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EXECUTIVE SUMMARY

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

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CONTEXT AND PURPOSE

Non-technical losses (NTLs) are one of the most persistent challenges to the financial and operational sustainability of utilities in Latin America and the Caribbean. Beyond the direct impact on revenues, high levels of unbilled energy distort demand signals, compromise service quality, increase public safety risks, and erode the legitimacy of the tariff system. In a context of energy transition, where digitalization and operational flexibility are imperative, reducing these inefficiencies is no longer an isolated goal but an enabling condition for the viability of the distribution model.

According to the study by the Inter-American Development Bank (IDB) that serves as starting point for this work, in the last three decades it is estimated that, on average, about 17% of the energy generated in the region has been lost, a level three times higher than that of OECD countries. In 2019, losses that exceeded the 10% reference threshold reached approximately 120 TWh, and the problem is widespread: 22 out of 26 countries analyzed exceed that threshold, with cases ranging from levels close to efficiency (Peru) to others exhibiting losses above 25% (Jamaica, Paraguay) or critical absolute magnitudes (Venezuela, Honduras).

In this framework, the study systematizes the measures implemented by distribution companies in Latin America and the Caribbean to reduce non-technical losses, with the aim of building an operational repertoire of good practices that guides decision-making and the design of contextualized strategies. This executive summary condenses the central findings, with a focus on the proposed taxonomy as the main methodological contribution, a synthetic overview of the survey methodology and a description of the key measures identified in each axis of intervention.

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

02

CONCEPTUAL FRAMEWORK: FROM ELECTRICAL LOSSES TO NTLS

Electrical losses are defined by the energy balance of the system, as the difference between the energy injected into the grid and the energy actually billed to end users. This indicator functions as a gauge of sectoral performance and allows us to distinguish two major categories whose nature, and therefore whose management strategies, differ substantially.

Technical losses are inherent to the electromagnetic and thermodynamic phenomena of grid operation (Joule effect, corona, losses in the core of transformers). They depend on the topology, length, gauge of conductors and voltage level, as well as the load transported. They are susceptible to reduction through investments in infrastructure, but they are limited by physical laws: they cannot be completely eliminated and their reduction faces diminishing returns.

Non-technical losses (NTLs), on the other hand, are an empirical and residual quantity: the fraction of total losses that has no electromagnetic explanation. Their origin is human, commercial and institutional, and therefore they are theoretically avoidable through management, technology and oversight. Managing NTLs transcends engineering and enters the field of economic, political and social conflict, by involving payment culture and access to basic services.

The study identifies three categories of NTLs, whose delimitation is decisive in defining the tools of action available to the distribution company:

- **Unintentional NTLs.** They correspond to energy effectively supplied but not invoiced, without deliberate conduct by the user. They originate in internal operational weaknesses: measurement errors (defective or obsolete meters), failures in the billing process (incorrect readings, inadequate estimates) and commercial management problems (poorly recorded contracts, unmetered collective consumption). In many cases, they reflect corporate governance issues, misaligned internal incentives, or a lack of accountability mechanisms.

- **Intentional NTLs.** They correspond to unregistered or unpaid consumption as a result of deliberate actions aimed at evading formal measurement mechanisms. They include unauthorized reconnections after formal suspensions, meter manipulation (intermittent or selective interventions to under-register consumption) and illegal direct connections to the grid. Added to this is internal collusion, an enabling factor where personnel linked to the operation facilitate, falsify or do not report the irregularity, violating internal protocols.

- **Structural irregularity and gray areas.** Situations associated with informal settlements, users without property titles, precarious inherited access or historically tolerated consumption. The connection occurs outside the formal schemes, but the irregularity does not respond to an explicit intention to evade payment, but to material, legal or administrative restrictions that prevent regularization. A purely punitive response is often ineffective or counterproductive.

This distinction explains the focus of the study: intentional NTLs are those over which the distribution company has the greatest margin of direct action through management, control and operation tools under its control. The structural dimension is approached in a complementary way due to its intertwining with the previous ones.

