTLs y reduces the universe of analysis and enables more precise operational actions, such as prioritizing crews in specific sectors, triggering focused inspections, targeting advanced analytics on a limited set of customers, and planning technical or commercial interventions around a network asset common.

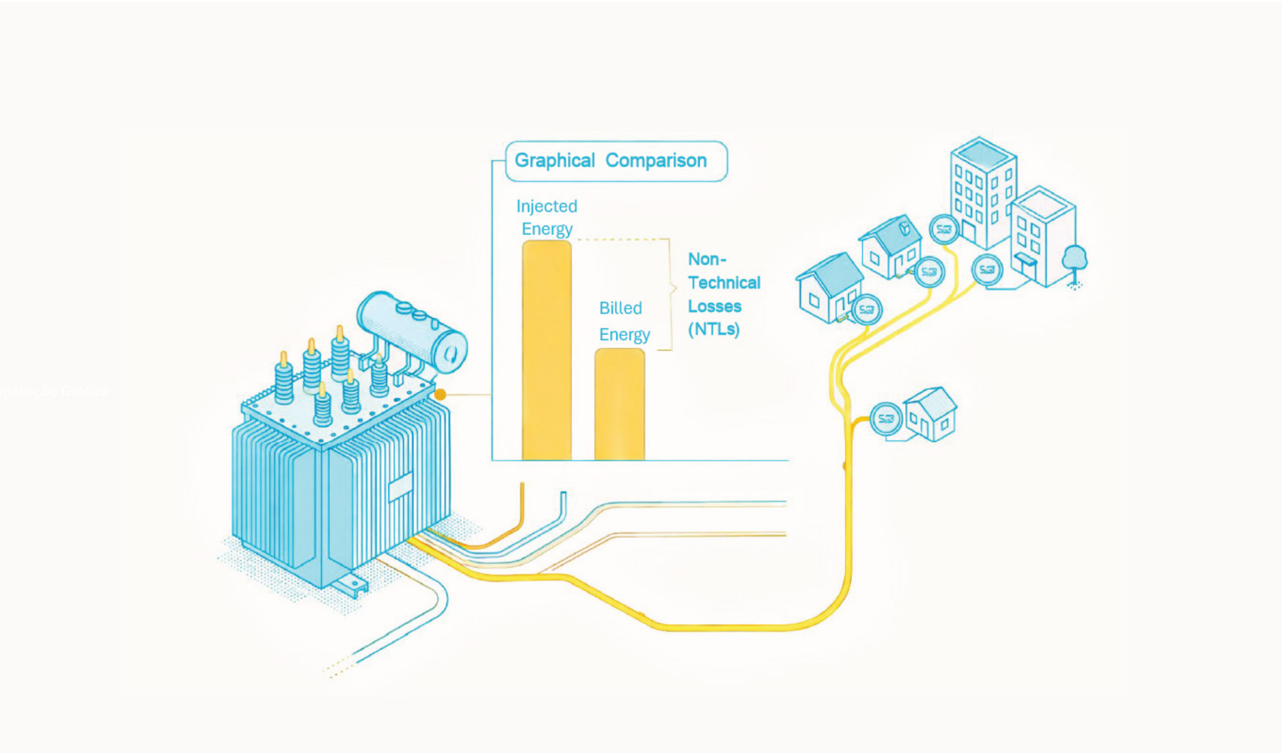
At the distribution transformer level, the nuances between distributors are more pronounced, both in technological and operational terms. Companies such as EPM, Electro Dunas and DELSUR have opted for the traditional approach consisting of the installation of fixed totalizing meters with telemetry to build systematic balances and feed prioritization and intelligence schemes in fraud; others have developed specific uses of data. EPEC, on the other hand, uses telemetering in transformer substations mainly as technical and evidentiary support to demonstrate the existence of real losses and enable the collection of unbilled energy. While this level of metering delivers significaNTLs y higher resolution and allows for more precise targeting of operational resources, it also involves intensive deployment of devices distributed in the field, which not only leads to higher investment and operating costs, but also increased exposure to vandalism, including theft of equipment, conductors, and intentional damage to devices installed on public roads. Faced with these limitations, some distributors have explored intermediate schemes, such as CENS, which uses portable metering equipment installed temporarily to build balances by sector and then rotate the metering to other points in the network, reducing permanent investment and exposure to vandalism. In this same context, UTE has developed virtual microbalances based on electrical models, voltage profiles and impedances, which allow estimating losses and guiding inspections without requiring the massive installation of equipment on the street.

An emerging challenge beginning to affect the reliability of transformer-level balances is the expansion of small-scale self-generation and other forms of distributed generation. When a customer injects energy into the grid, conventional macro meters – designed to record unidirectional flow – distort the transformer's balance, generating false or late signals about non-technical losses and making it difficult to correctly prioritize interventions. This phenomenon imposes unforeseen costs on distributors: the early replacement of equipment that has not yet reached its useful life and additional inspection visits that are not recognized or remunerated by the regulator.

Colombia clearly illustrates this tension. Since the enabling of small-scale self-generation through Resolution CREG 030 of 2018, the sustained growth of these schemes has begun to erode the quality of energy balances in those transformers where the existing macro-metering is not bidirectional or hourly. The distributor EDEQ has identified this problem as a source of operational and information inefficiencies, pointing out the need for the regulatory framework to explicitly recognize the costs associated with the adaptation of metering infrastructure in the face of the growing penetration of distributed generation.

6.1.3. Monitoring and sensor deployment of the low-voltage network

Monitoring with low-voltage sensors is the last level of network observation before moving on to individualized customer analysis. This measure consists of the incorporation of metering or sensor monitoring devices installed downstream of the distribution transformer, with the aim of observing the electrical behaviour of the low-voltage circuits and re-limiting non-technical losses in an even smaller area. Through this instrumen-



tation, it is possible to identify overloads, phase imbalances, anomalous currents or events associated with physical interventions in specific sectors of the low-voltage network, enabling an even more precise targeting of subsequent actions compared to the measures applied upstream. The information generated makes it possible to prioritize branches for inspection, activate early warnings of manipulations in the network and reduce the universe of customers to be analyzed through more advanced analytical tools.

The interviews show that monitoring with low-voltage sensors responds to the same need to progressively limit the problem, although through different mechanisms. Some distributors use sensor monitoring to spatially delimit the network, physically subdividing the area supplied by a transformer. ESSA installs measuring devices in low-voltage branches to observe currents and loads by section, allowing to identify in which arms of the circuit imbalances or losses are concentrated and reduce the universe of customers to be inspected. Other distributors use sensor monitoring as an operational limitation tool, aimed at identifying anomalous events or behaviors that justify an intervention. In this regard, Enel Colombia incorporates sensors and telemetry equipment with current and voltage signal analysis to detect alterations associated with illegal bridges or bypasses, while SECHEEP, EDP and Enel Brasil prioritize more continuous monitoring schemes, capturing information with hourly resolution or through alarms on electrical flows and operational events. In all cases, low-voltage sensor monitoring seeks to narrow the scope of analysis before descending to the level of the individual customer.

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Monitoring with low-voltage sensors constitutes the final level of network observation

6.2. CUSTOMER-LEVEL LOSS IDENTIFICATION AND ANALYSIS

While the measures analysed in the previous section seek to progressively limit the scope of analysis at the network level, the tools presented below are aimed at identifying the specific origin of non-technical losses at the level of the individual customer. At this stage, the focus shifts from the observation of assets and circuits to the reduction of uncertainty about specific supplies, relying on a diverse repertoire of measures that use different types of information and degrees of intervention. These tools do not constitute a single or exclusive sequence, but are combined by distributors according to their operational, technological and regulatory context, with the aim of prioritizing, verifying and confirming individual cases of non-technical losses.

6.2.1. Aggregation and analysis of consumption profiles

The aggregation and analysis of low-voltage consumption profiles is an analytical measure aimed at identifying non-technical losses by comparing a customer's consumption behavior with reference patterns constructed from similar groups. The underlying logic is that customers with comparable characteristics, such as location, type of tariff, socioeconomic stratum or line of activity, should exhibit consumption curves that are consistent with each other. Based on more granular historical billing or metering information when available, utilities construct typical consumption profiles and detect significant deviations, such as steep drops, persisteNTLs y low consumption, flat profiles,

or behaviors inconsistent with the reference group. This measure does not confirm the existence of fraud on its own, but it makes it possible to identify supplies with a higher probability of non-technical losses and prioritize them for subsequent analysis, reducing the universe of customers to be reviewed and improving the efficiency of control actions.

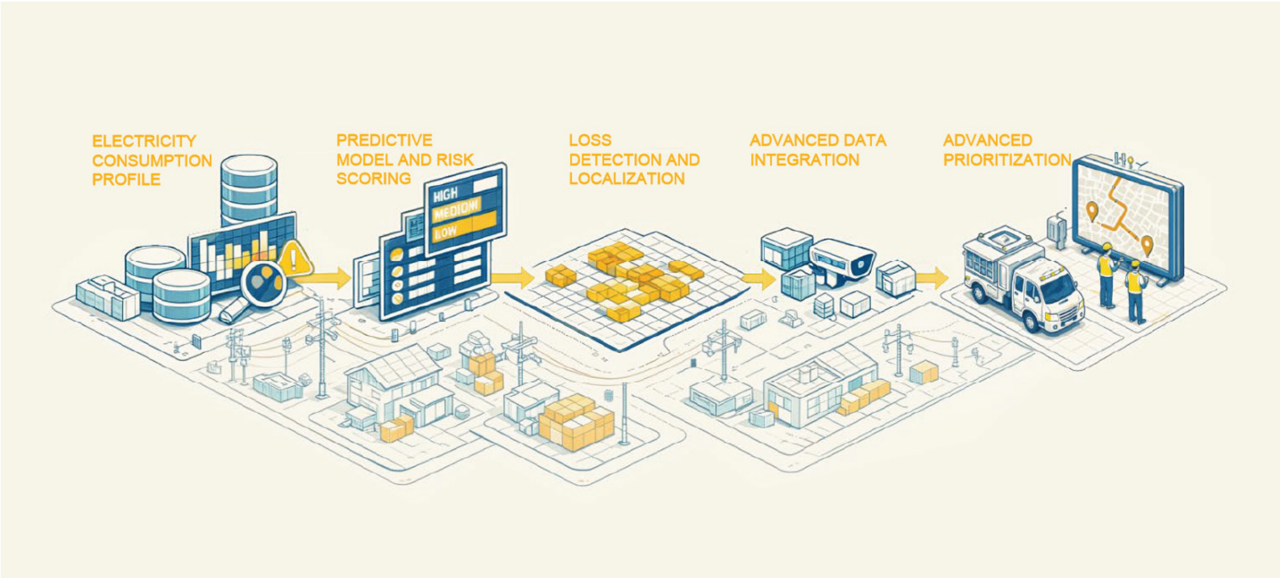
As they are analytical tools based on the use of consumption data, the aggregation and analysis of low-voltage profiles admit different degrees of depth depending on the strategic priorities and available resources of each distributor, which are mainly expressed in the level of analytical sophistication applied, the granularity of the available information and the set of variables used to build the reference profiles. Some companies structure this analysis based on historical comparisons and segmentations based on the observed behavior of the customer or on groups limited as a reference; this approach includes experiences such as those of EDEA and Electro Dunas, which prioritize the identification of relevant consumption breaks or significant percentage variations with respect to the historical one, as well as cases such as EEQ, which organizes profiles based on socioeconomic stratification and the analysis of aggregate consumption by stratum using billing histories of the last twelve months. Other distributors are moving towards statistical grouping schemes, where reference profiles are built by identifying groups of customers with similar behaviors; Centrosur and EPEC, for example, use clustering techniques and statistical metrics to define typical consumption curves and detect deviations outside expected ranges, facilitating their direct incorporation into operational prioritization processes. Finally, some companies integrate the analysis of consumption profiles within broader data analysis platforms, incorporating additional variables such as inspection history, recurrence, payment behavior or commercial events, along with data mining tools to refine the identification of atypical consumptions; in this group are experiences such as those of Enel Brasil, SAESA and EEGSA.

6.2.2 Advanced analytics for the identification and prioritization of non-technical losses

Advanced analytics comprises a set of tools and approaches aimed at supporting operational decision-making in non-technical loss management, by systematically estimating the risk associated with each individual supply. Its central objective is to maximize the effectiveness of field inspections, optimizing the allocation of control and inspection resources based on the prioritization of those cases where the probability and potential impact of a non-technical loss are greater. To this end, these systems integrate multiple sources of information and translate them into risk indicators or relative scores, which allow us to progressively abandon random or sweep inspection schemes and focus on interventions where there is a greater probability of finding and recovering energy.

Unlike aggregation and analysis of consumption profiles, which is mainly based on contrasting a customer’s behavior with reference patterns to identify relevant deviations, advanced analytics combines signals of various nature, historical, technical, commercial and operational, to build a more integrated assessment of risk at the individual level. While the profiles allow the detection of atypical consumption within a comparable group, advanced analytics seeks to prioritize the cases by simultaneously considering the probability of occurrence of the loss, its expected magnitude, and the potential effectiveness of the intervention. In this process, consumption profiles can be one of the inputs of the analysis, although advanced analytics can operate both by relying on them and by integrating other sources of information independeNTLs y.

In practice, advanced analytics is not a one-off measure or a specific technology, but a decision architecture that can take a wide variety of configurations. These differences are manifested in the level of analytical sophistication applied, the temporal granularity of the available data, the type and number of variables incorporated and the degree of integration of the models with the operational processes of inspection and control. More than a single solution, advanced analytics brings together a set of analytical approaches and designs that can be analyzed along different dimensions, which are presented below.



6.2.2.1. Operating logic

Advanced analytics in non-technical loss management is based on assigning each individual supply a risk estimate, usually expressed in the form of a score, which reflects both the probability of non-technical losses and their expected magnitude. This approach allows operational recovery decisions to be directed towards those cases that combine a higher probability of fraud with a greater volume of potentially recoverable energy. This score is built from the joint processing of multiple signals associated with individual consumption, which can include historical consumption information, technical events, commercial history and results of previous inspections. In general terms, the experiences reported by the distributors show that the implementation of advanced analytics measures is structured as a cycle composed of four stages: the ingestion and consolidation of relevant information, the analytical processing of this data, the assignment of a risk indicator that allows prioritizing supplies, and the feedback of the system based on the results obtained in the field.

In the first stage, advanced analytics is supported by the collection and integration of information necessary to build an informative profile of the individual supply, which constitutes the foundation on which the subsequent stages of the model are developed. In this phase, distributors seek to consolidate data that was historically distributed in different systems, combining consumption information, technical events from meters or telemetry systems, commercial and customer behavior background and, in some cases, unstructured information generated in the field, such as reader observations or visual records. The interviews show that, rather than moving indefinitely towards the incorporation of a greater number of variables, the most effective efforts are focused on improving the quality, consistency and correct classification of the available information. In this regard, the digitalization of business and technical processes appears as a key enabler, as large volumes of incomplete, misclassified, or inconsistent data not only degrade model performance, but can also limit the use of more complex analytical approaches.

On this basis, the processing stage takes the information consolidated in the previous phase and transforms it into analytical signals that allow estimating the risk associated with each supply. In this instance, the data cease to be descriptive and begin to be interpreted through different analytical approaches, whose degree of complexity varies according to organizational maturity, the quality of the information available and the operational objectives pursued. At the initial levels, processing is supported by heuristic rules or descriptive logics, where certain combinations of variables trigger predefined alerts, such as abrupt drops in consumption or atypical behaviors with respect to the historical one. As analytical capacity increases, these fixed rules give way to statistical schemes that group comparable supplies and detect significant deviations from standard curves or reference groups. In the most advanced approaches, processing is based on predictive models trained on inspection histories, which learn patterns associated with confirmed cases of non-technical losses and estimate probabilities of occurrence from multiple combined signals. Beyond the specific technique used, the experiences collected show that the central purpose of this stage is to convert complex and heterogeneous information into a synthetic and comparable signal between supplies, capable of feeding the operational prioritization mechanisms. Likewise, the interviews highlight that the adoption of more sophisticated approaches is not an initial requirement, and that many organizations start with simple models, progressively evolving as they strengthen data quality, consolidate reliable historical bases, and develop internal capabilities to interpret and use the results of analytical processing.

The production of scoring constitutes the main result of analytical processing in the management of non-technical losses and is materialized in the assignment of a score or relative probability to each individual supply. This output does not express a binary certainty of fraud, but a probabilistic estimate that allows cases to be classified and ordered according to different risk criteria. In its most basic formulation, the score expresses the probability that a supply will present a non-technical loss; while in other schemes the score also incorporates an estimate of the potential impact in terms of recoverable energy, integrating technical and economic considerations into a single metric to guide the prioritization of interventions. In this way, analytics is not limited to pointing out anomalous behaviors, but transforms the processed information into an explicit criterion for operational decision-making, which serves as the basis for selecting, ordering, and focusing control actions in the field.

Finally, the process is completed through feedback mechanisms, in which the results of on-site inspections are reincorporated into the system as validated information, allowing the predictions of the model to be contrasted with the operational reality. This feedback enables the progressive adjustment of rules, weights, or analytical models, either by correcting false positives, refining the score assigned to certain profiles, or recalibrating algorithms with new labeled data. Reported experiences show that this learning can operate at different levels, from simple adjustments to avoid unnecessary re-inspections to continuous retraining schemes based on large volumes of historical inspections. Without this cycle, models tend to quickly become obsolete in the face of changes in consumption patterns and fraud patterns.

6.2.2.2. Data and variables used

Advanced analytics for the detection of non-technical losses is based on the construction of multidimensional models that transcend the exclusive analysis of energy consumption and combine variables of different nature. The experiences collected show that distributors integrate, in different combinations, historical consumption information, metering technical data and operation of the network, commercial and customer behavior background, as well as external variables and unstructured data.

At the base of these models are the consumption pattern variables, aimed at identifying anomalies with respect to the history of the supply itself or of comparable groups. Among the most used are indicators derived from the consumption curve, such as abrupt falls or relevant breakdowns, persisteNTLs y flat consumption, zero consumption readings in active supplies and significant deviations from the average of customers with similar characteristics, defined by location, tariff or socioeconomic status. These variables are not the result of the analysis, but analytical inputs that feed the risk models, and represent the starting point of most advanced analytics schemes, even in contexts with low technological availability.

For distributors that have smart metering or telemetry systems, technical and event variables become relevant, which allow the incorporation of physical signals of the supply status. These include meter alarms associated with openings, cuts, or tampering, sequences of electrical events, and parameters such as voltage and current measured at high frequency. The use of this type of information enables earlier and more accurate detection of physical interventions, and in some cases allows the analysis not only of isolated events, but also temporal or sequential patterns associated with specific types of fraud.

Another key set corresponds to commercial and behavioral variables, which seek to capture the relationship between the propensity for irregularities and the customer's administrative conduct. These include the history of debt and arrears, repeated inspections with findings, frequent changes in ownership of the supply and the classification of the customer according to their use or economic activity. The interviews underscore that inconsistencies in this information, such as commercial supplies recorded as residential, ill-defined business types, or incomplete administrative histories, can significaNTLs y degrade the performance of the models, by introducing noise and biases that make it difficult to correctly interpret consumption patterns.

In more advanced schemes, distributors also incorporate exogenous variables and unstructured data, expanding the scope of the analysis. This includes climate and seasonal information, geospatial data linked to the supply environment, textual observations recorded by field personnel, and even automated image processing of meters or facilities. These sources allow you to enrich the context of the analysis and capture signals that are not directly reflected in the consumption records.

6.2.2.3. Levels of analytical sophistication and modeling approaches

The experience in analytical processing in the detection of non-technical losses shows a range of approaches ranging from simple rules to advanced machine learning models, and the choice of which depends largely on the quality of the available data, the internal capabilities of the organization and the objectives of each distributor.

At a first level, processing is supported by business rules and heuristic approaches, where case detection is based on predefined triggers derived from operational experience. In these schemes, the analysis consists of applying simple thresholds on consumption variables, such as abrupt drops, zero consumption, or unusual variations with respect to recent history. This type of approach has been used by distributors such as EDEA, EDESA or Electro Dunas, and allows inspections to be ordered without requiring complex models or large volumes of data, being frequent as a starting point in analytics adoption processes.

A second level corresponds to statistical and clustering approaches, where processing is no longer based on fixed rules and begins to compare the behavior of each supply with that of reference groups defined by criteria such as location, stratum or type of customer. Through techniques such as clustering or deviation analysis, supplies that deviate significaNTLs y from the expected behavior of their peers are identified. Experiences such as those of Centrosur and EPEC show that this approach can be especially useful when data quality does not allow more advanced predictive models to be trained, offering an operationally robust solution to detect relevant anomalies.

At a more advanced level, the processing incorporates predictive models based on machine learning, which use inspection histories with known results to estimate the probability of non-technical loss at the individual level. This includes evolutionary algorithms, hybrid models, and data mining techniques that allow the identification of more complex patterns that are not evident through descriptive analysis. Cases such as those of Grupo EPM, EEGSA or Enel Colombia illustrate how these models can improve the effectiveness of inspections, although they also require greater internal capabilities for their design, operation and continuous adjustment.