The study is limited to the operational and commercial management of the NTLs within distribution companies. It systematizes the set of actions under the company's direct control – from investment in measurement and data analytics to the deployment of on-site control strategies and regularization mechanisms – to detect, reduce and prevent unbilled energy. The design of public policy, legal reforms, and regulatory discussion constitute the contextual framework within which the company optimizes its decisions, but fall outside the scope of this study.

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METODOLOGIA

The study was developed with a mixed methodological approach, combining quantitative and qualitative tools to identify, classify and analyze the practices used by distribution companies. The aim was not only to reveal the existence of certain measures, but also to examine their implementation conditions, the associated challenges, their observed performance and the lessons learned from their application in real contexts. The process was structured in six sequential stages.

- **Stage 1 — Initial questionnaire.** A structured questionnaire was applied to participating distributors, designed from a preliminary classification that covered technological, regulatory, commercial, community and monitoring dimensions. A total of 38 responses were received, 24 of them consistent and complete, which made it possible to identify 191 measures as the initial basis for analysis.

- **Stage 2 — Semi-structured interviews.** 30 remote interviews (40–60 minutes) were conducted, mainly aimed at those responsible for non-technical loss areas. The objective was to capture qualitative information that is not observable in standardized instruments: operational challenges, conditions of success, local adaptations and learning.

- **Stage 3 — Construction of the taxonomy.** Based on the above inputs, the taxonomy of measures was developed, organized according to their nature, scope of application and logic of intervention. This taxonomy is one of the main methodological products of the study and structures all subsequent analysis.

- **Stage 4 — Systematic qualitative analysis.** The interviews were transcribed, coded and analyzed thematically, which made it possible to compare patterns, identifying convergences and differences between companies according to their operational contexts, capacities and local conditions.

- **Stage 5 — Second quantitative questionnaire.** A quantitative instrument (20 responses) was applied to survey the evolution of the NTL indicators in the last five years and to identify the degree of implementation of the measures described. It made it possible to build comparable indicators and detect patterns between the characteristics of companies and the adoption of tools.

- **Stage 6 — Consultation with regulators.** A consultation phase was carried out with Ibero-American regulatory bodies with the aim of contrasting the operational vision with the current institutional frameworks and validating the regulatory dimension of the taxonomy.

Overall, cross-referencing primary sources (questionnaires and interviews with distributors and regulators) with secondary sources allowed for the construction of a robust empirical base, on which the operational conclusions and transferable learnings presented in the following chapters are based.

04

PANORAMA REGULATÓRIO REGIONAL (SÍNTESE)

While utilities face common problems of theft, irregular connections, and measurement failures, the economic incentives and enforcement powers available vary significantly between jurisdictions. The comparative review allows us to identify four axes of differentiation that explain the disparate results observed in the region.

- **Tariff recognition and economic signals.** Countries with mature regulation (Brazil, Chile, Colombia, Peru, Mexico) explicitly define the levels of losses recognized in tariffs. Brazil stands out for its econometric benchmarking among distributors with comparable socioeconomic contexts; Chile and Peru operate with an efficient model company scheme (ex ante). In contrast, countries such as Paraguay, Bolivia or Cuba present recognition that is partial, non-existent, or weakly linked to real management, weakening the signal of efficiency.

- **Non-tariff goals, plans and instruments.** The Dominican Republic, Honduras, Ecuador and Paraguay have national or sectoral plans with quantitative targets. Their effectiveness is greater when they are integrated with clear operational and budgetary instruments; they lose effectiveness when they function only as programmatic statements without accountability.

- **Transparency and quality of information.** Energy balance is the basic cross-cutting tool, but the quality, frequency and regulatory use vary. Brazil, Colombia, Ecuador, Chile, Peru, Spain and Portugal have auditable periodic reports, for tariff-setting and benchmarking purposes, and with public disclosure of at least aggregated data. Other countries (Bolivia, Paraguay) report internally without systematic regulatory auditing, which limits sectoral learning.

- **Coercive powers and inter-institutional coordination.** Energy theft is codified in all the countries analyzed (administrative or criminal), but the effective coordination between distributors, regulators, prosecutors' offices and security forces is very heterogeneous. The Dominican Republic and Brazil stand out with specialized prosecutors' offices and formal protocols; in other contexts, the response is fragmented, slow, or limited by security conditions, and isolated coercive control tends to generate short-lived effects.

Countries that manage to coherently articulate clear economic signals, reliable and audited information, effective inter-institutional coordination, and inclusion strategies show more stable trajectories of NTL reduction. The absence of any of these components weakens progress and makes it dependent on extraordinary efforts.

05

TAXONOMY OF NTL MANAGEMENT MEASURES

The main methodological contribution of the study is an operational taxonomy that organizes the set of available tools in three sequential axes. This classification is not arbitrary, but follows the logic of managing a loss: first visibility is required (knowing where it occurs), then control capacity (containing and discouraging fraud) and, finally, sustainability mechanisms (integrating the user into the formal system).

- **Axis 1 — Detection and localization (Visibility).** It groups the measures whose central attribute is the processing of information to identify and locate anomalies. Its function is not to stop fraud per se, but to efficiently direct operational resources. It includes everything from energy balances to advanced data analytics, sensor deployment and customer characterization.

- **Axis 2 — Deterrence and control (Containment).** It brings together physical, regulatory, and social measures aimed at increasing the cost and difficulty of committing fraud. It integrates technological barriers (physical hardening, smart metering), on-the-ground inspection, sanctioning capacity and cultural strategies that delegitimize irregularity.

- **Axis 3 — Regularization and inclusion (Integration).** It includes initiatives aimed at transforming the irregular user into a formal customer. It addresses economic and social barriers to access through commercial and community solutions that make payment for the service over time viable, particularly in contexts of vulnerability.

The taxonomy, presented in Fig. 1, reflects a relationship of complementarity, not substitution: the sustained effectiveness of the strategy depends on articulating the three axes. A company can detect accurately (Axis 1) without the ability to intervene in the field (Axis 2); can exercise strict control (Axis 2) without resolving the return to irregularity (Axis 3). The taxonomy therefore seeks to guide the reading of the operational repertoire and facilitate contextualized decisions according to the reality of each distributor.

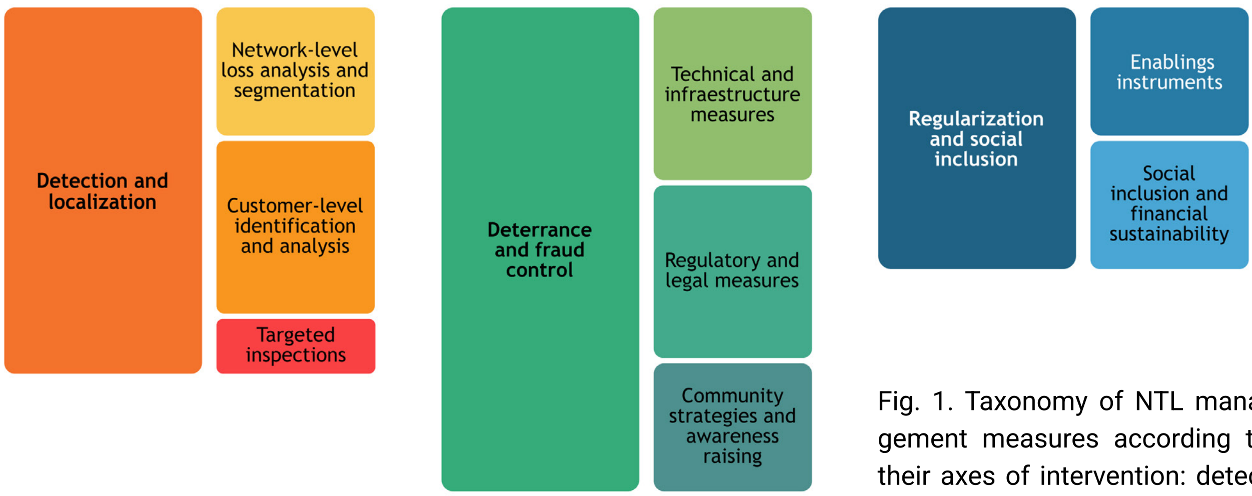

Fig. 1. Taxonomy of NTL management measures according to their axes of intervention: detection, control and social inclusion.