Finally, some distributors have moved towards deep analytics schemes, incorporating neural networks and the processing of more complex data, such as sequences of events, text or images. Experiences such as those of UTE, Enel Brasil or SAESA show that these approaches make it possible to address more sophisticated fraud modalities, but also that improving performance does not always involve larger or more complex models. In several cases, the lessons learned have led to simplifying architectures, reducing variables and concentrating on those signals that provide greater operational value.

6.2.2.4. Operational Integration and Field Performance

The effectiveness of advanced analytics does not depend only on the quality of the models or the variables used, but also on their proper integration with the operational processes of inspection and control. Interviews agree that without a seamless connection between analytical analysis and field execution, even the best scoring schemes lose value and tend to degrade into marginal results.

A critical first element is the end-to-end digitalization of the process. Several distributors report that the elimination of manual supports and the complete traceability of inspection orders are necessary conditions for analytics to generate sustained impact. The work order must be derived directly from the scoring, arrive at the field technician's device with relevant contextual information, and return to the central system with the result of the inspection in a structured and timely manner. This traceability not only improves operational efficiency, but enables feedback on the model and validation of its performance.

Second, advanced analytics changes the way inspections are prioritized and organized. Instead of sweeping or random selection schemes, utilities use scoring to build prioritized target lists and, in many cases, group them geographically to optimize routes and travel times. This integration with logistics tools allows for increased crew productivity, reduced downtime and maximizing the number of cases reviewed per day, while keeping the focus on those supplies with the highest expected recovery value.

Likewise, the interviews highlight the value of analytics as an operational pre-diagnosis tool. In the most integrated schemes, the analytical information not only indicates which supply to inspect, but also provides guidance on what type of irregularity is most likely to be found, allowing the crew to prepare for the intervention and reduce uncertainty in the field. This approach increases the success rate, shortens inspection times and strengthens the technical and evidentiary soundness of the findings.

6.2.2.5. Limits, challenges and learnings from advanced analytics

The interviews conducted allow us to extract a consistent set of learnings about the use of advanced analytics in the management of non-technical losses, a tool that is rapidly expanding among distributors, but whose effectiveness depends strongly on how it is implemented. Beyond the technological differences between companies, cross-cutting lessons emerge related to data quality, the level of complexity of the models, their integration with the field operation and the strategic decisions around the development and maintenance of these capabilities. Taken together, these learnings show that advanced analytics is a progressive process that requires organizational, technical, and operational adjustments.

One of the most repeated warnings by distributors is the critical importance of data quality as an enabling condition for advanced analytics. The interviews indicate that the availability of complete, consistent and correctly documented histories of consumption, inspections and supply characteristics is decisive to obtain useful results. In several cases, initial attempts to implement analytical tools did not achieve the expected performance precisely because of deficiencies in the database, such as incomplete records, misclassifications, or lack of traceability of field results. In this context, experiences agree that greater algorithmic sophistication is not able to compensate for deficient data, and that the effective deployment of advanced analytics requires, as a preliminary step, a systematization and strengthening of the processes of capture, validation and management of information.

A second relevant lesson shared by distributors is that increasing the complexity of the model or the number of variables considered does not guarantee better results. On the contrary, several experiences report a process of progressive simplification, aimed at identifying and retaining only those variables that provide real predictive power. This debugging of excessively complex models has made it possible to reduce noise, improve the stability of the results and facilitate their operational interpretation. In this same sense, the selection and delimitation of variables not only responds to technical detection criteria, but also to an explicit economic logic: the most effective models allow estimating the expected value of the intervention and prioritizing those cases where the potential recovery of energy justifies the operational effort. This can mean a reduction in the total number of detections, accompanied by an increase in the energy recovered per inspection, which improves the overall cost effectiveness of loss control.

A third key learning relates to the effective integration of advanced analytics with field operation. Interviews show that even well-calibrated models quickly lose effectiveness if they are not fully integrated with the inspection and control processes that allow field results to be captured, systematized and reincorporated for continuous retraining and adjustment of the models. This operational feedback is essential to recalibrate risk scores, reduce the incidence of false positives, and avoid redundant inspections. In this context, end-to-end digitalization, from the generation of the analysis to the structured recording of the result of the on-site inspection, appears as a critical condition to close the analytical cycle, both to ensure the traceability and quality of the information collected and to guarantee its timely availability for the analytical models.

As a fourth lesson derived from the comparative analysis, it is concluded that, although the advanced metering infrastructure (AMI) significaNTLs y enhances the detection of irregularities through the analysis of quarter-hourly load curves and manipulation alarms in real time, it is not a strict enabling condition to initiate the use of advanced analytics. The evidence collected shows that it is possible to deploy effective predictive and deterministic models using exclusively monthly or bimonthly billing data, based on the analysis of historical deviations in consumption, abrupt slopes in demand and their cross-referencing with commercial variables such as delinquency, changes of ownership or inspection history, provided that there is consistency, traceability and systematic feedback of the information. In this framework, the AMI should be understood as an accelerator and sophisticator of analysis, which enables additional layers of detection and validation, but not as a barrier to entry, which is especially relevant for distributors that do not yet have massive deployments of smart metering and that can initiate advanced analytics processes incrementally by leveraging their traditional metering systems.

Finally, the experiences gathered show different approaches to the development of analytical capacities. Some utilities have opted for external solutions or commercial platforms, valuing their rapid implementation, immediate access to mature tools, and reduced initial development efforts. However, this approach often implies a lower level of transparency about the inner workings of the models, as well as limitations in adjusting the analytical logic to local specificities and the evolution of fraud patterns. Other companies have privileged the internal development of their analytical capabilities, with the aim of retaining knowledge, understanding the models in depth and continuously adapting them to their operational reality. This path offers greater flexibility and control, but requires sustained investment in specialized human resources, technical capabilities, and knowledge management. In practice, hybrid schemes that combine external solutions with in-house developments are also observed. Beyond the strategy chosen, the interviews agree that advanced analytics is not an immediate or standardized solution, but an incremental process that requires sustained investment in data, people and processes to generate lasting results.

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Non-technical losses are characterized by their heterogeneity, spatial variability and dynamics over time

6.2.3. Smart Metering and Telemetry

6.2.3.1. Benefits of Smart Metering

Advanced metering infrastructure (AMI) has established itself as a central pillar of the energy transition and the electricity distribution modernization (ADELAT, 2026), to the extent that its deployment enables an integrated digitalization of the distributor's operation. For the distribution company, AMI allows automating and optimizing commercial and technical processes, reducing dependence on field work, reducing operating costs associated with reading, inspections and commercial maneuvers, improving the accuracy and timeliness of billing, and strengthening the technical control of the network through greater visibility of consumption behavior and electrical variables. For the end customer, smart metering translates into greater transparency about their consumption, reduction of complaints associated with reading errors, potential access to new tariff schemes and payment methods, and the progressive enabling of functionalities associated with the energy transition, such as the integration of distributed generation, electromobility and future demand management and flexibility programs.

Within this broad set of benefits, several smart meter functionalities have been specifically used as tools for non-technical loss management. In the first place, and probably the most widespread and traditional application, are the functionalities associated with telemetering and energy recording, which allow increasing the frequency of reading, having load curves and demand records, and observing with greater granularity the behavior of each customer's consumption, facilitating the early identification of deviations from historical or expected patterns. an aspect that is addressed in this section with a focus on consumer microanalysis. Second, smart meters incorporate tampering detection capabilities, by recording anomalous events such as cap openings, voltage losses, phase reversals or supply disturbances, which are a key input for fraud control and are discussed in greater detail in Section 7.2.1. Third, the remote cut-off and reconnection capability enables coercive and deterrent mechanisms against repeated non-compliance, reducing action times and operating costs, functionality that is discussed in greater depth in Section 7.3.1. Finally, the resilience and preservation of data through mass memory allows energy and event information to be stored during interruptions, communication failures or deliberate outages, ensuring the traceability of consumption even in contexts of intentional manipulation.

6.2.3.2. Barriers, costs and deployment strategies

Although the functionalities enabled by AMI offer relevant benefits for the operation of distributors, their deployment in Latin America has been conditioned by a persistent set of economic and regulatory barriers (ADELAT, 2026). On the one hand, the unit cost of AMI systems is substantially higher than that of conventional meters, not only because of the hardware, but also because of the need to incorporate communications, data management platforms, software licenses and cybersecurity capabilities. On the other hand, these costs are not always explicitly recognized by current regulatory frameworks, which in many countries continue to be designed under a logic of traditional physical assets and present difficulties in incorporating investments of a digital nature.

In this context, and with the aim of reducing non-technical losses, distribution companies have opted for pragmatic implementation strategies that seek to maximize the operational impact at the lowest possible cost. A recurrent practice has been to reduce the functional scope of installed systems, privileging basic telemetry schemes over complete AMI architectures. Thus, instead of deploying meters with all the capabilities associated with the second generation of AMI, many companies prioritize minimum functionalities aimed at remote reading, consumption monitoring and the construction of energy balances, postponing more complex attributes that increase costs and require greater regulatory definitions.

In addition to the functional reduction of installed systems, distributors have chosen to limit and prioritize deployment areas, following selective coverage strategies aimed at maximizing the cost-benefit ratio of the technological investment. The most mature and widespread strategy in the region has been the prioritization of the large customer and industrial segment, given that a small number of users concentrate a significant proportion of the energy billed. In EPESF, for example, just over 3,300 large demands (from multiple activities) represent 49.9% of the total energy billed, compared to more than 1.3 million residential customers; while in DELSUR around 5,000 users account for more than 50% of billing. In this context, multiple distributors report schemes of total or close to 100% telemetering coverage in large users, using different prioritization criteria, such as contracted demand thresholds or installed power. ENSA, for example, concentrates telemetering on customers with demands greater than 100 kW, while CENS applies this approach from consumption greater than 50 kW.

Although the universe of customers is limited, industrial fraud is usually more sophisticated and less visible than residential fraud, which has led to the use of specific analysis techniques, such as the systematic comparison of quarter-hour load profiles, phasor coherence analysis and electrical signals to detect synchronism losses or internal interventions. and the installation of mirror meters or dedicated macro-measures. An example of the latter strategy is ESSA's Padlock Plan, which consists of installing an independent telemetry metering upstream of the industrial customer and continuously contrasting it with the commercial meter register, allowing the immediate identification of deviations attributable to manipulation or unauthorized derivations. Likewise, the accumulated experience has made it possible to identify industry sectors particularly prone to energy theft, including plastic recycling plants, refrigeration and ice production industries associated with the tourism sector, and certain mining or agro-industrial activities, reinforcing the logic of focused and highly instrumented deployments in this segment.

A second deployment strategy widely reported by distributors consists of prioritizing residential areas of high social complexity, characterized by high levels of theft, informality and operational restrictions for field work. In these contexts, crew access is often limited, intermittent, or outright unfeasible, making telemetry an essential tool for monitoring consumption, detecting deviations, and reducing reliance on on-site inspections. Under this logic, remote metering is not implemented as an isolated solution, but as part of an integrated approach that is later complemented with physical hardening measures and, in some cases, with prepaid schemes.

From the perspective of the remote reading and metering architecture, two recurring configurations are observed. The first corresponds to centralized metering systems, in which the meters are concentrated in collective boards or cabinets, generally located on poles or near transformers, allowing remote reading and reducing the direct exposure of the equipment to manipulation by users. The second configuration is the two-body metering, where the metering unit is installed out of reach of the customer, typically on the pole or in a protected cabinet, while only a display or information repeater is available in the house. This alternative is mainly used in regulatory frameworks that enable the prepaid modality, since this modality requires the individualization of the metering point and limits the viability of fully concentrated schemes. The physical hardening measures associated with these configurations are addressed in Section 7.2.2, while the implementation of prepayment as regularization and control tools is discussed in greater detail in Section 8.2.2.

6.2.3.3. Lessons, Specific Cases, and Limits

The experience accumulated by distributors in the region shows that smart metering and telemetry are not isolated or automatic solutions for the reduction of non-technical losses, but tools whose impact depends strongly on how they are integrated into a broader operational strategy. In this sense, the lessons learned focus on the indirect effects generated by its deployment and on the need to sustain active management of the territory. The most recurrent learnings are grouped into three dimensions: the strategic prioritization of deployment, the displacement of fraud within the network, and the role of market culture in the sustainability of results.

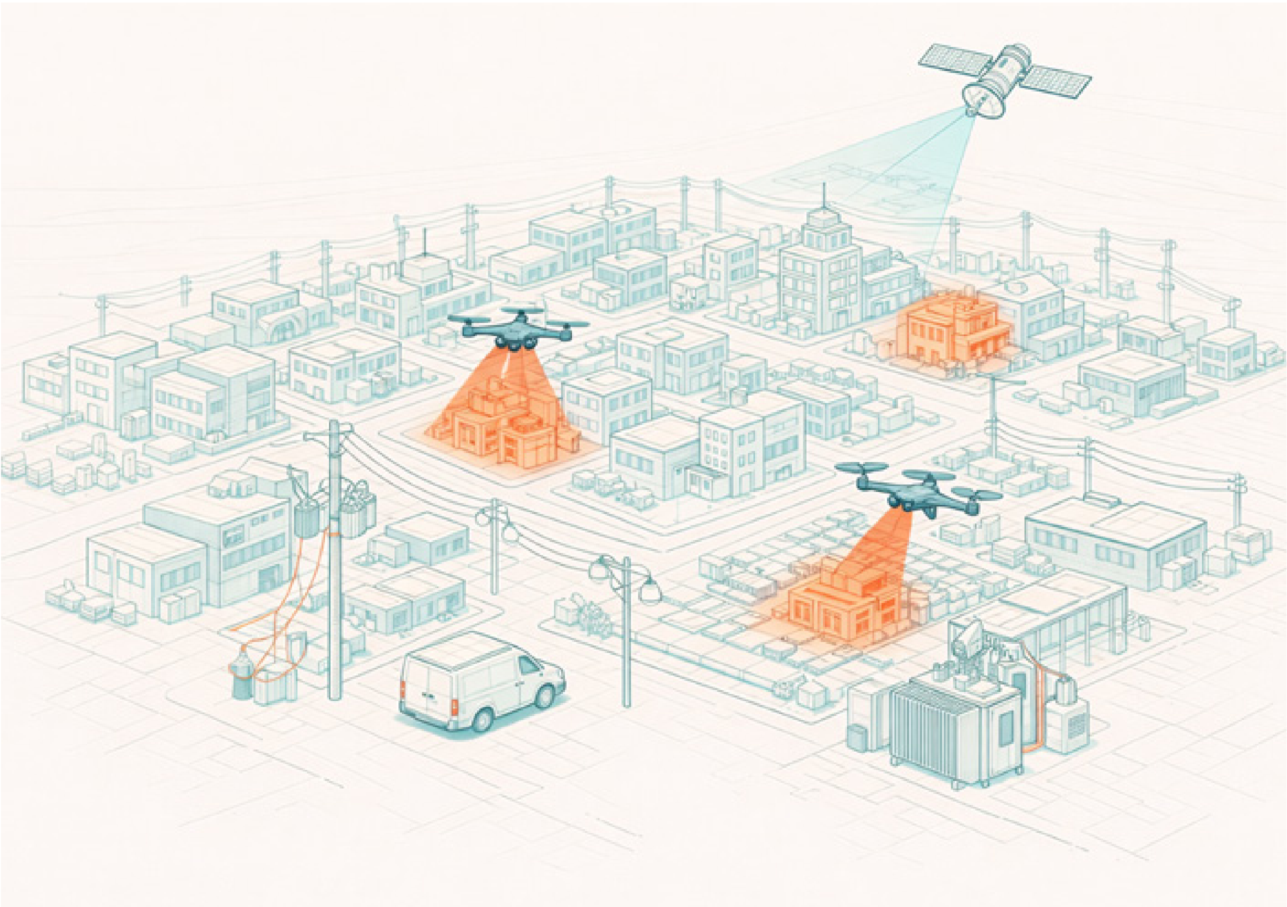
Given that massively deploying AMIs throughout the customer fleet is now highly expensive in most Latin American contexts, many distributors have opted for a gradual entry strategy, starting with ensuring control of large industrial and commercial customers. This approach responds to a logic of economic efficiency, since a small number of users concentrates a significant proportion of the distributed energy and total billing, so its monitoring through telemetry or smart metering allows to reduce relevant risks with limited investments. The prioritization of this segment thus emerges as a robust and replicable starting point, which allows early benefits to be captured, commercial and technical control to be strengthened, and capacities to be built before moving towards more massive segments.

A natural next step has been the progressive extension of smart metering into the residential and commercial segment, particularly in areas with higher levels of non-technical losses. The experience accumulated by the distributors reveals a particularly relevant learning regarding the impact of the AMI on the fraud modality. In many cases, the greater complexity associated with the direct manipulation of the meter does not eliminate theft, but transforms its manifestation within the network. As it is difficult to intervene on the metering equipment, irregular practices tend to move to other points of the system, appearing upstream in connections, branches or even in sections of the distribution network. This phenomenon highlights that the AMI cannot be understood as an isolated solution, but must be deployed in coordination with strategies for the physical protection of the infrastructure, such as pre-assembled networks, lifting of conductors and safeguarding of critical points, measures that are developed in greater detail in Section 2.1.

Another relevant lesson associated with the deployment of AMI and its impact on fraud behavior, reported by various distributors, is related to the interaction between telemetry and on-site inspection. A number of companies have observed that when the increase in telemetering is accompanied by a significant reduction in operational presence and regular inspections, non-technical losses tend to reappear. In these contexts, automation can be interpreted by users as less effective surveillance, weakening the initial deterrent effects of the technology. This experience has reinforced the notion that the control of theft requires maintaining a certain enforcement, understood as the combination of technological monitoring and visible presence of the company in the territory. ConsequeNTLs y, telemetry and AMI should be conceived as tools that complement, but do not replace, territorial management, face-to-face inspection and sustained presence in critical areas, which continue to play a key role in the containment of non-technical losses, consistent with the community work and social engagement strategies developed in Section 7.4.

6.2.4. Image-based tools and remote observation

The use of image-based tools has been gaining ground as a complement to traditional non-technical loss detection methods, providing an additional layer of visual information to support the identification, validation and prioritization of interventions in the field. These technologies cover a wide spectrum of applications, ranging from more general and remote approaches, with a lower level of intrusion on the customer, to progressively more focused and direct tools on specific assets and facilities. The following subsections present these solutions gradually, starting with those of broader scope and non-face-to-face, and moving towards more specific and intensive uses.



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The use of image-based tools has been gaining ground as a complement to traditional non-technical loss detection methods

6.2.4.1. Satellite imagery for identification of unregistered connections

The use of satellite images is a complementary and minimally invasive tool for the identification of unregistered consumption, understood as irregular or undeclared connections that do not appear in the distributor's commercial bases. Its most widespread application is based on the use of daytime satellite images through the analysis and superimposition of geospatial information, contrasting the reality observed in the images with the georeferenced cadastre of customers, networks and supply points contained in the commercial and technical systems, which requires prior basic territorial information of the network and the customer park. Enel Brasil has developed schemes to overlay its network and customer information on open satellite platforms, which allows them to identify existing buildings that do not have an associated supply point and guide inspections in areas with high levels of theft, especially where physical monitoring is complex. Similarly, SAESA uses the systematic cross-referencing between its network and customer registries and satellite information to isolate buildings without commercial links, which become priority targets for inspection, an approach that has been particularly useful for detecting widespread fraud in rural areas and supporting diagnoses before the regulatory authority. Along the same lines, Equatorial uses satellite images to analyze the expansion of informal areas and map areas that have electricity supply without a contractual relationship with the distributor, using this information as an input for operational planning and the targeting of control actions.

More specifically, the use of night-time satellite images has also been reported, mainly aimed at auditing public lighting. In these cases, the light intensity observed in a given area is compared with the consumption billed or declared by the municipalities, which makes it possible to detect luminaires that are not registered or direct connections that are not registered. In addition, satellite images have shown usefulness in niche applications, such as the inspection of distributed generation to identify undeclared facilities or unreported capacity expansions, as well as in the monitoring of intensive rural consumption, for example, in agribusinesses, silos or productive facilities that are difficult to access, where face-to-face inspections are costly or complex.

Overall, the main advantage of the use of satellite imagery lies in its ability to identify unrecorded consumption and reduce the need for physical exposure of personnel in large, dangerous or hard-to-reach areas. However, this technology has relevant limitations. Daytime images available for free often have temporary lags that make it difficult to detect recent fraud, while nighttime images with adequate resolution involve high costs, limiting their continued or mass use. In this context, the experience of distributors suggests that the greatest value of this tool is found in focused applications, periodic campaigns and as a complementary input within an integrated strategy for detecting non-technical losses, rather than as a permanent real-time monitoring solution.

6.2.4.2. Field images and photographs

The use of field images and photographs is the most widespread and traditional application of visual tools in the management of non-technical losses, mainly relying on records captured by crews, readers or operators in the field using mobile phones or cameras. In its most common uses, photography fulfills functions of reading validation, visual identification of illegal derivations or connections, and evidentiary support for administrative and judicial actions, consolidating itself as a basic operational input in fraud control processes.