06

AXIS 1: DETECTION AND LOCALIZATION

NTLs are characterized by their heterogeneity, spatial variability, and dynamics over time. Without precise information on where, how and to what extent they occur, inspection, sanction or regularization actions tend to be inefficient. Observed practices shows a transition from random inspections and complaints to a predictive and focused detection, understood as a process of progressive narrowing of the search: from the substation to the feeder, from the transformer to the low-voltage circuits, and finally to the individual customer.

6.1. NETWORK-LEVEL LOSS ANALYSIS AND SEGMENTATION

- **Energy balances at feeder level.** They constitute the first layer of loss analysis. They are supported by measurement and telemetry systems installed at the head of medium voltage feeders, where current, voltage and energy are recorded. The energy injected into the circuit is contrasted with the energy billed downstream, aggregated from the commercial records. The difference between the two magnitudes provides a first estimate of the level of losses for the entire feeder, without yet identifying individual customers. Its value lies in guiding the next layer of analysis: it allows healthy circuits to be discarded, those with relevant deviations to be prioritized and inspection campaigns or reinforcement investments to be targeted. Its limitations derive from the coarse resolution: heterogeneous areas coexist within a feeder, so a positive balance in aggregate does not rule out localized losses, nor does the magnitude detected allow users to be prioritized on its own.

- **Energy balances at the distribution transformer level.** They increase spatial resolution by comparing the energy delivered by a specific transformer to the sum of the energy billed to customers powered from it. The scope of analysis ranges from a circuit of several kilometers to a limited group of tens or hundreds of users. This enables more precise operational actions: prioritizing crews in specific sectors, targeting inspection campaigns to a closed group, focusing advanced analytics on a manageable subset of customers, and planning technical interventions around a common asset. Its implementation requires installation and sustained maintenance of bulk meters with telemetry, which entails relevant costs and exposure to vandalism (theft of equipment and conductors, intentional damage). There are low-cost alternatives: portable measurement that rotates between points in the network to build temporary balances, and virtual microbalances based on electrical models, voltage profiles and impedances that estimate losses without requiring massive deployment of equipment in the field. An emerging challenge is the penetration of distributed generation: when the customer injects energy into the grid, conventional unidirectional bulk meters distort the balance, generate false or late signals and force an early replacement of equipment with bidirectional and hourly ones, a cost that is not always recognized in the regulatory framework.

- **Low-voltage monitoring and sensor deployment.** This represents the last layer of observation before the individual customer. It consists of installing measurement or sensing devices downstream of the transformer, in branches and critical points of the low-voltage network, to observe currents, loads, voltage profiles and events associated with physical interventions. The purpose is, on the one hand, to spatially delimit the problem, identifying in which arm of the circuit imbalances or overloads are concentrated and thus reducing the pool of customers to be inspected; on the other, to capture anomalous events (illegal bridges or diversions, physical interventions, profiles inconsistent with the expected behavior) that justify an operational action. This layer can operate under two approaches: continuous monitoring with hourly resolution and real-time alarms, or spot monitoring using mobile equipment. Its main requirements are communications (reliable telemetry in low-voltage areas), management of the volume of data generated and sensor maintenance procedures in the event of failures or interventions.

6.2. CUSTOMER-LEVEL IDENTIFICATION AND ANALYSIS

- **Aggregation and analysis of consumption profiles.** It is an analytical technique that compares the consumption of each customer with a reference standard built from a comparable group (location, tariff, socioeconomic tier, line of business or economic activity). The underlying hypothesis is that customers with similar characteristics should exhibit consistent consumption curves; significant deviations – abrupt falls, flat profiles, persistently low consumption, zero readings in active service points, consumption consistently far from the group average – are actionable signals. This measure does not confirm fraud, but it limits the pool of customers to be reviewed. The level of sophistication may vary: comparisons against the customer's own history; simple stratifications based on demographic or tariff variables; statistical groupings by clustering that construct typical curves and measure deviations from them; and integration within broader platforms with data mining and business variables. Its performance depends critically on the quality and consistency of the commercial databases, as misclassifications (a commercial customer registered as residential, an ill-defined business type) introduce noise that distorts the reference standards.

- **Advanced analytics and risk scoring.** It is not a single technology, but a decision architecture that assigns each service point a risk score that reflects both the probability of non-technical losses and the expected magnitude of recoverable energy. Its purpose is to move companies from random or sweep inspections to focused operations that maximize both the rate of discovery and the energy recovered per inspection. The typical operating cycle has four stages. (i) **Ingestion and consolidation**: Integrates historically dispersed data (consumption, meter events, business history, results of previous inspections, unstructured field data) into a unified customer profile. (ii) **Analytical processing**: transforms these signals into a risk estimate, using heuristic rules, statistical anomaly detection models or supervised machine learning algorithms trained with validated inspection histories. (iii) **Score assignment**: produces a comparable value between service points that allows ranking and prioritizing; in some schemes the score combines probability and impact in a single metric. (iv) **Feedback**: the results of field inspections are reincorporated into the model, recalibrating rules, weights or algorithms; without this cycle, models quickly become obsolete in the face of changes in fraud patterns. The variables used are grouped into four families: consumption patterns (falls, breaks, flats, deviations from the group), technical variables and meter events (opening alarms, manipulation, atypical electrical sequences), commercial and behavioral variables (default, recidivism, changes of ownership, classification of use) and exogenous or unstructured variables (weather, geospatial data, textual observations of crews, images of installations, etc.). The study's findings are consistent on one point: data quality outweighs algorithmic sophistication, and simple models on clean datasets often outperform complex models on inconsistent databases. Therefore, the digitization of business processes and the systematic cleansing of records appear as indispensable enablers.

6.3. TARGETED INSPECTIONS

The on-site inspection is the closing of the detection cycle: it confirms or rules out the loss and, if confirmed, collects the evidence that supports the recovery of the energy and the penalty. Its effectiveness depends on three elements. First, good prioritization: when crews work on lists ordered by risk score, the discovery rate rises substantially compared to random inspections, thereby reducing the unit cost of the energy recovered. Second, the strategy requires standardized protocols for collecting evidence, standardizing metering procedures, and calculating unbilled energy, capable of sustaining subsequent administrative or judicial processes. Third, systematic feedback to the analytical system must be established, labeling the results of each inspection (finding, false positive, no access, recovered energy) so that the models learn. Without this integration, inspection becomes reactive, false positives overwhelm crews, and the legitimacy of the process is eroded.

In short, operational profitability is not achieved by inspecting more, but by limiting the search space in a gradual and economically efficient way. By prioritizing the analysis from macro to micro scales, distributors discard large healthy areas of the network and focus resources with a precision not previously available. However, knowing exactly where the loss occurs does not guarantee its recovery: in contexts of restricted access, staff insecurity or deteriorated payment culture, detection technology finds a natural limit that requires moving to the second axis.

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

07

AXIS 2: DETERRENCE AND FRAUD CONTROL

The premise of this axis is that fraud is an economic and behavioral decision: it occurs when the expected benefit exceeds the perceived cost. The deterrence logic seeks to reverse this equation by raising the barriers to entry and increasing the expected cost of fraud, simultaneously articulating three dimensions: technical (infrastructure), regulatory (penalty) and social (culture).

7.1. TECHNICAL AND INFRASTRUCTURE MEASURES

- **Digital monitoring and analytical alerts at the point of measurement.** They constitute a non-physical layer of protection, complementary to structural hardening. They operate on two levels. The first corresponds to intrusion or tamper sensors integrated into the meter or its enclosure, which generate automatic alerts in the event of the unauthorized opening of the lid or box, the removal of the equipment or the presence of external magnetic fields intended to slow down the disc or deceive the sensor. These signals trigger rapid inspections and provide objective evidence about the intervention. The second plane corresponds to analytical or behavioral alerts, which are constructed by comparing the declared service state with the events recorded by the meter and the effective flow of energy: presence of load after a disconnection (indication of unauthorized reconnection), prolonged absence of voltage without an associated network event (possible manipulation of the connection), electrical profiles inconsistent with the contract. Each of these planes fulfills a different function within the hardening strategy: the first detects physical intervention; the second detects its consequence. The real value of these alerts, however, does not lie in their mass generation but in their management: without filtering, prioritization and routing rules to field teams, the volume generates saturation, false positives and loss of traceability. Therefore, its effectiveness depends on integration with risk analytics and with subsequent operational processes.