In its most traditional form, photography is used as a reading validation mechanism, allowing corroboration that the manually entered data effectively corresponds to the physical record of the meter. This practice contributes to reducing operational errors, fictitious readings or inconsistencies associated with metering failures and business processes, which constitute a relevant source of non-technical losses of a non-voluntary nature. Some distributors have formalized this approach by incorporating the mandatory nature of photography as part of the reading process, so that the system verifies the consistency between the reported value and the captured image.

On this basis, other companies have moved towards more demanding imaging protocols, expanding the focus from the meter to the immediate surroundings of the facility and transforming photography into a tool for visual identification of illegal taps or connections. In these cases, broader images are used that include the house, the meter and the elements of the connection, which allows for the visual detection of bridges, branches or direct connections upstream of the metering equipment. As this volume of visual information grows and becomes recurrent, some distributors have begun to exploit these images systematically through advanced analytics and artificial intelligence, using field photographs not only as operational support, but as an automated input for the detection of anomalies. In these approaches, computer vision algorithms process large volumes of images to identify visual patterns associated with physical intervention of the meter, such as open caps, damaged seals, alterations in the connection or anomalous configurations of the equipment. EDP, for example, processes around 1.7 million photographs of meters using artificial intelligence models that generate a fraud probability score based on the visual state of the equipment. Enel Brasil incorporates the automatic evaluation of photographs into its data mining models, allowing the detection of signs of physical manipulation reported by the readers. Similarly, SAESA has begun to exploit images as unstructured data through vision and language models, with the aim of identifying recurring patterns of intervention, such as uncapped or altered meters, strengthening the targeting of technical inspections.

In addition, field images have been consolidated as a critical input to support administrative and judicial actions associated with electricity fraud. EPESF reports that the technical reports drawn up in the face of the detection of irregularities must be accompanied by georeferenced photographs that document the state of the meter. The digitalization of these minutes and photographic evidence seeks to strengthen the traceability of the procedure and ensure its administrative and legal support, constituting the evidentiary basis for energy recovery processes and criminal complaints. In the same vein, EDESUR has completely digitized this flow, integrating the capture of images from mobile devices directly with the commercial system, where they are stored in central repositories, guaranteeing their integrity, traceability and validity as evidence in the event of complaints from customers or regulatory bodies.

6.2.4.3. Drones for aerial inspection of networks and connections

The use of drones in non-technical loss management is at a heterogeneous adoption stage, varying between experimental pilots and very specific niche applications. While some distributors have actively incorporated this technology to support the detection of irregularities or validate assets in the field, others have chosen to rule out its massive use due to reputational, privacy and social acceptance considerations. In this sense, the drone is not presented as a transversal tool, but as a punctual complement within broader loss control and operational efficiency strategies.

In their most basic application, drones are used as a tactical support tool for crews in the field, integrating into the suite of instruments available for visual inspections in hard-to-reach locations, complex facades, or areas with security restrictions. Its use allows the observation of elevated connections, branches, roofs or network elements that are not easily visible from ground level, reducing inspection times and avoiding direct exposure of personnel. Some companies have also evaluated their potential to identify visible indicators not consistent with billed consumption, such as heated swimming pools or high-consumption equipment. However, several distributors have desisted from this type of application in residential environments, considering that the use of the drone for fraud detection purposes could be perceived as invasive, generating social rejection and reputational risks associated with customer privacy.

A more direct application to combat non-technical losses is the use of drones equipped with thermal cameras for the detection of technical anomalies. This approach is based on the fact that illegal or faulty connections often have higher levels of electrical resistance, which translates into temperature increases detectable by thermography. ESSA, for example, has used drones on pilots focused on informal settlements to identify high-temperature points in the network, associated with precarious or overloaded connections that are not always obvious to the naked eye. Similarly, EPM reports the use of thermographic inspection with drones for the detection of technical irregularities and potential fraud, allowing complex areas to be intervened without initially exposing crews and improving the direction of actions in the field.

Finally, beyond the direct management of non-technical losses, drones have shown utility in niche applications linked to asset validation and operational efficiency. A relevant case is the inspection of distributed generation, where EEGSA uses drones to verify photovoltaic installations, count panels and inverters and contrast the actual installed capacity with that declared by the customer, detecting unreported expansions or relevant deviations. At the corporate level, some companies have also begun to use drones for the survey of information from aerial networks and the construction of three-dimensional models of the infrastructure, enabling virtual inspections, predictive maintenance and the creation of digital twins, with indirect benefits on operation and loss control.

Overall, the experience gathered suggests that the drone adds value mainly when it is used to expand the observation capacity with respect to traditional methods, allowing the identification of signals not obvious to the naked eye, such as the heat associated with illegal connections or the condition of assets located in areas of difficult access, and when its deployment remains clearly limited and justified. However, their extensive use as a surveillance tool in residential environments continues to be limited by social and reputational considerations, which reinforces the idea that drones should be understood as a complementary and selective instrument, integrated within a broader strategy of non-technical loss control and territorial management.

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The use of field images and photographs is the most widespread and traditional application of visual tools in the management of non-technical losses

6.3. TARGETED INSPECTIONS

6.3.1. Prioritization Strategies and Inspection Logistics

Targeted inspections represent the final operational stage of the non-technical loss detection strategy, in which information from the tools presented in the previous sections, such as energy balances, data analytics, images and operational signals, is translated into concrete actions in the field. By relying on previous selection criteria, this approach increases the probability of detection and significaNTLs y reduces the cost per case inspected. This represents a substantial advance with respect to traditional mass inspection or sweeping schemes, characterized by a low success rate and an intensive use of operational resources. In practice, distributors combine different methodologies to define who to inspect, ranging from technical-geographical approaches based on energy balances to scoring models and operational signals, also presenting relevant differences in the way these inspections are executed and managed in the field.

A key aspect of focused inspections is related to the methodologies used to decide who to inspect, which take up and articulate tools already analyzed in previous sections. On the one hand, many distributors use energy balances in feeders and transformers as an initial criterion for territorial targeting, as explained in Section 6.1, limiting the search to areas or assets with anomalous levels of losses before descending to the specific inspection of customers. On the other hand, these approaches are complemented by scoring and advanced analytics models presented in Section 6.2.2, which allow individual users to be prioritized based on consumption patterns, operational events, and business histories. In practice, both methods are usually combined and reinforced with the operational knowledge of the readers and crews, who provide qualitative signals through the report of visual anomalies or atypical behaviors in the field, thus integrating analytical criteria and operational experience in the final selection of the cases to be inspected.

In addition to the methodology for selecting candidates for inspection, distributors have been introducing relevant changes in the way the inspection is carried out in the field. A first relevant aspect is that, once the objectives to be inspected have been defined, companies have incorporated route optimization tools to organize the routes of the crews. EPM uses mobility applications to organize optimal routes for its readers, while DELSUR groups inspections into geographical clusters and integrates practical considerations associated with the working day, such as the location of lunch areas, into the design of the routes, aligning logistics planning with the real needs of the teams in the field and avoiding recurrent deviations from the planned routes. A second aspect is observed at the very moment of carrying out the inspection, where there is a progressive transition towards the integral digitalization of the process, so that work orders, field findings and associated documentation are recorded directly on mobile devices and integrated in near real time with commercial and technical systems. reducing transcription errors, improving traceability and speeding up subsequent management. This digitalization, in turn, enables feedback mechanisms, since the information reported by readers and inspectors allows for the recalibration of prioritization models and adjustment of selection criteria. Finally, in contexts of greater social complexity or operational risk, some distributors have complemented targeting with specific strategies for support and security in the field. As an exceptional measure, EPESF resorts to "cut and hold" operations, in which the crew remains in the vicinity after the procedure to verify illegal reconnections in flagrante delicto. Requiring coordination with security forces and a high deployment of resources, this tactic is not a common practice, but is reserved for very specific interventions aimed at loss control. For its part, Enel Brasil is executing the "Legal Energy" program, combining focused inspections with a reinforced institutional presence and on-site commercial regularization actions.

Beyond the nuances in the selection methodologies and operational execution schemes, the evidence reported by the distributors is consistent in pointing out that the focused inspection far exceeds traditional random sweep schemes, both in effectiveness and in use of resources. Enel Chile indicates that sweep inspections, understood as the systematic review of all the joints in a sector, have success rates of less than 1 percent, which makes them operationally inefficient. Electro Dunas, similarly, pointed out that inspection without prioritization criteria generated few findings. In contrast, companies that have incorporated analytical models to select inspection objectives report substantial improvements in performance. EPM and ESSA report that the fraud detection rate went from ranges of 2 to 3 percent to values in the order of 15 to 16 percent, even reaching levels close to 40 percent when considering technical anomalies. Enel Brasil, for its part, points out that the use of data mining made it possible to double the effectiveness of inspections, from around 20 to 40 percent, also reducing operating expenses by concentrating efforts on cases of greater probability, consolidating targeting as a structural change in the way of approaching the control of non-technical losses in the region.

6.3.2. Human factor management and quality assurance in the field

The effectiveness of inspections depends not only on the accuracy of the selection algorithms, but also on the integrity and performance of the teams in charge of executing the inspection in the field. The interviews reveal that the risk of "collusion" or operational corruption—where in-house technicians or contractors fail to report irregularities in exchange for informal incentives—is a critical challenge. To mitigate this, distributors have deployed strategies on three levels: crew management, technology supervision, and incentive alignment.

With regard to the management of work teams, companies have focused on strategic configuration to avoid the generation of undue trust links with customers or the consolidation of operational vices. In this sense, staff turnover emerges as a fundamental practice; Electro Dunas, for example, highlights that the constant rotation of areas and the specialization of the crews – dedicated exclusively to fraud and not to general commercial operations – are key to maintaining the focus of the inspection. There is also an active debate regarding the ideal contracting model: while EPM operates with outsourced personnel managed by strict effectiveness goals, Enel Brasil has found that, specifically for loss inspection, the use of its own crews significaNTLs y increases technical quality and reduces claims, reserving outsourcing for less complex tasks.

In terms of technological supervision, the use of digital tools has been consolidated as a mechanism to audit performance in the field and reduce the discretion of the inspector. Distributors such as SAESA and EDP have implemented image registration and analysis systems; Although its central purpose is usually the validation of the correct execution of the task, the existence of this visual support also acts as a control barrier, allowing the detection of omissions or inconsistencies that could escape traditional supervision. In this line, SECHEEP uses these documentary records to carry out subsequent audits and contrast the veracity of the field report against the physical reality. Likewise, these tools allow the process to be shielded from involuntary errors, as reported by EEQ, where the digitalization of data capture using tablets eliminated typing and transcription errors that previously generated administrative losses.

Finally, in relation to the alignment of incentives, some companies address the risk of operational corruption from the organizational culture. A prominent case is that of UTE, which implemented a policy of participation in the results, distributing a fraction of the recovered income among the officials involved in the loss plan. This strategy seeks to align the objectives of the workforce with the effective recovery of energy, generating a sense of belonging and discouraging tolerance to fraud within the organization, by turning the reduction of losses into an achievement shared by the team.

6.4. KEY LESSONS

A fundamental lesson derived from the analysis of non-technical loss detection and identification strategies is the paradigm shift from extensive search to progressive uncertainty stratification. Comparative experience shows that operational profitability is not achieved by inspecting more, but by limiting the search space in a gradual, logical and economically efficient way. By prioritizing the analysis from macro scales, such as feeder and substation balances, to micro levels, such as transformer balances and low-voltage sensor monitoring, distributors are able to discard large healthy areas of the grid with relatively low investments. This approach makes it possible to abandon ineffective random sweeps and concentrate technical resources on those nodes where the probability of recovery justifies intervention.

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Comparative experience shows that operational profitability is not achieved by inspecting more

In parallel, the integration of advanced analytics and digitalization is consolidated as a central enabler of more efficient, less invasive and socially sustainable management. The ability to anticipate irregular behavior by analyzing consumption profiles and cross-referencing historical data makes it possible to identify risk situations before direct interaction with the customer. This not only increases the effectiveness of crews in the field, but also reduces friction with regular users. The hope for utilities is that a fully deployed smart metering infrastructure is not essential to start this journey. Intelligence applied to existing data, combined with the integrated digitalization of field processes, constitutes an immediate and accessible lever to improve energy recovery.

However, technological precision and accurate diagnosis find clear limits in the complex physical and social reality of the territory. Even with accurate fraud identification and advanced telemetering tools, there are contexts where crew accessibility is restricted, staff safety is compromised, or the payment culture is profoundly impaired. In these scenarios, knowing exactly where the loss occurs does not guarantee its recovery. Detection technology thus faces barriers that require a different approach, no longer focused only on observation and diagnosis, but on physical containment and behavior management mechanisms. It is at this point that it becomes necessary to move from diagnostic intelligence to strategies aimed at discouraging and controlling fraud, giving way to Pillar 2 of measures.

07

PILLAR 2: DISINCENTIVE AND FRAUD CONTROL

7.1. DETERRENCE RATIONALE

The diagnostic accuracy pursued in Pillar 1 faces an unavoidable operational limit: the identification of fraud does not guarantee, by itself, the recovery of energy, especially in contexts where physical accessibility is restricted or the payment culture is severely deteriorated. Accurate knowledge about the location of the loss loses practical value if the company lacks effective tools to intervene, correct and, fundamentally, prevent recurrence. ConsequeNTLs y, the management of NTLS s requires going beyond the observation stage to deploy a parallel and complementary effort focused on the effective containment of the crime.

This second pillar of intervention focuses on modifying the incentive structure of the irregular user. Its fundamental premise is that fraud is a rational economic and behavioral decision, which occurs when the benefit of stealing energy outweighs its perceived costs and risks. To reverse this equation, distributors deploy a "disincentive logic" that seeks to raise the barriers to entry to fraud and increase the expected cost of committing it. This strategy is simultaneously articulated on three dimensions or edges of action:

- Technical Dimension (Infrastructure): It is aimed at "hardening" the network through physical investments – such as network hardening, anti-theft cables and inaccessible metering – that aim to reduce the material possibility of manipulating the supply, increasing the technical difficulty and the effort necessary to carry out the fraud.

- Regulatory Dimension (Penalty): It seeks to increase the financial and legal cost of irregularity through an institutional framework that ensures the effective application of sanctions, the collection of unregistered energy and, in serious cases, criminal prosecution. Its purpose is to strengthen the coercive power of the company and send a clear signal of enforcement.

- Social Dimension (Culture): Aims to decrease the cultural acceptability of fraud through community and educational strategies that delegitimize energy theft. This aspect works on public perception, seeking to ensure that irregularity is no longer seen as a "skill" or an acquired right and becomes socially reprobated.

Next, the specific tools that make up each of these dimensions and how they interact to form a robust control system are analyzed.

7.2. TECHNICAL AND INFRASTRUCTURE MEASURES

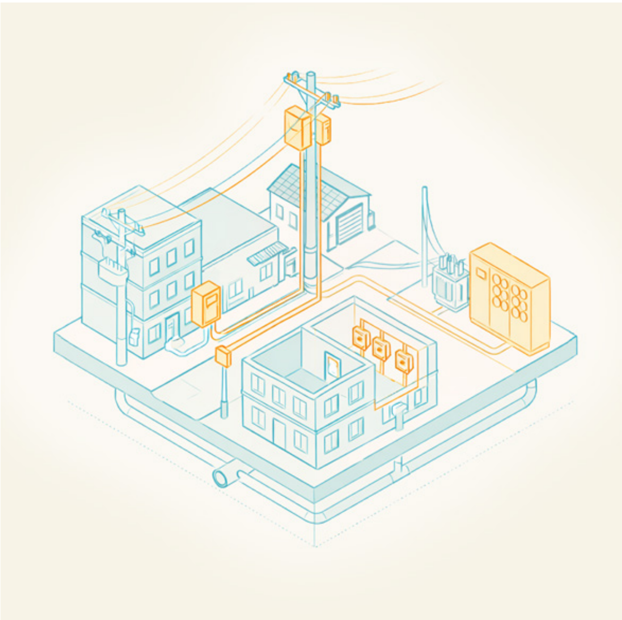
7.2.1. Digital monitoring and automated alerts at the metering point

Digital monitoring and the alert systems associated with the metering point constitute one of the first layers of network hardening. Unlike traditional physical hardening measures, aimed at preventing access or structurally reinforcing the infrastructure, this approach does not seek to directly prevent manipulation, but rather to detect interventions, inconsistencies or anomalous behaviors early, reducing the time window of fraud, increasing the risk perceived by the user and enabling faster and more focused responses. The interviews show that this evolution, in which purely physical protections are complemented by logical and remote detection mechanisms, is mainly expressed in two monitoring levels: on the one hand, the surveillance of the physical integrity of the metering point and, on the other, the verification of the operational coherence between the state of supply and its effective behavior.

The foreground corresponds to the intrusion or tamper sensors integrated into the meter or its enclosure. These functionalities generate automatic alerts in the event of unauthorized opening of the meter cover or box, as well as in the event of equipment removal. Distributors such as UTE and ESSA use this type of signal to trigger automatic inspections or react within very short periods of time to possible interventions. Enel Brasil, for its part, processes more than two million alarms from its smart meter fleet and uses the alerts to open the box as an input for its advanced analytics models as a criterion to decide whether to send inspections in the field. Although experience shows that this type of alert can shift fraud modalities to other points in the network, its value lies in its deterrent effect and in the early generation of objective evidence on physical interventions at the metering point.

The second plane corresponds to logical or behavioral alerts generated when the system identifies inconsistencies between the commercial status of the supply, the events recorded by the meter and the effective flow of energy. This approach is based on the verification of operational coherence, rather than on the direct detection of a physical intervention. Enel Brasil and Enel Chile use alerts associated with the presence of cargo after a formal disconnection to identify unauthorized reconnections. Likewise, automated alerts are used to detect supply or voltage absences that are not explained by network events, allowing to discriminate between legitimate technical failures and manipulations of the equipment or connection; in this framework, Enel Chile has meters with watchdog functions that quickly notify the loss of voltage to the central system, while CVC Energía uses alerts of absence of voltage as an input to verify in the field if the condition responds to an operational interruption or a fraudulent intervention, depending on the configuration of the supply.

Finally, the interviews underscore that the operational value of monitoring and alerting depends critically on its subsequent management. The massive generation of events can lead to saturation, false positives or loss of traceability if there are no filtering, prioritization and effective integration mechanisms with inspection processes. In this context, while some companies warn that poorly contextualized alarms can increase operating costs, those that have managed to automate and prioritize signals report substantial improvements in targeting and response times. Therefore, monitoring is not an autonomous solution, but a tool whose real impact depends on its coordination with operational management and with other physical and analytical hardening measures.



7.2.2. Physical hardening of meter access

Physical hardening of meter access is one of the most traditional measures in non-technical loss management. Unlike digital alerts, this type of intervention seeks to make it materially difficult to manipulate the metering point, making fraud more expensive and reducing its recurrence through physical barriers that limit direct access to the equipment. In practice, the interviews show that these strategies focus mainly on two approaches: the encapsulation of the meter, by means of enclosures or reinforced protection devices; and the relocation of the metering point at height, out of the immediate reach of the user, both aimed at increasing the effort and risk associated with the fraudulent intervention.

Meter encapsulation consists of the installation of reinforced enclosures that limit or prevent direct access to the equipment. These solutions include high-strength metal or plastic boxes, sealed and anchored to the infrastructure, designed to make it difficult to unauthorise open, remove the meter or intervene on its terminals. From an operational point of view, encapsulation seeks to increase the effort and time required to handle the equipment, acting as a deterrent and reducing the recurrence of opportunistic fraud. However, the interviews show that its effectiveness strongly depends on the context of application and the quality of the design and installation, since poorly adapted or deteriorated enclosures can be violated relatively easily. These solutions also introduce significant operational challenges: they increase the complexity and duration of meter reading, maintenance, and replacement tasks, require specific tools and protocols for authorized access, and can create friction with users and field personnel. In this sense, meter encapsulation appears to be an effective measure to raise physical barriers, but whose impact must be evaluated considering not only its deterrent capacity, but also the operating costs and additional demands it imposes on the day-to-day management of the network.

Relocating the meter out of reach of the user constitutes a more structural form of physical hardening of the metering point. This measure consists of installing the measuring equipment in elevated areas, poles, exterior facades or technical enclosures with restricted access, while on the customer's premises there is only a display device or consumption repeater without intervention capacity. In practice, this approach is usually materialized by concentrating meters in cabinets or shielded boxes, located at common technical points and out of manual reach, so that the measuring equipment is completely protected and separated from the user's home. This line includes schemes such as MULCON and BARCAR, developed by EDENOR, which use compact grouped metering modules installed at height or in "on-the-fly" boxes, as well as the blocked box systems implemented by ENSA, where multiple meters are concentrated in cabinets installed on the pole, from which direct connections to the homes depart. From these protected points, conductors are extended to power individual display devices, decoupling physical access to the meter from everyday supply use. The interviews indicate that this approach is especially effective in contexts of high recurrence of fraud, since it substantially modifies the modalities of illegal intervention. However, its implementation implies higher installation costs, relevant adaptations in the existing infrastructure and an increase in operational complexity for maintenance, replacement and commercial service tasks. In practice, this type of configuration is usually articulated with prepaid metering schemes, developed in section 8.2.2.