- **Physical hardening of meter access.** It is the most traditional measure of the axis and seeks to materially increase the cost of the intervention. It takes two main forms. The first is the encapsulation of the meter by means of reinforced enclosures (high-strength metal or plastic boxes, sealed and anchored), which limit unauthorized opening and intervention on the terminals; its effectiveness depends on the design, the quality of installation and the rigor of maintenance, since deteriorated enclosures can be violated relatively easily. The second is the relocation of the measurement point at height, out of the user's immediate reach, which requires authorized technical access and reduces the opportunity for daily manipulation. Both variants increase the effort and time required to defraud, which acts as a deterrent against opportunistic fraud. On the other hand, they make it more expensive to read, maintain and replace the meter; they can generate friction with users; and they are rarely sufficient on their own: fraud tends to move to unshielded points of the network, which justifies complementing the physical hardening with logical monitoring and upstream interventions (connection, diversion, transformer).

- **Remote metering and centralized metering.** Smart or advanced metering (AMI) replaces the electromechanical meter with digital equipment with two-way communication, capable of recording consumption at high resolution, reporting events in real time and executing remote actions such as service disconnection and reconnection. Centralized measurement takes this logic a step further: it groups the measurement of multiple users at a physically protected point (typically at height or inside a chamber) and dramatically reduces the equipment's exposure to tampering. The two ways share four structural benefits: they reduce the physical opportunity for fraud, generate quality data to feed Axis 1 analytics, enable rapid responses to irregularities (remote cut-off, alerts) and eliminate the need for physical visits for reading, which reduces the exposure of personnel in insecure areas. Their main requirements are significant upfront investment, reliable communications infrastructure, in-house capabilities to process massive volumes of data, and a regulatory framework that recognizes the associated costs, without which the business case may not close even when the operational benefits are clear.

7.2. REGULATORY AND LEGAL MEASURES

The regulatory component fulfills a specific function within the deterrence logic: to raise the expected financial and legal cost of fraud. This is articulated on three levels. At the administrative level, the company must have the power to inspect facilities, suspend irregular supply, standardize metering procedures, calculate and charge for unregistered energy and apply associated charges; the procedures must be standardized, robust in the evidentiary chain and respectful of the user's right to dispute, which protects the legitimacy of the collection against challenges. In civil proceedings, the company must be able to exercise collection actions and, where appropriate, report those responsible. On the criminal level, the criminalization of theft and manipulation of energy enables the prosecution of serious cases, especially illegal connections of great magnitude and operational collusion, and requires coordinated action protocols with prosecutors' offices and security forces. Regional evidence shows that the sanctioning capacity operates as a multiplier of the technical component: analytics and physical hardening lose effectiveness if administrative recovery is slow or if the jurisdictional response to massive fraud is fragmented. Its limit is clear: the toughening of sanctions is effective in the face of opportunistic or sophisticated fraud with malicious intent, but it loses traction when the irregularity responds to conditions of structural exclusion, where the sanction feeds the cycle of conflict without sustainably reducing losses.

7.3. COMMUNITY STRATEGIES AND AWARENESS RAISING

The cultural acceptability of fraud is a variable that is often underestimated and yet decisive. In environments where energy theft is perceived as a recognized skill or an acquired right, technical and legal deterrence faces strong resistance. Community strategies act on this dimension and are materialized in three lines of work. First, **prevention campaigns** that explicitly communicate the legal, electrical and economic consequences of fraud (risk of fire and electrocution, transfer of the cost to paying customers, applicable penalties) and that counteract the informal offer of manipulation "services". Second, **civic training and energy education** in schools, neighborhood associations and training spaces, aimed at building payment culture and responsible use. Third, work with **neighborhood leaders and community leaders**, which operates both as a channel of communication and as a mechanism for early mediation in the face of conflicts. These measures have a low unit cost, do not produce immediate energy recovery and are therefore often underutilized, but they reinforce the effectiveness of technical and regulatory measures by reducing the social base of recidivism and by building conditions for eventual regularization.

In contexts of high vulnerability and urban exclusion, fraud does not always respond to an opportunistic decision, but to a subsistence strategy. Purely coercive measures, such as repeated cuts, shielding, massive operations, tend to generate exhausting cycles of immediate reconnection and social conflict, without resolving the root cause. Operational experience shows that the exclusively punitive approach finds an insurmountable border when irregular connection is the only way to access an essential service. It is precisely this recognition that motivates the third axis of the repertoire.