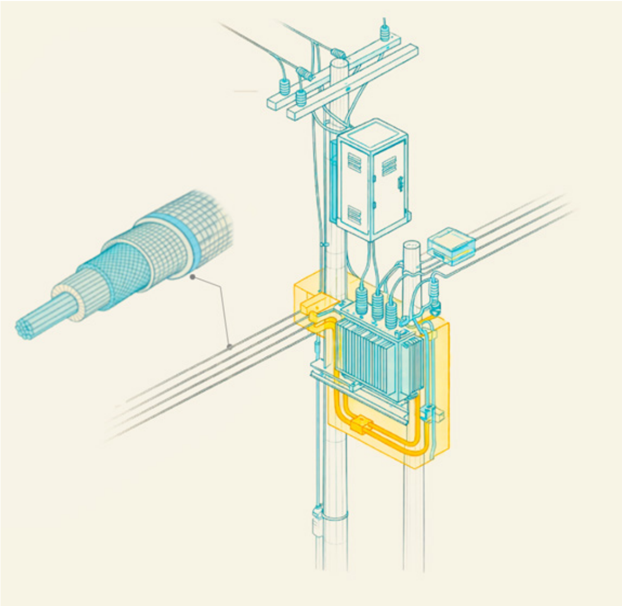
7.2.3. Protection of branches and connections

The interviews agree that, once digital monitoring and meter hardening have been strengthened, the fraud modalities tend to move towards the sections that feed the metering equipment, particularly the connection and the low-voltage branches. In this context, the protection of these elements becomes critical. Hardening strategies at this level seek to reduce accessibility to the conductor, make it more difficult to make illegal bypasses, and limit opportunities for direct connection upstream of the meter.

In practice, many of the measures aimed at the protection of branches and connections focus on the design of the conductor and its physical layout, with the aim of reducing the opportunities for energy diversion before the metering point and, at the same time, improving the safety conditions of the system. In this context, several distributors have progressively replaced bare or conventional cables with concentric, pre-assembled or anti-theft cables, whose construction configuration makes unauthorized interventions on the network difficult. These designs incorporate technical provisions, such as the neutral envelope and additional layers of insulation, which make any improper manipulation more evident and allow possible irregularities to be detected early, reducing both losses and electrical risks associated with informal interventions.

These solutions are usually complemented with criteria for the layout and accessibility of the connection that privilege external and visible routes, through facades or other areas of easy inspection, avoiding hidden pipes inside the property. In this way, improvements in cabling materials are articulated with network design decisions that facilitate monitoring, early detection of interventions and, at the same time, contribute to reducing electrical risks for both users and third parties.

In contexts of greater operational complexity or high predisposition to fraud, such as multi-family buildings, underground networks or areas of high vulnerability, distributors complement conventional solutions with more structural hardening measures on branches and connections. In buildings, a widespread practice is the concentration of meters and connections in collective cabinets or technical rooms with restricted access, which reduces individual manipulation and facilitates centralized control. In underground networks, where access to chambers or ducts has historically enabled illegal diversions, physical fortifications are resorted to such as reinforced enclosures, the deliberate reduction of useful space in chambers, or the use of high-strength slabs and lids that limit unauthorized access. On the other hand, in areas of high vulnerability, specific network designs are implemented that include dedicated connections from protected points, cabinets near the transformer and simplified routes, with the aim of eliminating informal connection points on the pass-through network.



7.2.4. Physical hardening of the distribution network

Finally, the physical hardening of the distribution network includes interventions carried out directly on the lines, branches and transformers, with the aim of hindering or eliminating the possibilities of illegal connection upstream of the metering point. Unlike actions focused on the meter or the connection, these solutions involve modifications to the electrical infrastructure itself and are usually applied selectively in critical areas, due to their higher cost, technical complexity and operational requirements.

One of the most widely used strategies to reduce direct theft from the network is to increase the height of low-voltage lines and modify the positioning schemes, physically moving the conductors out of the user's reach. Several distributors report the installation of pre-assembled networks at heights significaNTLs y higher than conventional ones, reaching between 11 and 13 meters in areas of high conflict, which makes access difficult from roofs, terraces or improvised structures and reduces the possibility of making direct connections through hooks or artisanal derivations. The experiences collected show, however, that this measure involves relevant technical challenges, since the increase in height and the use of certain fastening configurations can generate high mechanical stresses and bending moments on the posts, affecting their stability and useful life if the anchoring systems are not properly adjusted. Likewise, its applicability depends to a large extent on the current regulatory framework, given that in some countries the dimensions of the position and the admissible network configurations are regulated, which limits the margin for innovation.

The change in conductor technology is one of the most widely used tools for the physical hardening of the network, as it has a direct impact on the ease with which illegal connections can be made. In low voltage, the replacement of the bare network with pre-assembled network has become the most widespread standard: these are insulated conductors twisted together, usually around a carrier neutral, which makes it difficult to use hooks or quick taps and forces any offender to intervene in the insulation, a slower action, visible and risky. At higher voltage levels, semi-insulated or compact networks are used, where the conductors have protective covers and are arranged in more closed configurations, preventing direct electrical contact and blocking theft by throwing cables or hooks. In areas of high recurrence, some distributors have incorporated concentric or telescopic cables, in which the neutral completely surrounds the phase; in this scheme, any attempt to access causes an immediate short circuit or the tripping of protections, making illegal intervention practically unfeasible without generating an obvious failure. Together, these technologies raise the technical barrier to fraud and shift theft from quick and opportunistic interventions to more complex, visible and costly actions.

The most advanced level of physical hardening of the network is observed in the interventions that act directly on the distribution transformer and its low-voltage output. These strategies seek to protect the point where the secondary network originates, eliminating or severely restricting any possibility of unauthorized access to the conductors downstream of the transformer. Initiatives such as Enel Brasil's BT Zero model are based on the physical hardening of the transformer output and the elimination of exposed low-voltage network sections, so that energy only circulates through conductors protected and controlled from their origin. Similar experiences have been reported by other distributors in areas of high vulnerability, where the transformer becomes a physically protected node and the secondary network is designed to minimize informal connection points. Although this type of solution has very robust results in terms of reducing losses, its application involves significant investments and is usually reserved for areas with extreme levels of theft or high recurrence.

7.3. REGULATORY AND LEGAL MEASURES

7.3.1. Disconnection authority

The disconnection authority represents the most immediate and, at the same time, one of the most complex and debated tools within the management of non-technical losses (NTLS s) in Latin America and the Caribbean, placing itself at the center of a constant tension between the financial viability of distributors and the recognition of electricity as an essential service for a dignified life. This prerogative should not be understood as an absolute discretionary power of the companies, but as a regulated right that emanates from the public service contract of an adhesive nature, designed to protect the integrity of the infrastructure and ensure the economic consideration necessary for the sustainability of the system. In the regional legal architecture, there is a fundamental technical and procedural distinction between suspension, which constitutes a temporary or transitory interruption of the electricity flow without the removal of the metering equipment, and the cut-off, which implies the definitive cessation of the service, the termination of the contract and, frequeNTLs y, the removal of the connection and the meter. The exercise of this power seeks to balance operational efficiency with respect for due process, prior notification and the right to defense, principles that have been reinforced by various constitutional courts and regulatory bodies to prevent the interruption of service from resulting in a violation of fundamental rights, especially in subjects of special protection or critical institutions such as hospitals and educational centers.

The regulatory implementation of this measure varies profoundly among countries in the region, reflecting different regulatory philosophies regarding company responsibility and compliance. In Chile, the General Law of Electrical Services establishes that companies are empowered to suspend the supply once 45 days have elapsed since the expiration of the first unpaid bill, with the unavoidable condition of notifying the user at least five days in advance. A relevant legal nuance in this market is that the right of disconnect must be exercised in a timely manner; If the company does not suspend the service before the issuance of the next bill after the expiration of the term, the debts generated are no longer located in the property and become a personal responsibility of the debtor, thus protecting future owners or tenants from historical debts of third parties. In Colombia, regulation is particularly robust in upholding due process, forcing companies to investigate what are called "significant deviations" in consumption before proceeding with any charge for recovered energy or suspension. This requirement seeks to ensure that eventual charges are based on verifiable technical background, protecting users against metering errors, technical failures or inconsistencies in billing. At the same time, these investigations allow the identification of unintentional non-technical losses and operational problems in metering systems, contributing to improve the quality of commercial information and service management. Likewise, the omission of this prior investigation, or the failure to comply with the duty to suspend the supply after three periods of arrears, can be interpreted as negligence of the company, limiting its ability to demand the payment of debts accumulated at the time of reconnection.

On the other hand, Mexico's model under the Electricity Industry Law allows differentiated procedures: while for ordinary non-payment, 10 calendar days are granted after the payment deadline for the suspension; in cases where the existence of installations that alter the operation of the metering equipment is proven, the immediate suspension is authorized to stop the economic damage and mitigate security risks for the network. In Argentina, the Supply and Connection Regulation (Subannex E) empowers distributors to suspend service after fifteen days of arrears, also applying surcharges of 40% on the energy recovered in proven cases of misappropriation. However, testimonies from companies such as Edesur stress that the cut-off is used only as a last resort after exhausting instances of mediation, recognizing the risk of physical confrontation and violence that the crews face on the ground.

The operational experiences of the distributors reveal that the supply cut, although legal, presents critical limitations in its effectiveness as an incentive for payment. From Enel Chile's perspective, this measure is described as the most unpopular and, paradoxically, the worst mechanism to get a delinquent customer to regularize their situation, since it does not address the root causes of non-payment and encourages the cycle of clandestine self-replacement. Users who are cut off often resort to direct connections that not only perpetuate non-technical loss, but exponentially increase the risks of fires, transformer overloads and electrocutions, affecting the quality of supply to the entire surrounding community. In addition, frequent outages deteriorate the relationship between the user and the company, since the consumer loses confidence in the distributor's ability to provide a decent service, which in low-quality contexts can exacerbate the rejection of formality. In contrast, CRE RL reported that in Bolivia the regulations explicitly prohibit cutting off the supply in cases of detected theft, forcing the company to maintain the flow while economic sanction and energy recovery procedures are exhausted, allowing the cut only in the event of ordinary debts or imminent danger.

The technological transformation led by the Advanced Metering Infrastructure (AMI) is redefining the paradigm of cutting power, allowing the transition from an act of manual force to a digital and less invasive management. Smart meters enable remote shutoff and reconnection capability, eliminating the operational costs of moving crews and reducing the risk of physical aggression to technical personnel in areas of high conflict. One of the best practices identified is the migration towards restricted power or digital power limiters, such as those implemented by EPEC in Argentina that, instead of totally interrupting the supply, reduce the home's charging capacity (for example, to 20 amps) to allow basic consumption. This educational approach allows the user to maintain the service while being forced to manage their demand, avoiding the social damage of the total blackout and facilitating an assisted transition to formality.

Finally, the sustainability of the authority to cut off vulnerable sectors depends on its integration with social inclusion and regularization measures. The experience of EPM in Colombia and DELSUR in El Salvador shows that the cut is not financially viable on a recurring basis if a viable alternative is not offered. EPM has made a prominent commitment to prepaid energy, which allows users to pay only for what they need and avoid the accumulation of unmanageable debts; DELSUR, on the other hand, has focused its strategy on financing for regularization, making it easier for users in an irregular condition to formalize their supply without facing insurmountable economic barriers. The use of prepaid meters in areas of high delinquency has proven to be a “star measure” to transform the business relationship, granting autonomy to the customer and drastically reducing the need for coercive suspensions. Thus, although the power of disconnect continues to be a cornerstone of legal certainty and enforcement in the region, its modern success lies in its ability to become a component of a comprehensive network integrity management system, where digital technology and community support ensure that the recovery of income is not achieved at the expense of the fracture of the social fabric.

7.3.2. PROSECUTION

The prosecution of NTLS constitutes the set of legal processes and actions, both in the criminal and administrative spheres, aimed at sanctioning the theft of energy and ensuring the effective recovery of the income not received by the distribution companies. Within the framework of modern network management, this measure has ceased to be a reactive response based on manual physical inspections to become an integrated model of income defense that incorporates smart metering (AMI) technologies, advanced analytics and artificial intelligence to strengthen the evidentiary capacity before the courts. Prosecution seeks to transform technical irregularity into a concrete legal consequence, sending a signal of enforcement that discourages recurrence and protects the integrity of the national critical infrastructure.

Prosecution operates fundamentally under two routes: the criminal one, aimed at the punitive sanction of the crime of energy theft, and the administrative or contractual one, focused on the restoration of economic balance through the retroactive collection of the energy consumed. One of the main advantages of an efficient judicial system is the generation of a real deterrent effect; For example, the dissemination of effective sentences in the media contributes to society perceiving energy theft as theft with tangible consequences. It also allows businesses to recover vital cash flows that would otherwise become direct financial losses or charges unfairly shifted to users who pay their bills on time.

However, the implementation of these strategies faces significant structural barriers in Latin America. Congestion in judicial systems means that criminal proceedings are excessively slow; in countries such as Colombia, a fraud case can take between seven and eight years before a sentence is reached, leading to a perception of impunity. Added to this is the technical training gap for judges and prosecutors, who often underestimate the seriousness of these crimes in the face of crimes with a greater immediate social impact. In addition, there is a risk of social confrontation in areas of high vulnerability, where legal action without the support of normalization programs can lead to violence against inspection crews or territorial blockades.

Interviews and documentary sources allow us to identify contrasting models in the way of approaching the legal prosecution of fraud. Brazil stands out for its highly integrated approach with the security forces. Enel Brasil reports close collaboration with the police, achieving more than 300 arrests for energy theft in São Paulo in a single year, which significaNTLs y reinforces enforcement. This effectiveness is supported by the existence of police units specialized in delegated services, allowing arrests in flagrante delicto that are difficult to refute in court.

In Colombia, fraude de fluidos (energy theft) is a criminal offense, but companies face extremely lengthy legal proceedings, which can last between 7 and 8 years. Enel Colombia has hundreds of active processes before the prosecutor’s office seeking to transmit discipline, although the results of effective convictions are limited. For its part, EPM highlights the importance of expert service agreements with judicial investigators to strengthen the body of evidence, although they regret that judges do not always understand the technical complexity of the electricity sector.

In Peru, companies such as Electro Dunas have begun to prosecute cases more aggressively, achieving sentences of up to 3 years in prison. The distributor uses these sentences in its advertising campaigns to make the community understand that theft is a robbery “like any other”. CVC Energía also highlights that the agreement with the Peruvian National Police (PNP) has been key to identifying irregular supplies and generating a deterrent effect that spreads by “word of mouth” between neighbors.

The case of ENSA in Panama illustrates the evidentiary frustration. Despite documenting fraud through technical laboratories, the company reports that it loses 85% of the cases before the regulator, who usually agrees with the client because he considers the evidence provided insufficient. This shows that, without a normative consensus on what constitutes “full proof”, administrative prosecution can be sterile.

In Chile, the cooperatives grouped in FENACOPEL face extreme difficulties in proving unrecorded consumption (CNR), in addition to rural violence where inspection crews in some cases are received with firearms, preventing the collection of physical evidence. In Argentina, distributors such as SECHEEP point out that energy theft is not criminally punishable in its current framework, limiting its action to customer management. In contrast, EDENOR is committed to the total digitalization of the inspection report with georeferenced photos to ensure that the evidence cannot be questioned due to lack of traceability.

7.3.3. Loss Regulations

The rules and regulation of losses constitute the legal, technical and administrative scaffolding that establishes the fundamental rules of the game under which electricity distributors must manage unbilled energy. This regulatory area deals with the legal capacity of the company to intervene, the classification of infringements and the consumer protection protocols that govern the contractual relationship. In Latin America, the robustness of this framework is decisive, as NTLS s often overwhelm the operational capacity of companies to enter territories where informality is structural or public security is compromised.

A comprehensive regulatory framework must be based on an unequivocal technical and legal definition of what constitutes a loss, separating with arithmetical precision the technical losses – inherent to physical transport – from the non-technical ones, derived from human behaviour or administrative failures. In this sense, one of the most recurrent problems in the region is regulatory obsolescence in the face of technological advances. Testimonies collected in companies such as Pluz Energía in Peru highlight that the regulations in force in their market date back to 2006, a time designed for a fleet of electromechanical meters, which leaves enormous legal loopholes in the face of modern frauds that involve the sophisticated manipulation of electronic cards or the injection of loads into the network that the old regulations do not adequately typify. This lack of updating weakens the legal position of companies before the control bodies, which often rule in favor of the user due to the impossibility of supporting the evidence according to protocols that do not reflect the current digital reality.

In terms of good practices, the multi-sectoral approach to address the so-called "risk areas" stands out. In Brazil, companies such as Enel Rio and Equatorial operate under ANEEL regulations that have begun to explicitly recognize the existence of areas where organized crime exercises a parallel power that prevents technical action. This classification allows the distributor to support before the regulator the physical impossibility of reducing losses in these territories without an integrated intervention of the State that includes security and regularization of the property.

A recurring regulatory conflict point is the asymmetry of responsibilities between the distributor and the marketer. In Colombia, it has been identified as a critical "pain point" that the burden of combating losses falls almost exclusively on the grid operator (RO), while pure marketers do not bear the costs of the energy stolen by their customers or actively participate in the inspection of metering equipment, of which they are often legal owners. This fragmentation of incentives allows fraud to persist in the weakest links in the chain, underscoring the need for regulation that aligns the obligations of all market agents so that the fight against fraud is systemic and not an isolated effort of those who operate the infrastructure.

Regarding consumer protection and debt recovery, distributors face contrasting regulatory realities that impact their financial health. Experience in countries such as Ecuador indicates that regulatory frameworks with a strong focus on user advocacy can generate significant administrative barriers. In these contexts, complaint processes in consumer protection instances impose high evidentiary standards on companies. This procedural rigor, focused on customer protection, often limits the ability of distributors to materialize retroactive energy charges, even in the face of scenarios with technical evidence of manipulation. On the other hand, in Costa Rica, the ICE operates under a regulation that requires the recovery of all unbilled energy and allows the customer to be charged the costs of inspection and repair, sending a clear signal of enforcement. For its part, Chile's experience with the implementation of smart meters (AMIs) left a valuable lesson for the region: any regulatory change that affects asset ownership or perceived costs must be accompanied by a robust public communication policy; otherwise, social and political opposition may slow down vital technological investments.

Finally, regulation should address management autonomy, especially in publicly owned enterprises that are often more exposed to interference. Modern regulation should ensure that investments against NTLS s are based on data analysis and operational profitability, and not on the political availability of funds. In this sense, the digitalization of field processes, from detection by algorithms to automated invoicing, appears as the definitive regulatory tool to ensure the traceability and integrity of legal evidence, reducing discretion and improving the overall effectiveness of the regulated system.

7.3.4. Regulatory incentives and tariff recognition

Regulatory incentives and tariff recognition represent one of the most sophisticated and critical pillars in the institutional architecture designed to combat non-technical losses (NTLS s). These types of measures do not translate into physical action on the grid, such as hardening or inspection, but consist of the design of precise economic signals by the regulator to align the financial objectives of the distributors with the standards of operational efficiency. The basis of this strategy lies in the "regulation by incentives" scheme, where the regulator establishes a level of efficient or recognized losses that the company is allowed to pass on to the user's final tariff. Under this logic, if the distributor manages to reduce its real losses below the imposed target, it can retain the economic difference as an additional profit, but if its losses exceed the recognized limit, the company must absorb the full financial cost of the unbilled energy, which directly pressures its profitability.

This approach offers substantial advantages, providing the financial viability needed to undertake long-term investments in advanced technologies such as smart metering infrastructure (AMI), which often have high upfront costs that could not be recovered without a clear remuneration framework. In addition, the existence of these incentives fosters what is called an "NTLS vision" throughout the organization, making loss reduction not only a task of the commercial area, but a strategic objective that permeates from network maintenance to customer service. In the long run, a system that incentivizes efficiency allows tariffs to be lower and fairer, preventing users who pay on time from bearing the costs of system inefficiencies or third-party fraud.

However, the effective implementation of these incentives requires rigorous requirements, starting with the need for an extremely accurate calculation of technical losses. Because NTLS s are usually calculated on a residual basis, subtracting technical losses and billed energy from the total energy injected, any error in the technical modeling of the grid automatically distorts NTLS signal, punishing or rewarding the company unfairly. The regulatory framework should also be of exemplary stability and predictability, so that companies can take on investment risks with the certainty that remuneration rules will not change abruptly over the life of the assets.

Despite their benefits, there are critical barriers that can neutralize these incentives, the most notable being political sensitivity that often interferes in the design of tariffs, keeping them artificially low or preventing the recognition of real costs, which breaks the economic-financial equilibrium of the concession contract and discourages private investment. Some public companies, such as Argentina's EPE SF, suggest that the management of investments in technology and inspection crews is often subject to political cuts or swings, which contrasts with the greater inertia towards efficiency that private operators tend to show. In addition, tariff recognition often ignores unmanageable external factors, such as extreme poverty or insecurity in informal settlements. In Panama, for example, the regulator uses benchmarking based on U.S. companies operating in radically different socioeconomic contexts, resulting in unrealistic efficiency goals. To mitigate this, ENSA achieved the extraordinary recognition of 60% of the losses in the so-called "red zones", basing its request on official public security data that demonstrate the physical impossibility of acting in certain territories.

Looking at the regional landscape, there are stark parallels and differences in how each country approaches the recognition of losses. Colombia, under Resolution CREG 015 of 2018, has established an innovative model that allows operators with critical levels of losses to submit Reduction and Maintenance Plans. An aspect highlighted by EPM and Enel Colombia is that this framework not only recognizes the cost of recovered energy, but also the Administration, Operation and Maintenance (AOM) expenses specifically associated with combating NTLS s, understanding that sustaining low levels of loss requires a constant operational effort and not just an initial investment in assets. Similarly, DELSUR in El Salvador achieved outstanding results by having 100% of the technical loss and half of the non-technical loss recognized, which provided it with the financial oxygen to reduce its total losses from 10% to 7% in a period of five years through transparent and efficient customer management.

In contrast, Peru's model is based on the "Efficient Model Company", where the regulator sets a strict limit of NTLS , generally 2.56% at low voltage, based on an optimized theoretical network. Companies such as Pluz Energía have stated that this framework, originally designed in 2006, has lagged behind the technological evolution of fraud, as mentioned in the previous section. The difference with the models of Colombia or Brazil is that the Peruvian system exerts constant pressure towards maximum theoretical efficiency, which has generated controversies about whether operating costs in hard-to-reach areas are being fully recognized. A similar disincentive is observed in Centrosur (Ecuador), which despite having one of the best loss rates in the region (around 6%), the regulator recognizes exactly that value, without rewarding the additional effort to stay below the national average, which generates a sense of punishment towards the most efficient companies.

In Brazil, ANEEL applies a yardstick competition model that uses socioeconomic variables to group distributors into clusters of similar complexity. According to Enel Brasil, for this model and new technologies such as prepaid to work, tariff differentiation is essential to encourage users to adopt more efficient payment and consumption schemes. In addition, they emphasize the importance of proactive communication with the customer so that the inspection process is not seen as an arbitrary penalty but as a fair recovery of resources. On the other hand, in Costa Rica, the ICE operates under a simple metric where the regulator recognizes a maximum of 8.30% based on the market average, forcing the country's seven distributors to compete to be below that mark to avoid direct financial losses.

There are cases where the recognition of losses is transferred to the field of social policy, as is the case with SECHEEP in Argentina, which, since it does not have a formal tariff recognition by the regulator for areas of high vulnerability, depends on provincial programs where the government directly finances consumption in slums and settlements measured in substations. This situation is similar to the discussions in Chile, where Enel Chile faced strong social opposition in 2019 to the massification of smart meters (MILs), due to the fact that there was no clear public policy that explained the benefits of the investment or who should assume ownership of them, which ended up slowing down technological deployment and forcing a revision of the regulations.

Finally, it is important to mention that the modern regulatory trend is beginning to link loss reduction with environmental sustainability. Given that NTLS s encourage overconsumption as there is no real price signal for those who steal energy, it is estimated that this phenomenon generates between 5 and 6 million tons of CO_2 annually in the region. The integration of loss reduction targets into national climate change strategies could open up new sources of green financing, allowing investments in grid hardening and digitalization to be remunerated not only for their operational efficiency, but also for their contribution to the decarbonization of the economy.

7.4. COMMUNITY STRATEGIES AND AWARENESS

7.4.1. Prevention and electrical safety campaigns

Electrical prevention and safety campaigns represent a paradigm shift within the management of NTLS s in Latin America and the Caribbean, moving from a purely punitive approach to one based on social marketing and integrated risk management. This approach is based on the premise that the communication of life risk constitutes a much more powerful and socially acceptable deterrent than the threat of legal sanctions or financial fines. The scope of these initiatives transcends the technical warning to insert themselves in civic education and cultural transformation, linking the legal use of energy with the protection of the physical integrity of families and the community. It seeks to break the social justification of fraud by presenting the manipulation of networks as activities that put people's health at risk, such as death by electrocution, structural fires and loss of property, transforming the theft of an alleged "cunning or social mischief" into a behavior perceived as risky and criminal.

These campaigns are deployed under the concept that the human factor is the most critical link in the distribution chain. Companies such as ESSA in Colombia, with its slogan "Connect with safety, disconnect from danger", present information aimed at highlighting that the economic savings are perceived as insignificant in the face of the risk of permanent disability or loss of life. In addition, the user is educated on the protection of individual property, warning that clandestine connections, lacking protections such as fuses of correct capacity or grounding systems, generate voltage fluctuations that can destroy appliances whose replacement cost far exceeds the benefit of illegality. In fact, Pluz Energía in Peru indicates that up to seven out of ten fires in critical areas have their origin in irregular electricity consumption, which reinforces the need to use safety as the main argument to encourage citizen reporting.

The experiences collected through Latin American distributors reveal a diversity of good practices that combine technology, face-to-face and communicative creativity adapted to each territory. In Ecuador, the EEQ has identified that children act as highly effective information multipliers, using informative sketches and comic content in schools so that the message of risk escalates to adults, which has resulted in a notable increase in the channels of citizen complaints by neighbors who feel threatened by the fraud of others. Along the same lines, SECHEEP in Argentina and EDP in Brazil focus their awareness programs on rational and efficient use from the school stage, integrating agents who visit the field to encourage the change of old technologies for LED lamps, humanizing the commercial relationship. For its part, Enel Brasil has opted for technological transparency and proactive communication, using WhatsApp and YouTube to inform customers about inspection processes, sending clear messages when an irregularity is detected (Termo de Ocorrência e Inspeção - TOI) to ensure that the user understands that it is not an arbitrary penalty, but of a recovery of energy necessary for tariff justice.

Enel Chile has implemented the Center of Excellence, a laboratory that represents a full-scale distribution network, energized under safe conditions, so that the community physically understands the dangers of illegal manipulation. In contexts of high conflict, such as those reported by CVC Energía in Peru, the simple distribution of informative flyers and basic training on short circuits has made it possible to reduce fraud indicators even in areas where gangs were previously prevented from accessing by the aggressiveness of users. This "energy with purpose" seeks to make the population value formal supply not only as a service, but as proof of residence that grants dignity and access to other social benefits, reducing the inefficient overconsumption that characterizes theft and that generates between 5 and 6 million tons of CO_2 annually in the region due to the lack of incentives for savings.

The effectiveness of these campaigns also depends on their ability to adapt to seasonal and geographic cycles. Some distributors intensify their alerts during the holiday season, warning about the risk of fires due to the use of uncertified Christmas lights and as a constant reminder of the danger of interacting with the network. However, companies face critical barriers such as misinformation generated by organized groups that promote the "culture of non-payment", arguing that energy is a free right, which requires sustained social support by multidisciplinary teams that include sociologists and community managers.

Finally, the regional trend suggests that prevention campaigns are successful only when they are integrated with enabling business solutions and technological modernization. The experience of EPM in Colombia, with more than 300,000 customers in prepaid energy, and of Enel Colombia, with its "Safe Energy for All" initiative, demonstrates that offering a formal, safe and low-cost connection alternative eradicates the need to resort to artisanal connections. Network hardening and the installation of meters at height must be preceded by dialogue tables with local leaders to avoid rejection of the technology. Electrical safety is the most eloquent language for protecting life and infrastructure, demonstrating that a system with low losses is more resilient and sustainable.

> "Electrical prevention and safety campaigns represent a paradigm shift within the management of NTLS s in Latin America and the Caribbean

7.4.2. Legality and civic education

Legality and civic education operate on the cultural and ethical dimension of the user to transform their relationship with the electricity service. This category focuses on the construction of a "culture of legality", where the electricity supply is no longer perceived as an inexhaustible, free resource or a political booty, and is recognized as an essential public service that requires a fair consideration to guarantee its quality, expansion and safety. In Latin America, this challenge is particularly complex due to the persistence of a social norm that often treats electricity as an absolute right detached from the duty to pay, which generates "inefficiency traps" where theft is socially tolerated and, at times, encouraged. Therefore, the scope of these measures seeks to break the cycle of informality through social marketing, transparency in the communication of the real costs of fraud and the creation of a sense of belonging and shared responsibility between the distribution company and the community.

Best practices have migrated towards models of community management and social inclusion, recognizing that tougher penalties alone clash with the reality of energy poverty and institutional weakness. The IDB stresses that tolerance for losses is ineffective in promoting equity, since the costs of stolen energy end up being passed on to legal users or degrade the quality of service for the most vulnerable, who lack the resources to protect themselves against voltage instability. In this sense, a good practice identified is the use of exchange theory, where the company offers security, patrimonial stability and dignity (such as the invoice as proof of residence to access microcredits) in exchange for the formalization of the service. On the contrary, a recurrent bad practice is "punitive populism" or the politicization of the sector, where irregularity is allowed as a form of blind subsidy that weakens the investment capacity and credibility of institutions.

The experiences documented by Latin American distributors show different trajectories to promote formalization and citizen ethics. In Peru, companies such as Electro Dunas have opted for a direct and dissuasive discourse, launching campaigns that warn that "whoever steals energy goes to jail", using real court sentences of up to three years in prison to educate about the criminal nature of theft. In contrast, EPM in Colombia has developed a model of deep social management, where the pillar is not the cutting of the service, but the support of social managers who act as bridges with community leaders to introduce prepaid energy. This solution has made it possible to link more than 300,000 vulnerable customers to the formal system, allowing them to manage their consumption according to their daily cash flow and eliminating the need to resort to dangerous artisanal connections.

Enel Brasil's strategy under the "Legal Energy" program integrates technical oversight with education, bringing mobile offices to communities to negotiate debts and carry out joint inspections with the population. An interesting parallel can be seen in Argentina, where EPEC and EPESF have developed specific "electricity inclusion" programs for popular neighborhoods and slums, closely articulating with provincial and municipal governments. This strategy involves carrying out infrastructure works prior to commercial regularization, establishing them as an indispensable condition to guarantee electricity security and the sustainability of formalization. In these contexts, civic education includes teaching the responsible use of energy to neighborhood leaders, achieving a cultural change that is reflected in a higher rate of permanence and less recurrence in fraud.

For its part, DELSUR in El Salvador has identified that formalization requires direct economic incentives, such as the financing of internal electrical installations, eliminating the initial technical barrier that prevents low-income families from legalizing. Finally, the regional trend suggests that legality should be linked to environmental sustainability, communicating that loss reduction is not only a financial objective, but a direct contribution to the reduction of CO2 emissions and to the climate resilience of cities.

7.4.3. Community work and coordination

Community work and intersectoral coordination represent the most advanced and necessary frontier in the management of NTLS s, operating under the fundamental premise that energy theft cannot be solved exclusively through a technical or punitive approach, since its roots are deeply socioeconomic, political and environmental. This category of measures seeks to shift the pillar of the intervention towards the construction of a social license to operate, understood as the support and trust of the communities that allow the distribution company to execute its functions in environments of high social complexity. The scope of these strategies is holistic, integrating infrastructure modernization with social awareness programs, coordination with authorities, and the creation of permanent dialogue mechanisms that humanize the relationship between the company and the user. In the region, best practices show that loss reduction is sustainable only when it is linked to the real improvement of the quality of life of populations, transforming the electricity supply into an "energy with purpose" that provides dignity and legal certainty.

Institutional discoordination is one of the main traps of inefficiency in the region, since the absence of solid social policies leads the State to tolerate energy theft as a form of informal transfer of resources. On the contrary, successful experiences have been based on clear institutional support and a multi-sectoral approach that involves not only distributors, but also territorial planning and public security entities. A recurring good practice is the use of social marketing, where the company offers stability and asset protection in exchange for the legalization of the service. In contrast, a common bad practice has been the implementation of advanced technologies, such as smart meters, without adequate prior communication, which in contexts such as Chile generated strong social and political opposition that slowed down technological deployment.

The experiences documented by Latin American distributors offer details on how this community work is grounded in the territory. Enel Brasil has been a pioneer in the use of community leaders, with a network of more than 800 referents who act as mediation agents to build trust and facilitate the entry of technical crews to carry out joint inspections, negotiate debts and promote energy efficiency projects, such as the replacement of refrigerators or LED lamps. making the user feel like a partner in the system and not a victim of oversight. In Uruguay, the company UTE has innovated with its "proximity brigades", made up of a technician and a commercial agent, who visit homes to advise and fix internal installations free of charge as an incentive for formalization, ensuring that the customer avoids falling into unpayable debts.

In Argentina, companies such as EPEC have inverted the traditional logic, proactively going towards informal settlements to individualize each family and accompany the formalization process through low-voltage works that precede the inspection, working hand in hand with municipalities in the diagramming of safe lots. For its part, Edenor highlights the importance of working with foundations to train new users in the rational use of energy, ensuring that their consumption is payable and avoiding the recurrence of fraud due to unmanageable bills. However, the path is not without barriers; in areas of severe operational restrictions, companies face opposition from organized groups that promote a "culture of non-payment," forcing distributors to coordinate their shutdown and regularization operations with the support of the security forces, as in the cases reported by Electro Dunas in Peru and SAESA in Chile.

The Dominican Republic offers a distinctive model through the "Monitoring and Liaison Committees" (COSE) and the signing of "Social Pacts" between communities and distributors. In these agreements, the company undertakes to improve continuity of supply and repair dangerous networks, while the community assumes responsibility for not making illegal connections and reporting suspicious tampering, creating a system of co-responsibility that has made it possible to reduce commercial losses significaNTLs y. This type of innovation shows that community work must be flexible and adapted to the physical reality of each settlement to be effective.

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> Community work and intersectoral coordination represent the most advanced and necessary frontier in the management of National Territories

7.5. LIMITS OF THE PUNITIVE APPROACH

However, the effectiveness of physical barriers and legal persecution finds an insurmountable border in the social reality of the territories. Operational experience shows that, in contexts of high vulnerability and urban exclusion, fraud does not always respond to an opportunistic decision to maximize profits, but to a subsistence strategy in the absence of formal alternatives. In settlements where the state is absent – without property titles, street layouts or public infrastructure – the irregular connection becomes the only way to access an essential service. In these scenarios, purely coercive measures, such as repeated shutdowns or hardening networks, tend to generate an exhausting cycle of immediate reconnections and social conflicts, without resolving the root cause of unregistered consumption.

Faced with this evidence, distributors have begun to distinguish between malicious irregularity and structural exclusion, recognizing that there is a relevant segment of users who, living on the margins of the system, express willingness to regularize their situation in order to access a safe and quality service. This reading has prompted companies to complement their loss management with specialized areas of social management and inclusion, and to establish alliances with municipalities and state agencies. The objective is no longer only to protect the network to integrate the user, under the premise that the sustainable solution does not lie in preventing access, but in building the technical, economic and legal conditions for payment to be viable. It is precisely this repertoire of solutions that Pillar 3 deals with.

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PILLAR 3: REGULARIZATION AND SOCIAL INCLUSION

8.1. NEED FOR REGULARIZATION

The evidence collected in interviews shows that a relevant part of NTLS s in the region is sustained in structural situations of informality and exclusion from the service, where there are users without a contract, without a meter or with irregular connections in camps, precarious settlements or peri-urban areas of high vulnerability, as explained by UTE, SAESA and CENS. In these contexts, the control logic based only on detection and inspection tends to generate transitory results: a point is intervened, but the irregularity quickly reappears if a viable path to formality is not enabled, according to UTE and ESSA. In addition, Electro Dunas and ESSA report operational and security restrictions that limit the capacity for sustained inspection in the field, which reinforces the need for approaches that combine technical-commercial management with social and territorial strategies.

In this framework, regularization is understood as an enabling condition for a sustainable reduction of NTLS s, as it seeks to convert irregular consumption into formal supply, with stable metering, billing and service channels, reducing electrical risks and improving service continuity. The experience of ENSA and SAESA suggests that this process usually requires coordination with public actors on issues of land legalization, supply authorization, and multi-sectoral approach (for example, illegal settlements where formalization exceeds the distributor's capacity for unilateral action). ConsequeNTLs y, regularization is not an isolated measure, but a process that allows customers with high levels of socioeconomic vulnerability to be treated differeNTLs y and to sustain the reduction of losses beyond the reactive cut-off cycle (UTE and Enel Brasil).

8.2. ENABLING INSTRUMENTS

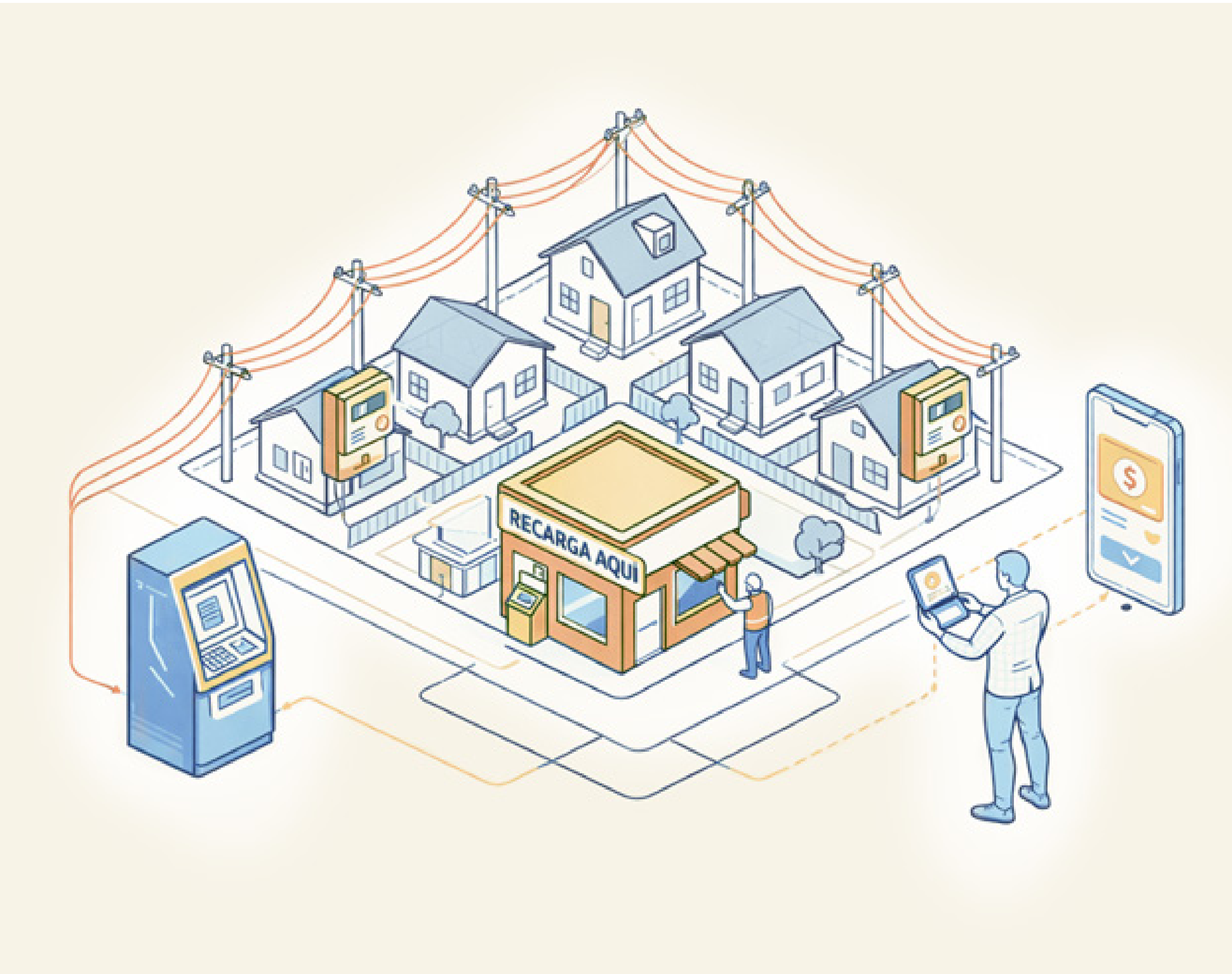
In contexts where NTLS s are associated with exclusion from the service, persistent informality, and socioeconomic vulnerability, the companies interviewed describe "enabling" instruments that complement control and oversight. These instruments seek to (i) incorporate clients into the formal system with social support and territorial adaptation; (ii) prevent debt and collection rigidity from driving the relapse into irregularity; and (iii) reduce economic barriers to access through social tariffs or subsidies, favoring the sustainability of the contractual relationship.

8.2.1. Energy inclusion

Energy inclusion is presented as a set of practices aimed at building user loyalty to the formal system in vulnerable neighborhoods, reducing electricity risks and creating conditions for a culture of payment. A recurring element is the work of proximity and the sustained presence in the field, for example, EPEC SAU has implemented programs that combine regularization with training of neighborhood referents on responsible use of energy and support in procedures and management of consultations/payments. In a similar logic, CENS reports the creation of teams or lines of social management to link users in settlements, including the execution of infrastructure associated with the formalization and mitigation of risks of electrical origin.