08

AXIS 3: REGULARIZATION AND SOCIAL INCLUSION

A significant part of the NTLs is sustained in structural situations of informality and exclusion from the service. Evidence shows that a logic based exclusively on detection and inspection produces temporary results: a point is intervened, but the irregularity reappears if a viable path to formality is not enabled. Regularization is therefore understood as an enabling condition for a sustainable reduction of NTLs.

8.1. ENABLING INSTRUMENTS

- **Energy inclusion.** A set of practices aimed at incorporating users living in vulnerable neighborhoods, informal settlements or peri-urban areas into the formal system, reducing electrical risks and building conditions for a sustainable payment culture. Its distinguishing feature, compared to traditional control, is its sustained presence in the field: specialized teams that combine technical and commercial profiles, visit neighborhoods, gather information, manage service regularization, accompany the customer on their first invoices and resolve administrative questions. This proximity fulfills several functions simultaneously: it facilitates formalization by reducing information asymmetry, prevents the newly regularized customer from being trapped in an unpayable debt, mitigates the electrical risks associated with informal connections and incorporates a social perspective into operations that can hardly arise from a remote service channel. The effectiveness of these initiatives depends on coordination with public actors – municipalities, housing agencies, social services – since regularization usually requires enabling conditions (ownership, urban layout, technical feasibility) that exceed the control of the distributor.

- **Payment flexibility.** Mechanisms designed to sustain regularization and avoid relapse into irregular connections due to temporary inability to pay. Its logic is to build intermediate alternatives between strict compliance and service disconnection. The most relevant practices include: payment agreements with defined terms and active communication from collections, which anticipate delinquency before it escalates; prepayment, in its different variants (automatic cut-off when the balance is exhausted, emergency energy, discounts on recharging to amortize previous debt), which inverts the collection logic and reduces the non-payment risk; reduction of contracted power as an alternative to total cut-off, maintaining a minimum and payable supply while the financial situation stabilizes; and diversification of recharge channels (banking, neighborhood businesses, third parties, face-to-face), recognizing that part of the vulnerable population does not operate with digital channels. The common objective is to prevent the rigidity of the collection from expelling the customer back into the informal circuit, but its design must be careful not to reward non-compliance or weaken the payment discipline of regular customers.

- **Direct financial support.** It includes social tariffs, solidarity tariffs and targeted subsidies, instruments whose purpose is to reduce the economic barrier to access to formal service in highly vulnerable segments. They serve a dual function within the NTL strategy. As an instrument of access, they make formalization viable for households that otherwise could not sustain the payment of the standard tariff. As an instrument of retention, they stabilize the contractual relationship over time, reducing the probability of a return to irregularity. Its sustainability as an operational tool depends on three conditions: clear and verifiable eligibility criteria, which make it possible to distinguish real vulnerability from opportunistic exploitation; stable budget forecasting, ideally via state transfers, to prevent the cost of the subsidy from falling exclusively on the distributor or being transferred via tariff to the rest of the users; and a customer segmentation that goes beyond the administrative layer, incorporating indicators of effective vulnerability and historical behavior, which simultaneously improves the targeting of the benefit and expected revenue.

8.2. SOCIAL INCLUSION AND FINANCIAL SUSTAINABILITY

Regularization is only effective if it is accompanied by conditions that allow the contractual relationship to be maintained over time. Three dimensions are critical. First, debt management: accumulated debt is usually a more relevant barrier than the tariff itself to sustain formal service. Effective practices seek to decouple the formalization of the immediate payment of historical debts, through refinancing agreements, partial forgiveness subject to future regularity, and differentiated treatment of debts associated with previous occupants of the property, which would otherwise block the formalization of the new owner. The underlying idea is to prioritize future regularity over the full recovery of the past. Second, social tariffs as stabilizers of payment over time, complemented by a dynamic segmentation of customers that adjusts commercial conditions to economic reality and user behavior. Third, sustained community support in the period after regularization: territorial teams that maintain interaction with neighborhood referents, support billing processes, promote the efficient use of energy and detect early signs of delinquency or informal disconnection, acting before the non-technical loss is reinstated.