Another good practice mentioned by SECHEEP and EEQ is the structuring of specific devices for the territorial approach: dedicated teams that visit neighborhoods, collect information and manage regularization, or focused projects to reach vulnerable areas and reduce conflict associated with historically unmeasured sectors. In Uruguay, the explicit segmentation of “customers without inclusion” is described as a group that requires differentiated treatment, articulating control strategies with a social inclusion project (UTE). Along the same lines, the UTE highlights the incorporation of proximity brigades made up of a technical and a commercial profile, aimed at regularizing and accompanying the customer to prevent them from being “trapped” in an unpayable debt, reporting an increase in formalized customers after the intervention.

Finally, several companies (SAESA, ENSA and Enel Brasil) point out that, in camps or illegal settlements, energy inclusion depends on external conditions (legality of the land, state coordination and security), so the key instrument is multi-sectoral coordination (municipalities/State and other services), and even the use of regularization processes of other services, such as water, to facilitate electricity regularization. Along the same lines, EDEQ has facilitated safe access to the service for 1,900 families in underserved conditions through joint work with municipal authorities, managing to reduce electricity risks for these customers. The experience also raises a fundamental reflection: the losses generated by the lack of urban control – whose origin is in territorial planning decisions beyond the control of the network operator – should not be assumed by the market as a whole, but require regulatory mechanisms that involve the responsible departmental entities, articulating technical solutions with broader institutional responsibilities.



8.2.2. Payment flexibility

Payment flexibility appears as a mechanism to sustain regularization and avoid relapses into irregular connections due to inability to pay or accumulation of debt. Among the practices reported by CVC Energía are payment agreements with defined terms and acceptance by both parties, accompanied by active communication from collections to anticipate delinquency and maintain the link with the customer. In cooperatives such as CRE RL, gradual schemes are mentioned where facilities are offered and, only ultimately, the supply is cut off, which operates as a progressive process before more invasive measures. In Chile, the use of payment facilities and recovery campaigns with a focus on customers willing to regularize, leveraged on high levels of collection, is described.

A specific instrument pointed out by UTE as an alternative to the total cut-off is the reduction of contracted power for certain segments linked to social inclusion, so that the customer maintains a minimum and affordable supply while transitioning to formality. In addition, EDEA warns that, when regularizing businesses or supplies with irregular history, the debt may be associated with previous occupants, so debt treatment criteria are required that do not block formalization.

At the same time, prepayment (pay before consuming) is reported as a tool of flexibility and control, with different variants: automatic cut-off when the balance is exhausted, provision of "emergency" energy or recharge mechanisms and discounts/withholdings to amortize previous debts (ESSA, ENSA and EPM). To improve accessibility, EPM highlights the enabling of multiple recharge channels (bank, neighborhood businesses, third parties), recognizing that part of the population prefers nearby face-to-face points. SECHEEP and Centrosur also mention limited prepaid pilots and applicability reviews according to segment.

8.2.3. Direct financial support

Direct economic support is mainly expressed through social tariffs, differentiated tariffs and subsidies, as instruments to reduce barriers to access and improve the sustainability of regularization in highly vulnerable segments. The need or existence of differentiated tariffs for vulnerable populations is reported, emphasizing that the sustainability of the scheme requires provision for the replacement/maintenance of equipment over time (SECHEEP). In cooperatives, CRE RL describes a regulated solidarity rate, applying discounts for low-income users. In Argentina, EDEA mentions a regulated and coordinated tariff to accompany formalization, although with challenges in its implementation when the starting point was a high prevalence of illegal connections. It is also highlighted that there is a relevant universe of customers in extreme vulnerability that requires differentiated treatment within the regularization strategy (EPEC SAU).

From a management perspective, EEQ points out that subsidy administration is usually organized as a specific function (administrative area), with state transfers operating as monetary control associated with access to the service. Finally, the use of customer segmentation is observed to define tariff schemes or commercial relationship conditions aimed at improving collection and equity of access in segments with a history of irregularity or vulnerability (Enel Chile).

8.3. SOCIAL INCLUSION AND FINANCIAL SUSTAINABILITY

The experiences gathered in interviews agree that the regularization of supplies in contexts of vulnerability is only effective if it is accompanied by economic and social conditions that allow the contractual link to be sustained over time. In this sense, social inclusion is not limited to initial access to the formal service, but is expressed in mechanisms that ensure continuity of payment, reduction of recurrence and financial viability for both the user and the distribution company.

From this perspective, the good practices identified focus on three complementary dimensions: the strategic use of social tariffs, the active management of the debt associated with regularization, and community support as an enabling factor for the process.

8.3.1. Social tariffs

Social tariffs appear as a structural element to sustain regularization in highly vulnerable segments, allowing formal supply to be economically accessible and reducing the risk of a return to irregularity. Unlike its role as an instrument of access, in this dimension the interviews highlight its function as a mechanism for stabilizing payment over time.

Companies such as SECHEEP, CRE RL and EPEC SAU point out that the existence of social or solidarity tariffs allows the contractual relationship to be consolidated after regularization, provided that there is clarity in the eligibility criteria and financing provision for the operation and maintenance of the scheme. In this sense, it is emphasized that the sustainability of the instrument depends on its coordination with public policies and state transfers, avoiding that the burden falls exclusively on the distributor.

Likewise, EEQ and Enel Chile highlight the importance of customer segmentation to assign differentiated tariff conditions, allowing commercial treatment to be adjusted according to levels of vulnerability and historical behavior, with positive impacts on collection and permanence in the formal system

8.3.2. Debt management

Debt management emerges as a critical factor to prevent regularization from leading to new cycles of delinquency and disconnection. The interviews show that, in many cases, the accumulated debt (real or estimated) constitutes a more relevant barrier than the tariff itself to sustain the formal supply.

Distributors such as UTE, CVC Energía and EDEA report practices aimed at decoupling the formalization of the immediate payment of historical debts, through agreements, refinancing or differentiated treatment of debt associated with previous occupants. This approach seeks to prioritize future regularity over the full recovery of the past, reducing the likelihood of abandonment of the formal system.

In addition, alternative strategies to the cutoff are mentioned, such as the reduction of contracted power in specific cases, which allow maintaining a minimum and payable supply while stabilizing the customer's financial situation (UTE). These practices reinforce the idea that debt management is not only a financial mechanism, but a tool for retention and sustainability of the commercial link.

8.3.3. Community support

Finally, community support is identified as an enabling factor to sustain the effects of regularization over time, especially in territories where informality has been the historical norm. More than a one-off action, companies describe this support as a sustained post-regularization presence, aimed at preventing relapses and resolving early frictions.

Experiences of EPEC SAU, CENS and Centrosur highlight the role of territorial teams that continue to interact with neighborhood leaders after formalization, supporting billing processes, efficient use of energy and early resolution of commercial problems. This monitoring makes it possible to detect early signs of delinquency or informal disconnection and to act before the non-technical loss is reinstated.

In this sense, community support operates as a mechanism to close the regularization process, reinforcing the social acceptance of formal supply and contributing to the financial sustainability of the strategy as a whole.

8.4. ROLE OF THE COMPANY IN CONTEXTS OF INFORMALITY

The interviews show that, in territories where informality is structural, the distribution company assumes a role that exceeds traditional technical-commercial management, operating in practice as a front-line actor in the management of social, territorial and access to service conflicts. In these contexts, NTLS s do not respond only to individual behaviors, but also to collective dynamics associated with housing precariousness, absence of property titles, and weak state presence, which redefines the company's margin of action.

UTE, SAESA and ENSA point out that the distributor is usually the first, and sometimes the only institutional actor present in the territory, facing demands for access to supply even when there are no legal or urban planning conditions. This situation stresses the regulatory mandate to control losses with social expectations of service provision, forcing companies to adopt operational decisions that seek to contain electricity and social risk, even if they do not always lead to immediate regularization.

In this context, several companies highlight the need to explicitly differentiate the treatment of NTLS s in contexts of informality with respect to other types of losses, avoiding applying standard control schemes that are ineffective or counterproductive. UTE and Enel Brasil stress that unilateral action based on massive cuts or repeated inspections tends to escalate the conflict and does not sustainably reduce losses, reinforcing the importance of a gradual and territorialized intervention.

From an operational perspective, EPEC SAU and CENS describe that the role of the company is reconfigured towards coordination and mediation functions, coordinating with municipalities, housing agencies, social services and security forces to enable more integrated interventions. In these cases, the distributor acts as a technical articulator of the process, providing information on electrical risks, feasibility of supply and intervention sequences, but recognizing that the resolution of informality exceeds its direct competence.

Likewise, Electro Dunas and ESSA report that security restrictions for personnel in the field decisively influence the definition of the business role, prioritizing strategies that reduce exposure to conflicts rather than sustained coercive actions, for example, programmed interventions, work with community leaders or joint deployments with local authorities. This operational adaptation is presented as a necessary condition to maintain a presence in critical areas and avoid the total loss of control over the network.

Finally, several interviews agree that the distribution company plays a key role in generating transition conditions between informality and formality, even when the process cannot be completed immediately. SAESA, ENSA and Centrosur highlight the importance of advancing in intermediate solutions (network management, risk mitigation, user identification) that allow the system to be stabilized while external enablers, such as land regularization or public policy decisions, are resolved.

09

MEASURE FACT SHEETS

In order to systematize and clearly communicate the experiences and tools identified in the study, a system of standardized fact sheets was designed that organizes the information into three complementary levels, following a logic that advances from a general vision to increasing levels of specificity. This structure seeks to facilitate the understanding of the contents, guide the reading of the document and articulate its different levels of analysis in an orderly manner.

The first level corresponds to a general file of the study, which synthesizes the three pillars of analysis, their respective sub-criteria and the measures associated with each one, through a differentiated visual coding. This worksheet serves an introductory and navigational function, since it allows the reader to immediately recognize the overall structure of the study and orient themselves within its main components. It also incorporates hyperlinks that facilitate access to the corresponding sections, articulating the reading between the different levels of the file system.

The second level is made up of the fact sheets by pillar, whose purpose is to present in a structured way the scope and areas of action, and their context of general implementation; in addition, they allow to offer an intermediate vision between the general vision of the study and the specific measures, facilitating the understanding of the internal organization of each area.

The third level corresponds to the specific measures or tools sheets, developed to synthesize the essential information of the measures identified within the different sub-criteria. These sheets contemplate a common structure composed of the general definition of the measure, its benefits, enablers and implementation challenges. Their orientation is mainly analytical and applied, as they allow the identification of the conditions that favour their adoption, the main obstacles observed in practice and the advantages they can generate in operational, commercial or managerial terms. In addition, they incorporate references to distribution companies and Latin American countries in which experiences of implementation of these measures are recorded.

Overall, the card system is designed to guide the reading of the study in a progressive and articulated way. The general file is the entry point; the intermediate level presents the internal structure of each pillar; and the specific level concentrates the particular information of each measure. In this way, the system allows us to move from a global vision of the study to the detail of the tools identified, articulating their different levels of analysis in a clear sequence. With this, it facilitates a progressive understanding of the content and makes it a useful resource for consultation, comparison and practical appropriation by the different actors in the sector.

In the annexes section you can find part of the fact sheets developed in this study. You can also find the complete set of fact sheets in the Collaborative Repository of the study, where the experience gathered around the implementation of management measures and practices for the reduction of non-technical losses is consolidated. This platform considers periodic updates aimed at maintaining the validity of the information published, especially with regard to applicable regulations and technical standards. In addition, it has a section for the collection of suggestions and comments from users, in order to identify potential errors and progressively strengthen the quality of the information available.

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LESSONS AND SUCCESS FACTORS

The review of the lines of intervention shows that the distribution companies have a robust technical and commercial portfolio to address irregularity. However, the evidence gathered through the interviews suggests that the availability of inspection technology or resources is a necessary, but not sufficient, condition for the effective control of non-technical losses.

The comparative analysis allows us to identify that the performance of these measures depends, to a large extent, on organizational and strategic variables that cross the different areas of the company. Beyond the specificity of each tool, common management patterns are observed in those experiences that have managed to sustain their indicators over time. Below, four critical factors are systematized that, according to the operational experience of the actors consulted, act as enabling conditions for the viability of the recovery strategy.

Institutional continuity. The first determining factor lies in the transition from a project logic to a continuous process one. Evidence indicates that non-technical losses behave as an elastic variable: they reduce under pressure, but rebound immediately when management relaxes. Therefore, it is necessary to internalize energy control as a permanent function of the operation, analogous to the maintenance of the network and not as a transitory initiative.

Data hygiene. The prioritization of information quality is established as a prerequisite of analytical intelligence. Although there is a trend towards the incorporation of predictive models, the effectiveness of these tools is limited if they are built on precarious databases. Operational experience suggests that the cleaning up of basic information is the enabling condition of any modern strategy, as algorithmic sophistication fails to compensate for deficiencies in data governance.

Operational discipline. Successful management requires rigorous control of the human factor, as metering technology maintains a degree of vulnerability to physical interaction. The risk of collusion or operational corruption forces the implementation of practices such as the systematic rotation of personnel and the specialization of crews dedicated exclusively to loss control, necessary mechanisms to avoid the generation of vices in the relationship between technicians and customers. Likewise, this control must consider the security restrictions of the environment, migrating towards technological hardening and telemetry strategies in areas where the integrity of personnel is compromised.

Contextual realism. Finally, the viability of the strategy depends on the recognition of the limits of utility-led action in the face of urban informality. There is consensus that the distributor cannot make up for the absence of territorial planning; When irregularity occurs in unrecognized settlements, technical solutions are unsustainable without prior legal authorization. In these scenarios, the main barrier is usually administrative, as regulations often prevent formal electrification without validation from the local authority. ConsequeNTLs y, regularization necessarily requires the action of the municipality to prepare the area for urban planning, an essential condition for the company to be able to deploy its customer management within a framework of legality.

11

FINAL THOUGHTS

A review of non-technical loss management strategies in Latin America allows us to conclude that this phenomenon is not a simple operational externality to be corrected, but a symptom of the complex relationship between the electricity service and the social structure of the region. The persistence of significant levels of losses, even in contexts of sustained investment, suggests that the traditional approach – focused exclusively on pursuit and hardening – although necessary, is insufficient on its own to address the root of the problem, requiring to be complemented with more integrated management dimensions.

The first reflection that this study yields is the need to overcome the user's binary vision. The rigid classification between "regular customer" and "fraudster" is insufficient to address the vast gray area of irregularity, where criminal opportunism coexists with structural exclusion. The distributors that lead energy recovery are those that have developed the sensitivity to distinguish these nuances and apply the appropriate remedy: criminal rigor for massive industrial and commercial fraud, but bridges of inclusion and flexibility for residential vulnerability.

Second, it is found that technology is an enabler, not a solution. Digitalization, smart metering, and data analytics have transformed visibility into the problem, enabling the shift from blind sweeps to surgical interventions. However, technology does not replace territorial management or political will. A smart meter in a neighborhood where the police don't enter or where there is no culture of payment is an asset at risk, not a solution. The modernisation of the network must invariably be accompanied by modernisation in the social and community management of the company.

Finally, the challenge of non-technical losses invites us to rethink the role of the distributor in the 21st century. In a scenario of energy transition, where the grid must be flexible, digital and participatory, the burden of financial and operational inefficiency caused by losses is unsustainable. Solving this challenge implies that the distributor ceases to see itself only as an operator of cables and transformers, but rather as an active agent in the economic formalization and social integration of the territories it serves. Loss recovery, ultimately, isn't just a profitability metric; It is the process of building a full energy citizenship, where access to a quality service and fair payment for it are two sides of the same coin.

REMAINING CHALLENGES AND IMPLEMENTATION GAPS

Despite the advances described throughout the study, the consolidation of effective management models for the reduction of non-technical losses continues to face relevant gaps that transcend the strictly technical dimension. In many cases, these challenges are located at the intersection between regulation, institutional governance, ethics of information use and socio-economic realities of the territories where distribution networks operate. In this sense, the approach to NTLS s requires recognizing that their solution does not depend only on technological tools or operational improvements, but also on the capacity of regulatory and institutional frameworks to adapt to new conditions and emerging tensions.

One of the most obvious challenges arises from the growing use of digital technologies for the early detection of irregularities. The expansion of smart grids, advanced metering systems (AMIs), and data analytics tools makes it possible to identify anomalous consumption patterns with unprecedented accuracy. However, this transformation also raises questions about the governance of the data generated by these infrastructures. The availability of detailed information on energy consumption patterns can reveal sensitive aspects of users' daily lives, posing challenges in terms of privacy, data protection and proportional use of information. In this context, it is necessary to move towards regulatory frameworks that more clearly define the limits and responsibilities associated with the processing of this data, promoting principles of "privacy by design" and ensuring that irregularity detection tools are used in a proportional, transparent and limited manner to the strictly operational purposes of the electricity system.

A second challenge relates to the social dimension of non-technical losses and to the limitations of approaches focused exclusively on control. In many contexts in the region, a significant part of the irregular connections are linked to situations of urban informality, housing precariousness or the historical absence of basic infrastructure. In these cases, interventions based solely on physical barriers or sanctions tend to produce transient effects, as they do not address the structural causes that give rise to irregularity. The evidence collected suggests that sustainable reduction of losses requires articulating control strategies with broader policies of regularization, inclusion, and territorial planning. In other words, the management of NTLS also poses an energy justice challenge: to ensure that the formalization of the service is technically and economically viable for vulnerable households, preventing control measures from deepening dynamics of exclusion.

Finally, a gap persists between the speed of technological innovation and the adaptability of regulatory frameworks. Many of the emerging solutions for loss management, including advanced metering systems, predictive analytics, energy inclusion programs or preventive customer management mechanisms, do not always find clear recognition within current tariff or incentive schemes. In some cases, this may limit the adoption of more preventive and integrated approaches, favoring traditional control strategies that are less efficient in the long term. In this sense, one of the most relevant regulatory challenges is to design frameworks that adequately recognize investments aimed at structural loss reduction and that encourage the creation of social and systemic value as part of distribution service management.

Taken together, these challenges suggest that the sustainable reduction of non-technical losses requires moving towards more integrated approaches, where technological innovation, regulatory adaptation, and social inclusion strategies are articulated in a coherent manner. Only through this convergence will it be possible to transform loss management from a reactive logic of control to a more preventive, efficient and socially sustainable model for the region's electricity systems.

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> A review of non-technical loss management strategies in Latin America allows us to conclude that this phenomenon is not a simple operational externality to be corrected

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APPENDIX A

Regulatory context related to NTLs

	Country under analysis						
Criteria	**Argentina**	**Bolivia**	**Brazil**	**Chile**	**Colombia**	**Costa Rica**	**Ecuador**
Total annual energy [GWh]	142.789	11.966,27	725.100	79,530.4 (38.35% regulated customers and 61.65% free customers)	82.084,9	12.790,6	28.935
Types of customers	Free customers over 300 kW of installed power, rest of the consumers are regulated.	Non-regulated consumer from 1000 kW, rest regulated consumer	Free consumer from 1.5 MW, special consumer between 500 kW and 1.5 MW only with renewable sources, rest regulated customers.	Free customers from 300 kW, the rest regulated customers.	Unregulated user with an average monthly demand greater than 0.1 MW, or an average energy of 55 MWh-month. Under these values they are regulated users.	Only regulated customers with differentiated tariff segments.	Consumers not regulated with a maximum monthly power demand ≥ 1,000 kW and minimum annual energy consumption ≥ 7,000 MWh, under these regulated customer values.
Defining Losses	Non-technical losses understood as energy delivered and not billed/not collected (theft, metering fraud, clandestine connections, metering/billing errors).	The revised regulatory framework does not provide a formal definition of "non-technical losses"; In sectoral documents they are associated with unbilled energy due to illegal connections, fraud and metering/billing errors.	Definition as theft (clandestine connection, diversion), fraud (adulteration of the meter), and also metering and billing errors. They are calculated as total losses minus technical losses.	Under the name of "Unregistered Consumption".	Non-technical are distinguished, by energy theft or lack of metering.	Defined as energy consumed and not billed for illegal connections, fraud, and metering and billing errors/inefficiencies.	The regulation distinguishes between technical and non-technical losses.
Level of total losses	Losses in distribution historically in the range of 15–18% at the aggregate level, with a strong weight of NTLS s in vulnerable urban areas.	No recent official data on total losses.	14.0% of the energy injected in 2024, with 7.4% (44.6 TWh) of technical losses and 6.6% (40.2 TWh) of non-technical losses.	No recent official data on total losses.	CREG diagnostics show operators with IPT (Total Loss Index) from efficient levels close to 8–10% to values above 20% in some low-voltage systems; the national average is around intermediate ranges	The Costa Rican electricity institute describes internal reduction goals but does not publish a recent consolidated percentage;	6.3% technical and 9.3% non-technical
% of losses recognized in the rate	The regulator sets recognized loss levels (technical and non-technical) consistent with an efficient company; Losses above that standard are not transferable to tariffs.	Between 6.01% and 22.06% recognized by each distributor in the Tariff Study every 4 years.	In the Periodic Tariff Review (RTP), regulatory % is defined by distributors of technical and non-technical losses that are incorporated into the tariff	The VAD recognizes the cost of the technical losses calculated for the efficient model company and an econometrically estimated level of theft; Only this standard level is remunerated, not the total actual losses	The tariff remunerates efficient rates of losses per voltage level calculated from load flows and technical studies.	The available information does not identify an explicit standard of losses	The regulation sets a maximum level of losses recognized via voltage level factors; Losses above that standard are not transferred to the tariff and must be absorbed by the distributor
Regulatory Entity	ENRE	AETN	ANEEL	CNE	CREG	ARESEP	ARCERNNR

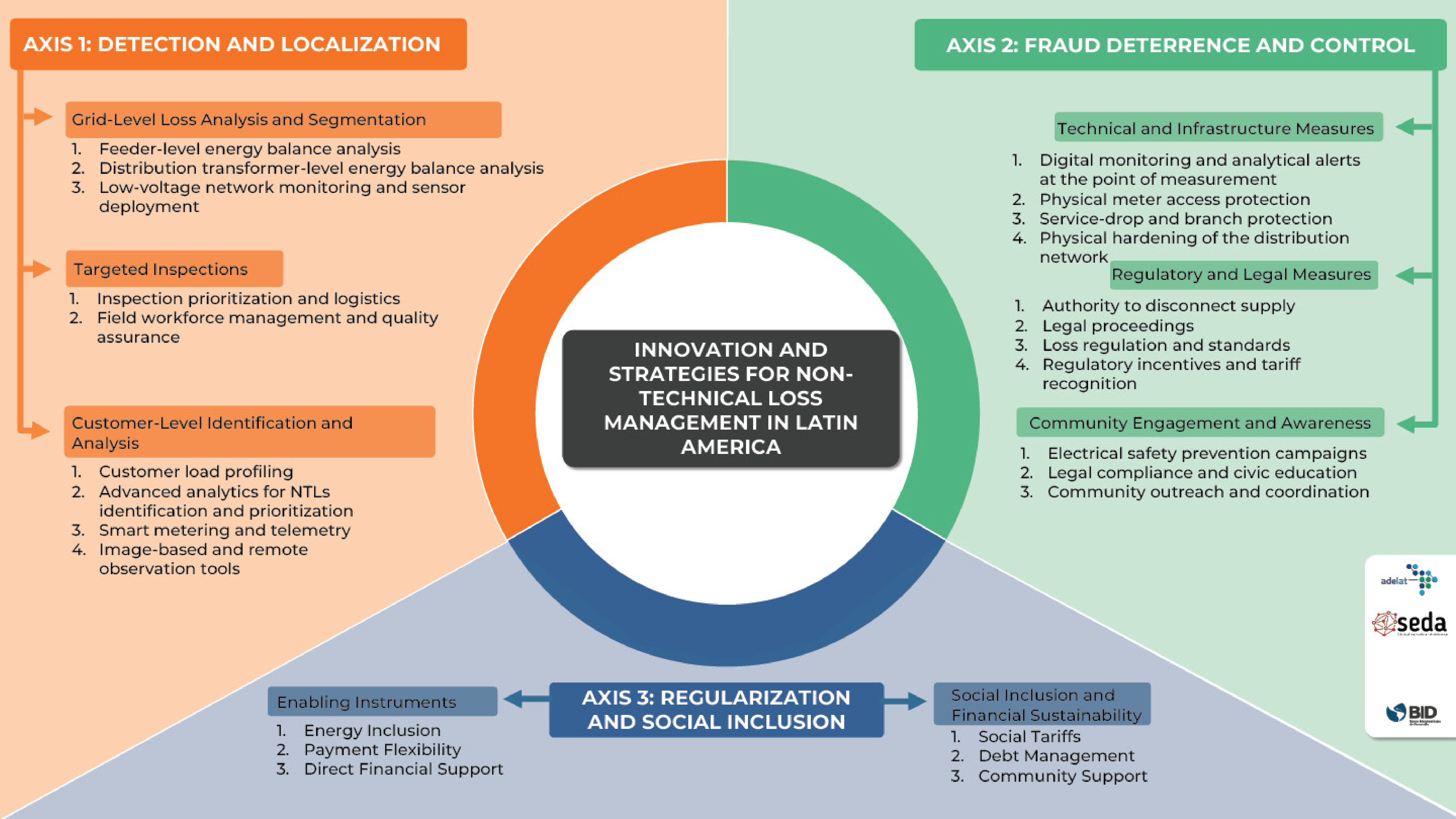
Regulatory Objective	Remunerate necessary and efficient operation, protect the user with fair and reasonable tariffs and encourage the reduction of losses, especially non-technical ones.	Energy balance transparency and cost discipline; reduce losses through management and inspection.	Incentivize efficiency and fraud reduction, protecting the consumer from transferring inefficient levels.	Encourage efficiency (reduce losses) by avoiding passing on inefficiencies to the user.	Reduce losses (especially non-technical) with incentives and co-responsibility, without overloading the user due to inefficiency.	Transparency of costs and efficiency of the service, with a focus on reducing losses.	Hedging costs with efficiency and incentives to reduce losses (especially non-technical) where they occur.
Impact on tariffs	The recognized loss level is integrated into the VAD/CPD and defined regulatory revenues. The additional NTLS s reduce the distributor's results without being reflected in higher tariffs.	No explicit mechanism of NTLS pass-through is identified; The regulatory approach is seen more as measuring/recording losses and monitoring performance.	NTLS s are recognized in tariff only up to the regulatory value (incentives: if the company is inefficient, the transfer to the consumer's account is limited).	Recognition up to an efficient level; The distributor assumes the difference between actual and recognized physical losses.	Tariff remunerates efficient indices; It can recognize additional losses/investments under conditions, with a decreasing path to efficient losses.	Losses affect service costs; no public evidence of explicit pass-through of NTLS s (rather a signal of efficiency and control).	Losses are determined and valued for consideration in regulated costs/revenues of the service (tariffs) through the different activities; NTLS restricted to distribution.
Type of tariff recognition	Not explicit	Not explicit	Incentive/Penalty	Efficient cap	Not explicit	Not explicit	Not explicit
Loss calculation methodology	RTI studies and energy balances (purchased vs. invoiced energy), technical and economic audits, and network modeling to separate technical losses and estimate the contribution of non-technical losses.	Energy balances that consider purchases, own energy, sale and losses; no separate explicit recognition of NTLS s was identified	Regulatory percentages of technical and non-technical losses in the Periodic Tariff Review; NTLS limits are calculated by methodology (PRORET).	VAD Technical Bases define the calculation of the CPEyP (Cost of annual energy and power losses of the distribution system), determining technical losses with power flow models and estimating theft through econometric models based on historical theft and GDP.	Efficient loss rates by voltage level; incentive scheme: conditional and limited recognition of additional losses, and plans to reduce NTLS s.	A distinction is made between technical and non-technical losses for management; there was no specific tariff mechanism that recognizes NTLS as a separate item.	NTLS s are calculated as total losses minus technical losses and are considered only in primary feeders and secondary networks
Additional incentive/penalty schemes	Investment and operational improvement plans required by ENRE, possible penalties for non-compliance with service obligations and supply standardization programmes in neighbourhoods/slums with public support	Penalties for infractions and irregular consumption through fines calculated as kWh × average rate, in addition to criminal sanctions, supply cut-off due to late payment and executive action for debts; The fines are intended for rural electrification.	criminal and administrative penalties for irregular consumption (theft/fraud), including the crime of "stealing" energy (CP art. 155 §3) and inspection/collection procedures for irregularities under REN ANEEL 1.000/2021	In the event of theft/fraud, the distributor can reliquidate and charge for unregistered consumption, for an estimated period and seek compensation for damages or losses through the courts, and may also suspend the supply according to the regulations.	Irregular consumption due to fraud or theft is punishable with a prison sentence of 16 to 72 months and a fine of 1.33 to 150 legal minimum monthly wages, and enables the company to suspend or cut off the service.	Irregular consumption faces administrative complaints and criminal sanctions for "illicit use", which can imply imprisonment for anyone who illegitimately seizes energy or manipulates metering equipment and networks.	There are official targets for reducing distribution losses, non-compliance with which implies not reaching the required efficiency levels and exposes distributors to economic and administrative sanctions and loss of access to certain tariff and energy efficiency incentives.
Social energy policy	Targeted Energy Subsidies (SEF), focusing on covering 50% of the cost of basic consumption for middle- and low-income households.	Dignity tariff, a 25% discount on the amount billed to consumers classified in the household category with consumption up to 70 kWh/month.	The Social Electricity Energy Tariff (TSEE), reduces electricity consumption rates by up to 65% for low-income families, and up to 100% for indigenous communities.	Electricity subsidy for vulnerable residential customers.	electricity subsidies by stratification of the population.	The Solidarity Electricity Tariff benefits families in poverty and extreme poverty with reductions in the cost of electricity. This aid applies to the first 100 kWh of monthly consumption.	Dignity Tariff, subsidy for vulnerable residential households

	Country under analysis						
Criteria	El Salvador	Guatemala	Mexico	Panama	Peru	Dominican Republic	Uruguay
Total annual energy [GWh]	7,145.2 GWh	13,496.3 GWh	304,011 GWh	9,604.68 GWh	60,029 GWh	22,672 GWh	13,040 GWh
Types of customers	Only regulated customers with differentiated tariff segments	Large (free) users over 100 kW of installed power, under this scheme are regulated customers.	Free customer with connected loads greater than or equal to 1 MW, under this regime they are regulated customers	On 300 kW you can opt for a free customer regime, under this value corresponds to regulated customers.	Free user over 2500 kW of contracted power, under 200 kW they are regulated users, and the regime can be chosen from the values.	Non-regulated user over 1.4 MW or more, under that value corresponds to regulated users.	Regulated customer under 500 kW, on that power you can freely choose the electricity supplier.
Defining Losses	No direct normative definition was found; It is usually used as consumed and unbilled energy (fraud/theft/errors).	The EVAD methodology contemplates technical and non-technical losses (especially in LV) on the balance sheet, but without a textual definition of NTLS .	The Metering Manual (DOF) treats "Non-Technical Losses" as losses associated with theft/irregular connections and/or metering failures/errors.	The tariff regulation develops the cost of losses based on technical losses (PET%, PPT%, PFT); although without an explicit definition of NTLS .	They are treated as "business losses" (unregistered/unbilled energy) within standard losses.	They are defined as unbilled energy.	They are defined as unmetered/unbilled energy for irregular connections, fraud, or metering/billing errors.
Level of total losses	The tariff study determines percentages of technical and non-technical losses per company.	The recognized level is set in the VAD study as part of the design of the efficient model company; Losses above the standard must be absorbed by the distributor.	2025 reported a level of distribution losses of 10.51%, with an approximate breakdown of 5.31% technical and 5.20% non-technical	Efficient loss percentages are set per company/representative area (PD%)	Standard levels are set per company based on market studies and historical levels.	Distribution losses of around 30% of the average purchased energy, according to distributor	National statistics report total electricity losses of around 15% of available energy
% of losses recognized in the rate	100% of technical losses and up to 50% of justified non-technical losses are recognized, with the distributor having to absorb the rest.	There is no explicit national percentage; only the total losses integrated in the efficient balance sheet of the model company are recognized, without additional recognition by NTLS	A maximum of 5% of non-technical losses is set for the calculation of distribution charges.	Efficient PD% is recognized per distributor plus an additional percentage specific per NTLS in zones.	Recognized business losses cannot exceed 50% of physical losses	Determined by the SIE in each quadrennial review under the Technical Tariff.	No explicit percentage of NTLS s recognized
Regulatory Entity	SIGET	CNEE	CRE	ASEP	OSINERGMIN	SIE	Ursea

Regulatory Objective	Cost recovery with signals to reduce losses and improve service efficiency.	Design an efficient VAD and avoid passing on "extra" non-technical losses to the user; Encourage control.	Reduce NTLS s with efficiency signals and limit the transfer of non-efficient levels to tariffs.	Cost coverage with standard parameters and efficiency signals.	Incentivize efficiency and reduce business losses without transferring excessive levels to tariffs.	Reduce unbilled energy and improve service sustainability; protect the regulated user from inefficiencies.	Reduce non-technical losses to improve efficiency and equity (so that they do not pay "righteous for sinners").
Impact on Tariffs	Recognition of technical and non-technical losses in tariffs in public analysis; The specific regulatory detail was not located in open sources consulted.	Press releases indicate that there is no additional recognition for non-technical losses/theft; Losses are recognized within the standard of the tariff study.	The recognized losses (technical and NTLS within the cap) are incorporated into the Regulated Transmission and Distribution Tariffs approved by the CRE and in the final tariffs of the basic supply.	The cost of losses is included in the toll/distribution charges according to standard technical coefficients.	Recognition in fees: the commercial losses to be recognized cannot exceed 50% of the physical losses; OSINERGMIN uses current standard levels (e.g., 2.56% in VAD according to technical reports).	Technical fee includes technical losses; NTLS does not appear as automatic recognition in that legal article (it is managed as a distribution/marketing problem).	No specific public regulatory cap/incentive was identified; Control and reduction are considered as operational/customer management.
Type of tariff recognition	Ex ante recognition in tariff	Efficient cap	Ex ante recognition in tariff	Not explicit	Cap/Regulatory Cap	Ex ante recognition of an efficient level of losses in the calculation of the technical fee.	Cap/Regulatory Cap
Loss calculation methodology	Balance of purchases-sales(total losses), consolidation and modeling of commercial and network information, power flows to separate technical losses, and application of caps for recognized NTLS s.	EVAD methodology based on competition simulation, design of an optimal company and annual and peak balance sheets where losses in MV and LV are modeled by means of expansion factors; these factors incorporate both technical and non-technical losses in BT.	Tariff methodologies and Metering Manuals of the CRE distinguish between technical and non-technical losses and define their allocation in settlements and charges; standard parameters and limits are used for NTLS s	Efficiency equations estimated by regression or other methods on energy input, peak demand, number of customers, etc., which define PD% per company/area; Allowable loss income (IPPD) is calculated according to RDC formulas.	Optimization of the company's efficient model facilities under quality standards for technical losses; commercial losses set per company based on its own and historical studies, within the 50% ceiling.	It is calculated as the difference between generation (terminals) minus own consumption, billing from distributors, non-regulated users and technical losses (according to CNE/SIEN statistical methodology).	Energy balance of the system and UTE reports; technical losses are estimated in network and remuneration studies, while NTLS s are identified from metering, invoicing and inspections
Additional incentive/penalty schemes	Procedure for irregular conditions for detection and recovery of unregistered energy, inspections, suspension/disconnection, requirement of guarantees and verification of calculations by SIGET.	Economic incentive through non-recognition of losses above the standard; powers to inspect facilities, suspend supply and charge for unregistered energy, in addition to the possibility of criminal complaint for energy theft.	Regulatory limit of recognized NTLS s, emphasis on network modernization and metering, and criminal prosecution of illicit use of energy equated to theft	Implicit targets via loss parameters, requirement of investment and reduction plans, non-recognition of excessive losses, formal procedures for fraud cases and the possibility of sanctions and fines.	Economic incentive for reducing losses below the standard, recognition of innovation/efficiency projects to reduce losses, criminal sanction for energy theft.	Performance goals, regulatory monitoring, administrative sanctions and criminal prosecution of electricity fraud.	Administrative penalties for non-compliance with metering and billing standards, regulatory suspension/reconnection, voluntary regularization programs, and payment facilities for inclusion and fraud reduction
Social energy policy	Residential Consumption Subsidy, aimed at families with average consumption	Social Tariff subsidizes low-income households with electricity consumption of 1 to 100 kWh/month.	Tariff Subsidies, Energy Justice Programs through the Federal Electricity Commission.	Targeted subsidies, applied to residential customers with low consumption and vulnerable sectors.	Electricity Social Compensation Fund (FOSE), a cross-subsidy mechanism. Energy Social Inclusion Fund and Residential Electricity Rate Compensation Mechanism.	Electricity tariff subsidies "Bono Luz" for vulnerable households	Social Bonus with discounts for vulnerable households and inclusion programs to regularize supply, complemented by energy efficiency measures

APPENDIX B

Fact sheets


AXIS 1: DETECTION AND LOCALIZATION
Grid-Level Loss Analysis and Segmentation
1. Feeder-level energy balance analysis
2. Distribution transformer-level energy balance analysis
3. Low-voltage network monitoring and sensor deployment
Targeted Inspections
1. Inspection prioritization and logistics
2. Field workforce management and quality assurance
Customer-Level Identification and Analysis
1. Customer load profiling
2. Advanced analytics for NTLs identification and prioritization
3. Smart metering and telemetry
4. Image-based and remote observation tools
AXIS 2: FRAUD DETERRENCE AND CONTROL
Technical and Infrastructure Measures
1. Digital monitoring and analytical alerts at the point of measurement
2. Physical meter access protection
3. Service-drop and branch protection
4. Physical hardening of the distribution network
Regulatory and Legal Measures
1. Authority to disconnect supply
2. Legal proceedings
3. Loss regulation and standards
4. Regulatory incentives and tariff recognition
Community Engagement and Awareness
1. Electrical safety prevention campaigns
2. Legal compliance and civic education
3. Community outreach and coordination
INNOVATION AND STRATEGIES FOR NON-TECHNICAL LOSS MANAGEMENT IN LATIN AMERICA
AXIS 3: REGULARIZATION AND SOCIAL INCLUSION
Enabling Instruments
1. Energy Inclusion
2. Payment Flexibility
3. Direct Financial Support
Social Inclusion and Financial Sustainability
1. Social Tariffs
2. Debt Management
3. Community Support
adelat
seda
BID

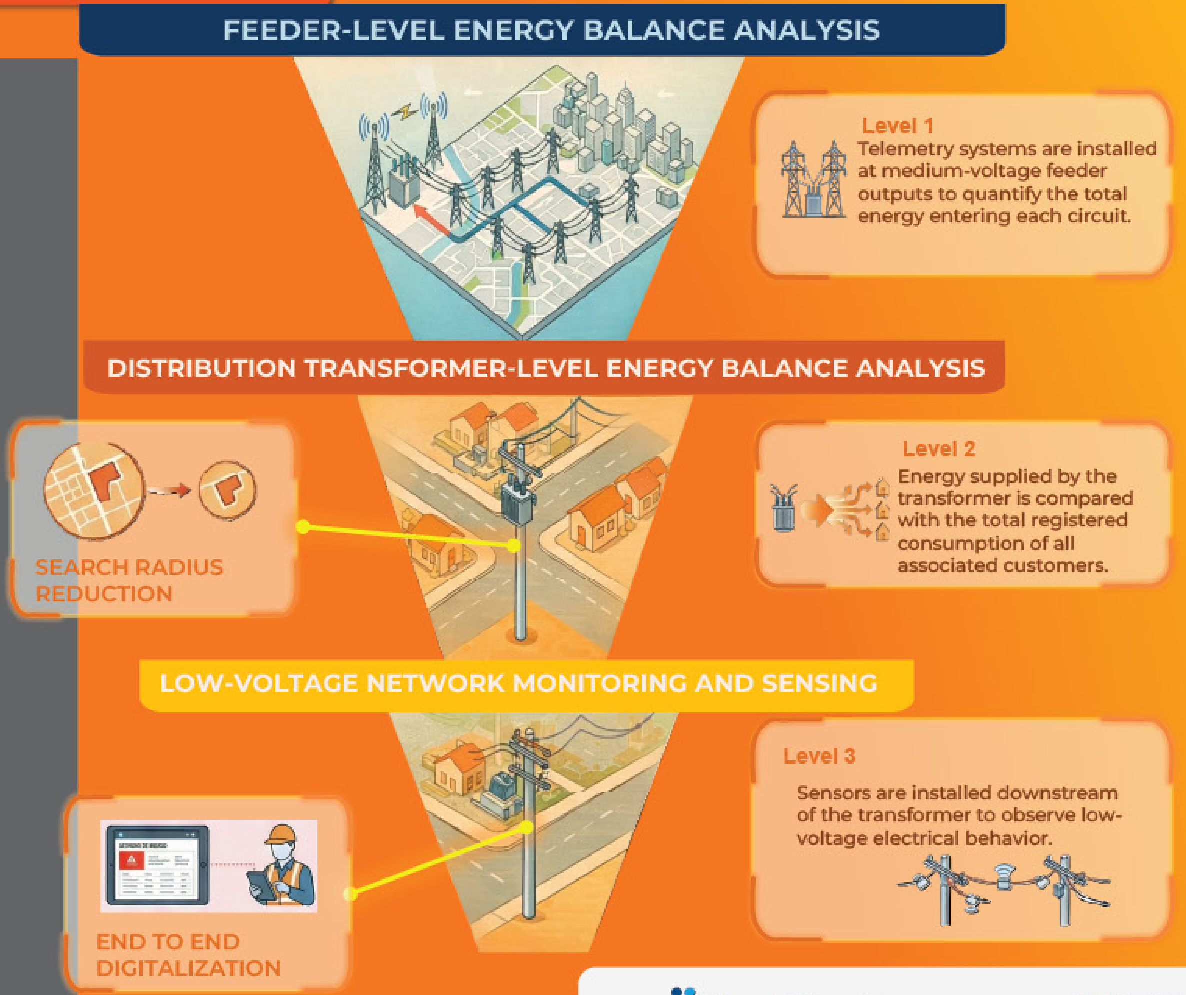
AXIS 1: DETECTION AND LOCALIZATION

Description

Loss detection and localization form the basis of non-technical loss management, given their spatial heterogeneity and temporal variability. The objective is to **reduce uncertainty about their origin, magnitude, and location, so inspections, investments, and corrective actions** can be targeted where the potential impact is greatest.