In territories where informality is structural, the distributor operates with an expanded identity: in addition to providing the service, it is usually the first and sometimes the only institutional actor present in the territory. This position creates tension between the regulatory mandate for loss control and social expectations of universal provision, and forces a redefinition of the scope of business action. In practice, this role manifests itself on three levels. On the technical level, the distributor provides information on electrical risks, supply feasibility and intervention sequences, which makes it a critical input for land use planning processes. At the level of coordination, it assumes a role of mediator with municipalities, housing agencies, social services and security forces, recognizing that the resolution of informality exceeds its direct competence and requires inter-institutional cooperation. At the operational level, security restrictions on field personnel require gradual and territorialized strategies. These include programmed interventions, collaboration with community leaders, joint deployments with local authorities, and intermediate solutions – network management, risk mitigation, user identification – that stabilize the system while external enablers such as land regularization are resolved. Ultimately, sustainable reduction of NTLs in these contexts requires explicitly assuming this complexity, rather than treating it as an externality of the operation.

09
LESSONS AND SUCCESS FACTORS

Beyond the specificity of each tool, the comparative analysis identifies four organizational factors that differentiate the experiences that sustain their indicators from those that regress once a campaign is over. These factors operate as enabling conditions transversal to the three axes of the taxonomy.

- **Institutional continuity.** NTLs behave like an elastic variable: they shrink under pressure, but rebound when management relaxes. Energy control should be internalized as a permanent function of the operation, analogous to grid maintenance, and not as a temporary initiative. The transition from project-based approaches to continuous operational processes is the first determining factor.

- **Data hygiene.** Algorithmic sophistication does not compensate for shortcomings in data governance. Large volumes of incomplete, misclassified, or inconsistent information degrade the performance of any model. The cleansing of the commercial databases (ownership, activity classification, socioeconomic tier, georeference) is a prerequisite for analytical intelligence and, in many cases, the best return on investment available.

- **Operational discipline and human factor management.** Measurement technology maintains vulnerability to physical interaction. Systematic rotation of personnel, specializing crews dedicated exclusively to loss control and tightening internal protocols are necessary to avoid operational collusion. When the environment compromises the integrity of the personnel, it is necessary to migrate to technological hardening and telemetry systems.

- **Contextual realism.** The distributor cannot make up for the absence of territorial planning. In unrecognized settlements, technical solutions are unsustainable without prior legal authorization, and regularization requires action by the municipality to prepare the area for urban planning. The explicit recognition of these limits avoids ineffective strategies and guides towards intermediate solutions that stabilize the system while external enablers are resolved.

> Analysis of the intervention areas reveals that distribution companies possess a technical portfolio.

10
FINAL THOUGHTS

A review of NTL management strategies in Latin America and the Caribbean allows us to conclude that this phenomenon is not a simple operational externality, but a symptom of the complex relationship between the electricity service and the social structure of the region. Three reflections summarize the findings of the study.

First, it is necessary to overcome the simplistic binary view of users. 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 most effective distributors are those that distinguish these nuances and apply the appropriate remedy: rigor in the face of massive industrial and commercial fraud, but bridges of inclusion and flexibility in the face of residential vulnerability.

Second, 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, they do not replace territorial management or political will: a smart meter in a neighborhood without payment culture or without institutional presence is an asset at risk, not a solution. The modernization of the network must invariably be accompanied by modernization in the social and community management of the company.

Third, the challenge of the NTLs invites us to rethink the role of the distributor. In a scenario of energy transition, where the grid must be flexible, digital and participatory, the burden of inefficiency caused by losses is unsustainable. Solving this challenge implies that the distributor stops seeing 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, is not just a profitability metric: it is part of building inclusive access to energy services, where access to a quality service and fair payment for it are two sides of the same coin.

Finally, pending challenges remain: the governance of data generated by smart grids (privacy, proportionality, legitimate use), the coordination between energy control and justice in vulnerable contexts, and the necessary adaptation of regulatory frameworks to a speed of innovation that today exceeds them. Progress on these fronts is a condition for transforming the management of NTLs from a reactive logic to a more preventive, efficient and socially sustainable model.

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