These measures are usually deployed first in **urban or peri-urban networks with high customer density and higher loss levels**, although they are also relevant for long rural feeders and hard-to-inspect areas.

They operate through a **progressive narrowing process**, starting with energy balance analysis at substations, feeders, and transformers, and then moving toward territorial segmentation and critical-circuit prioritization. This is complemented by consumption analysis, deviations, and load profiles, supported by telemetry, AMI, and data analytics, until customers, service drops, or connections with a high probability of irregularity are identified.



MEASURE 1.2: DISTRIBUTION TRANSFORMER-LEVEL ENERGY BALANCE ANALYSIS

IMPLEMENTATION EXAMPLES

- DELSUR
- UTE
- EPM
- ELECTRO DUNAS
- EPEC

This measure compares the energy supplied by a transformer with the billed energy of its connected customers. It narrows loss analysis to specific areas without identifying the individual irregularity.

BENEFITS

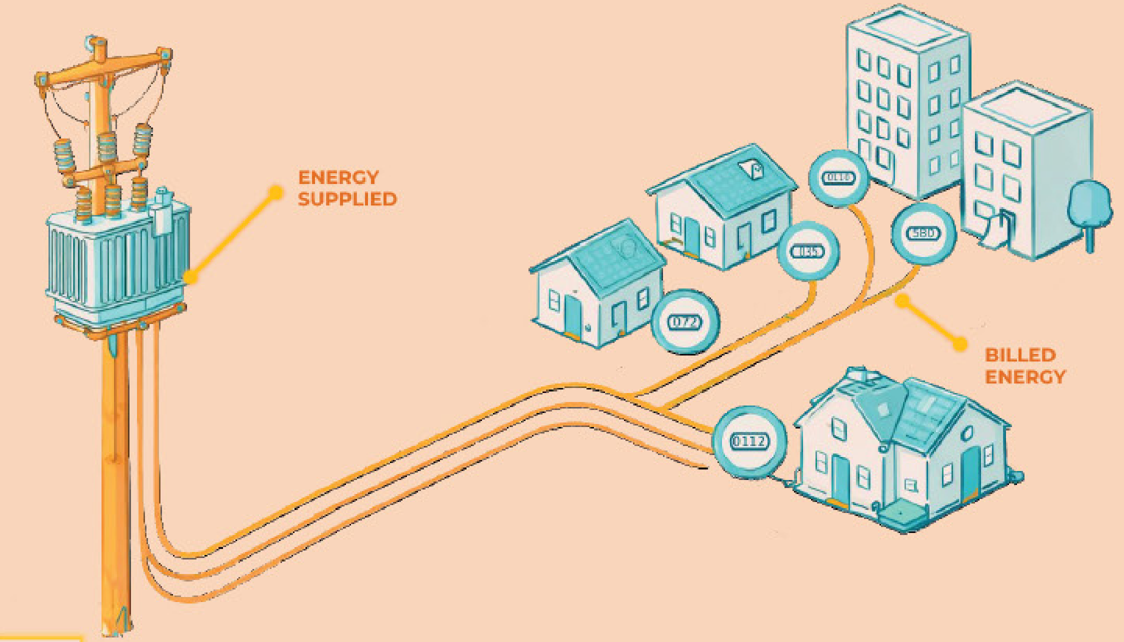
- Higher spatial resolution to identify critical areas.
- Better crew targeting and technical action planning.
- Flexible deployment according to metering infrastructure.

ENABLERS

- Reliable metering devices at distribution transformers.
- Quality and consistency of billed commercial data.
- Analytical capacity to detect and prioritize relevant imbalances.

CHALLENGES

- Requires investment in installation, operation, and maintenance of metering devices.
- Self-generation may distort balances if metering is not bidirectional.
- Metering devices are exposed to theft, vandalism, or intentional damage.



MEASURE 1.7: IMAGE-BASED AND REMOTE OBSERVATION TOOLS

IMPLEMENTATION EXAMPLES

EDP · EEGSA · ESSA · SAESA · ENEL BRASIL · EQUATORIAL · EPM · EDESUR · EPE SF

A set of visual technologies—satellite imagery, field photography, and drones with thermal cameras—that complement traditional detection by identifying unregistered consumption, validating readings, and prioritizing inspections while reducing field staff exposure.

BENEFITS

- Reduces physical exposure of staff in dangerous, extensive, or hard-to-access areas.
- Expands observation capacity through satellite imagery, thermography, and computer vision.
- Generates georeferenced evidence that strengthens administrative and legal traceability.

ENABLERS

- Updated georeferenced registries of networks, customers, and supply points.
- AI and computer vision models trained to detect meter and service-drop anomalies.
- Mobile devices with capture integrated into commercial systems and central evidence repositories.

CHALLENGES

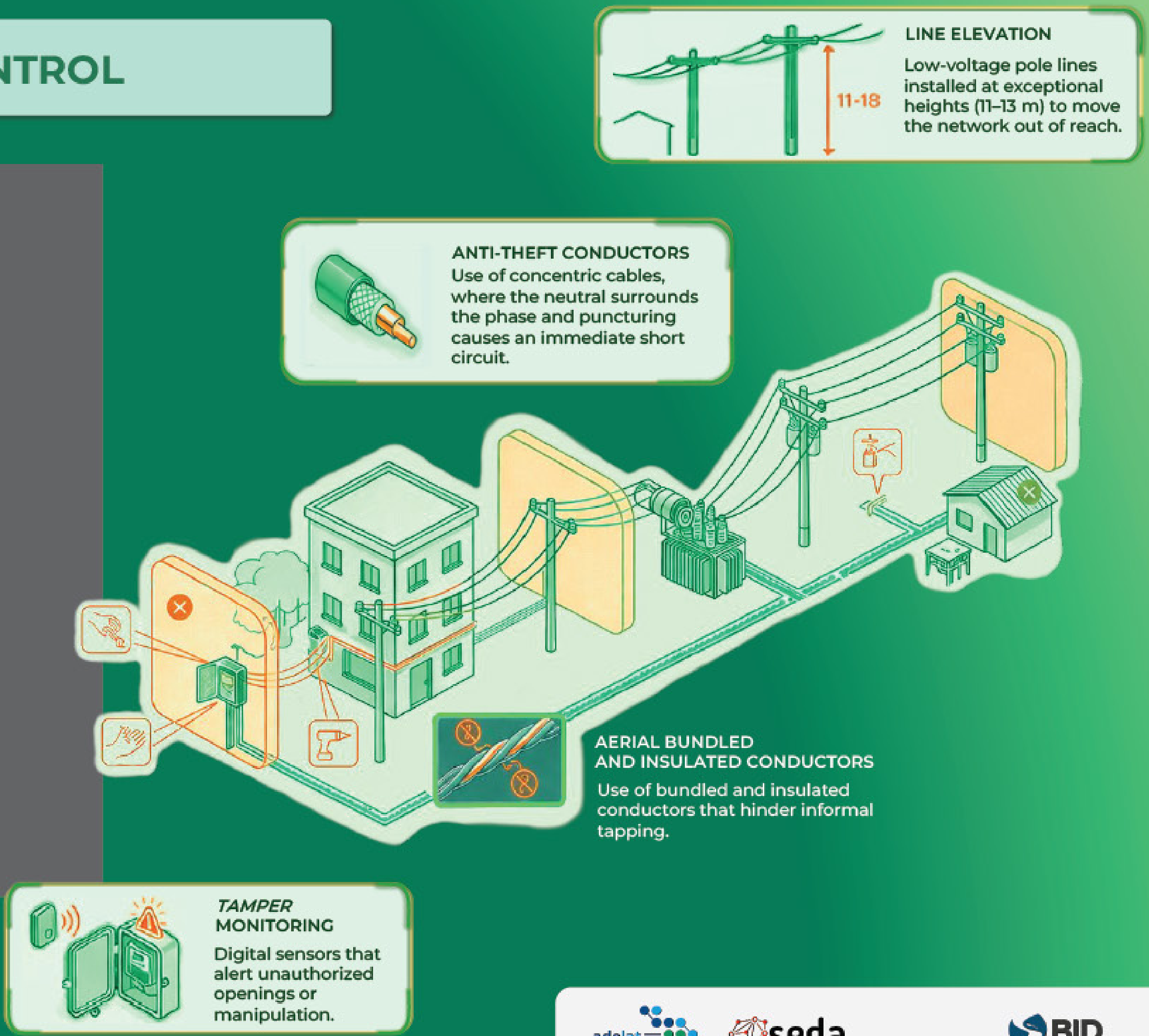
- High costs of high-resolution satellite imagery limit continuous use.
- Privacy and social acceptance concerns restrict drone use in residential settings.
- Time lag in free satellite imagery limits detection of recent fraud.

AXIS 2: FRAUD DETERRENCE AND CONTROL

Description

Fraud deterrence and control constitute the second axis of non-technical loss management, once areas, customers, or connections with higher irregularity risk have been identified. The objective is to **change the incentive structure that makes fraud viable** by increasing its cost, difficulty, and probability of detection, thereby **reducing recurrence and containing losses over time.**

These measures are usually deployed first in **urban or peri-urban contexts with high fraud concentration, recurrence, or weakened payment culture**, although they are also relevant in areas with **access restrictions, crew safety risks, or weak control capacity**. Their implementation combines three complementary dimensions: technical measures and grid-protection infrastructure, regulatory and sanctioning mechanisms, and community strategies aimed at reducing the social acceptability of irregularity.



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MEASURE 2.1: DIGITAL MONITORING AND LOGICAL METER-POINT ALERTS

A control measure using remote monitoring and automatic meter-point alerts to detect tampering, operational inconsistencies, or anomalous behavior. It complements physical protection and enables faster, targeted responses.

BENEFITS

- Reduces the time between irregular intervention and operational response.
- Increases perceived fraud risk through continuous monitoring and traceability.
- Improves targeting of field crews and inspection resources.

ENABLERS

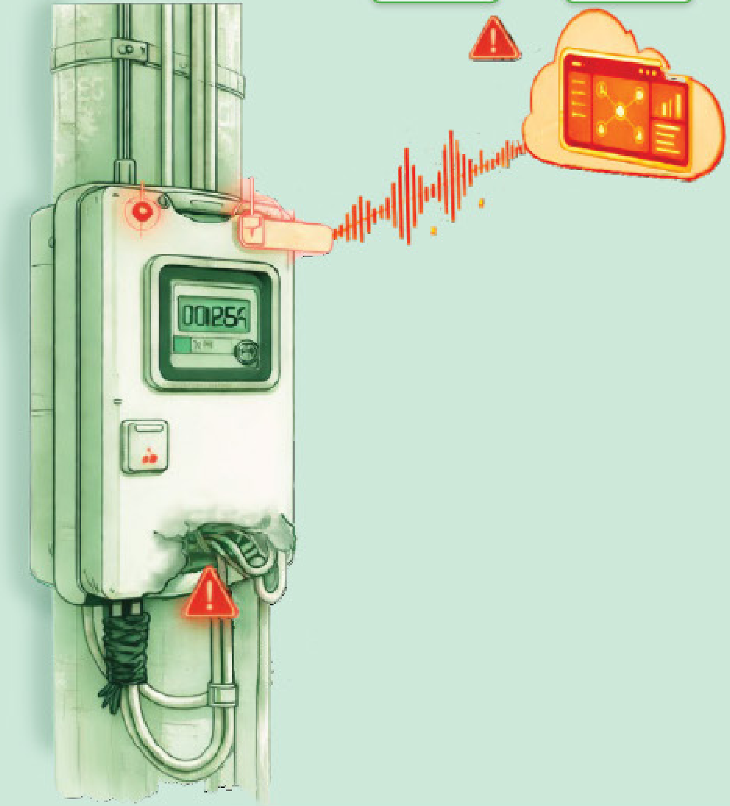
- Meters or enclosures with tamper sensors and event-recording capability.
- Telemetry and communications systems capable of timely alert transmission.
- Filtering and prioritization mechanisms to manage large alert volumes.

CHALLENGES

- Requires contextualizing alerts to reduce operational false positives.
- Effectiveness depends on robust operational and technological integration.
- May displace fraud toward other points of the network.

IMPLEMENTATION EXAMPLES

- ESSA
- CVC ENERGÍA
- ENEL BRASIL
- ENEL CHILE
- UTE



MEASURE 2.4: PHYSICAL HARDENING OF THE DISTRIBUTION NETWORK

IMPLEMENTATION EXAMPLES

EDENOR · ENSA · UTE · ENEL BRASIL · EPEC · ENEL CHILE · ENERGISA · EQUATORIAL

Interventions on lines, branches, and transformers—pole-line elevation, aerial bundled conductors, concentric cables, and transformer hardening—designed to hinder or eliminate illegal connections upstream of the meter.

BENEFITS

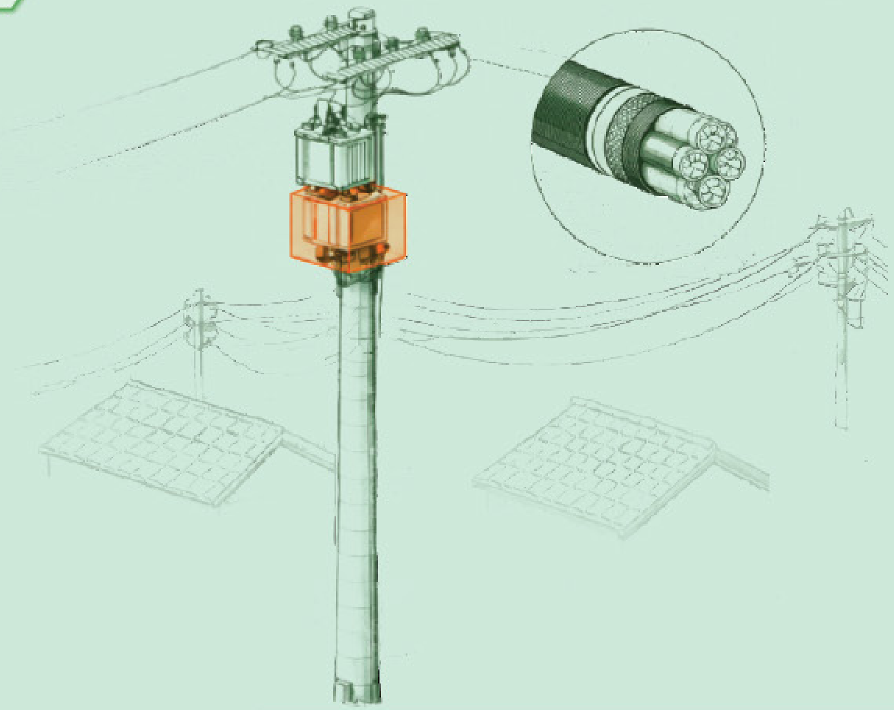
- Raises the technical barrier to fraud through insulated conductors and transformer hardening.
- Reduces recurrence in areas with high conflict and urban vulnerability.
- Some models (BT Zero) protect infrastructure from the source, eliminating exposed network sections.

ENABLERS

- Availability of technologies such as aerial bundled conductors, concentric cables, and compact semi-insulated networks.
- Regulatory framework allowing pole lines at exceptional heights.
- Capacity to adjust anchors and manage additional mechanical loads on poles.

CHALLENGES

- Requires significant investment and is usually reserved for areas with extreme theft levels.
- Technical complexity due to mechanical loads and bending moments affecting pole-line service life.
- Standards on permissible configurations limit room for innovation.



AXIS 3: REGULARIZATION AND SOCIAL INCLUSION

Description

Regularization and social inclusion constitute the third axis of non-technical loss management and address cases where irregularity is not solely a fraud decision, but also **reflects economic, urban, or institutional barriers to formal service access**. The objective is to **turn irregular users into formal and sustainable customers** through mechanisms that **align payment obligations with real conditions of vulnerability and exclusion.**

These measures are usually implemented in **informal settlements, highly vulnerable areas, zones with limited infrastructure coverage, or territories where fraud enforcement is insufficient or unviable.** Their implementation combines technical and commercial regularization, payment facilities, tariff adjustment, infrastructure upgrades, and community work to build a sustainable relationship between the utility and users and reduce losses permanently.

PAYMENT FLEXIBILITY

Mechanisms that adapt payment conditions to users' economic capacity.

ENERGY INCLUSION

Mechanisms that incorporate users into the formal electricity system.

DIRECT FINANCIAL SUPPORT

Financial support mechanisms that reduce supply costs for vulnerable users.

MEASURE 3.1: ENERGY INCLUSION

A set of practices aimed at incorporating primarily vulnerable users into the formal electricity system, reducing electrical risks, strengthening territorial engagement, and creating sustainable conditions for a payment culture.

IMPLEMENTATION EXAMPLES

ENSA · CENS · SECHEEP · EEQ · UTE · SAESA · EPEC SAU · EDEQ · ENEL BRASIL

BENEFITS

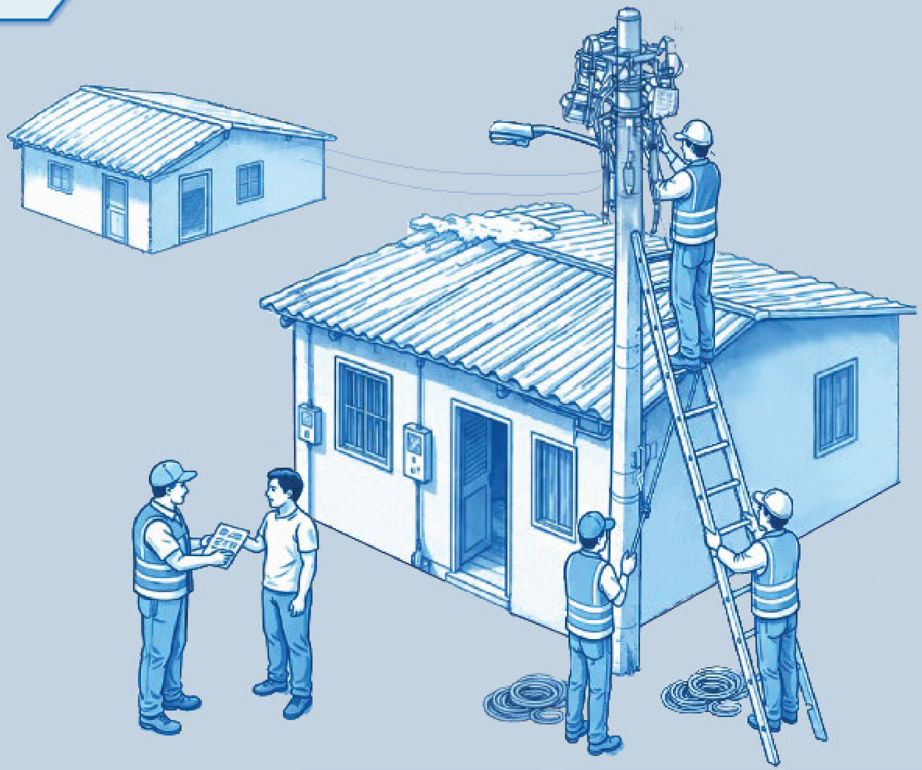
- Reduces electrical risks from precarious connections in vulnerable neighborhoods.
- Reduces conflict in historically unmetered areas.
- Strengthens payment culture through sustained territorial support.

ENABLERS

- Specialized teams for territorial surveys, regularization, and social management.
- Support for procedures, inquiries, payments, and formal commercial onboarding.
- Active coordination with municipalities, government agencies, and other local basic services.

CHALLENGES

- Lack of land tenure legality may prevent formal inclusion processes.
- Security issues limit sustained interventions in complex informal settlements.
- Requires regulatory frameworks that allocate responsibilities among relevant institutional actors.



MEASURE 3.2: PAYMENT FLEXIBILITY

Commercial mechanisms—prepayment, micro-payments, and adaptable installments—that align billing obligations with informal income flows of vulnerable users to facilitate regularization.

BENEFITS

- Reduces arrears by adapting to payment capacity and irregular income cycles.
- Reduces incentives for fraud or illegal reconnections after disconnection for non-payment.
- Promotes a progressive payment culture and empowers users over their consumption.

ENABLERS

- Billing platforms capable of processing micro-payments and non-traditional billing cycles.
- Technology deployment, including prepaid meters and accessible top-up channels.
- Regulatory frameworks allowing alternative payment schemes and prepaid electricity sales.

CHALLENGES

- High upfront investment to upgrade commercial software and replace meters.
- Regulatory restrictions or bans on prepaid basic services in some countries.
- Requires intensive user support and financial education for adoption.

IMPLEMENTATION EXAMPLES

ENSA
SECHEEP
EPM
CENTRO SUR
UTE
CRE
CVC ENERGÍA
EDEA
ESSA
ENEL BRASIL