Strategic Roadmap for Digital Transformation for Utilities

Strategic Digital Transformation Roadmap for Energy Distributors

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Introduction

Electricity distributors face a scenario of rapid technological change, pressured by the need to improve efficiency, reliability and integrate new energy sources. The digitalization of the distribution system is seen as a fundamental way to make smart grids viable. These grids, supported by artificial intelligence (AI) and cloud computing, enable bidirectional energy flow and communication, improving the balance between supply and demand and integrating distributed energy sources. In other words, digital transformation helps create a more efficient, resilient and flexible electricity grid, capable of incorporating decentralized renewable generation and active consumer participation (prosumers). On the other hand, companies are extremely verticalized, with well-defined data silos, as opposed to the need for systems with centralized and easily distributed data in the most diverse applications and management systems. The implementation of digitization faces a major challenge in terms of the company's structure and human resources.

Main Goals for the Digitization of Distribution Systems

Distribution companies are pursuing comprehensive digital transformation initiatives across several strategic areas to modernize their operations and enhance service reliability.

Advanced Network Automation represents a fundamental shift toward intelligent grid management through the implementation of sophisticated SCADA (Supervisory Control and Data Acquisition) systems. Organizations are expanding automation capabilities across reclosers, switches, and other field devices while achieving significant reductions in average interruption time through automated restoration processes.

Condition-Based Asset Management enables proactive infrastructure oversight through real-time monitoring of critical equipment including transformers and circuit breakers. This approach leverages IoT sensors and advanced data analytics to enable predictive maintenance strategies, ultimately extending asset lifecycles through more precise and timely interventions.

Integration of Distributed Energy Resources addresses the evolving energy landscape by facilitating efficient management of distributed generation sources such as solar and wind installations. This includes sophisticated control and orchestration of energy storage systems while maintaining dynamic balance between centralized and distributed generation sources.

Smart Meters and Advanced Metering Infrastructure transformation involves comprehensive deployment of intelligent metering systems that enable remote and automated consumption monitoring. These systems support dynamic, real-time pricing models that respond to market conditions and consumption patterns.

Demand Management and Demand Response programs focus on optimizing consumption patterns through strategic demand-side management initiatives. These include implementing incentive structures for off-peak consumption while enabling remote control of non-essential loads during peak demand periods.

Advanced Data Analysis and Artificial Intelligence capabilities are being deployed to enhance operational intelligence through fault prediction and network behavior analysis. These systems optimize power flow management and enable detection of both technical and non-technical losses, including theft prevention.

Resilience and Cybersecurity initiatives ensure robust protection against cyber threats while maintaining rapid recovery capabilities following extreme weather events. These comprehensive security frameworks include automatic fault isolation mechanisms and intelligent restoration protocols that minimize service disruptions.

Centralization vs. Decentralization: Current Trends

The evolution of distribution system architectures is fundamentally shaped by specific security, latency, and availability requirements that permeate architectural decisions. As organizations implement diverse applications and integrations, the prevailing trend has shifted toward a sophisticated hybrid model that strategically combines both centralized and decentralized elements.

Centralized Elements continue to play a crucial role in modern distribution architectures, particularly in areas requiring comprehensive oversight and coordination. Corporate integrated management systems provide unified control across organizational operations, while large-scale data analysis conducted in dedicated data centers enables sophisticated insights and decision-making capabilities. Strategic planning and network-wide operational coordination remain centralized functions, ensuring coherent system-wide management. Additionally, cybersecurity protocols and data governance frameworks benefit from centralized oversight to maintain consistent security standards and regulatory compliance.

Decentralized Elements address the need for autonomous operation and rapid response capabilities at the local level. Microgrids capable of independent operation provide essential resilience during network disruptions, while edge computing infrastructure enables fast, locally-executed decisions without dependency on remote systems. Distributed control systems facilitate real-time response capabilities, and local management of distributed energy resources ensures optimal utilization of renewable generation assets and storage systems.

Hybrid Model Framework emerges from compelling operational and technical justifications that address modern grid challenges. Enhanced resilience represents a primary advantage, as decentralized components enable partial system operation even during extreme events or widespread disruptions. Latency considerations drive the need for local decision-making capabilities, ensuring critical operations do not depend on potentially unreliable communication with remote control centers.

Capacity for Wireless Networks must be also taken into consideration especially because spectrum is a finite and expensive asset. A holistic view will avoid several issues in the implementation and network expansion.

The hybrid approach also delivers exceptional flexibility, recognizing that different network regions have distinct operational requirements and constraints that demand customized solutions. Scalability benefits emerge through decentralized architecture that facilitates gradual system expansion without requiring comprehensive infrastructure overhauls. Simultaneously, centralized elements provide efficiency advantages through economies of scale, particularly for complex analytical processes and big data operations that benefit from concentrated computational resources and specialized expertise.

> This hybrid model allows distributors to take advantage of the benefits of both approaches, generating a digital transformation that balances centralized control with local responsiveness, which

is crucial for operating increasingly complex and dynamic networks.

Analysis of the Infrastructure Strategy for Electricity Distribution Networks

Figure1 - Architecture shows a layered architecture for the technological infrastructure of electricity distribution companies, following a pyramid model. This approach reveals a very structured and hierarchical strategy, which offers several strategic benefits for the sector.

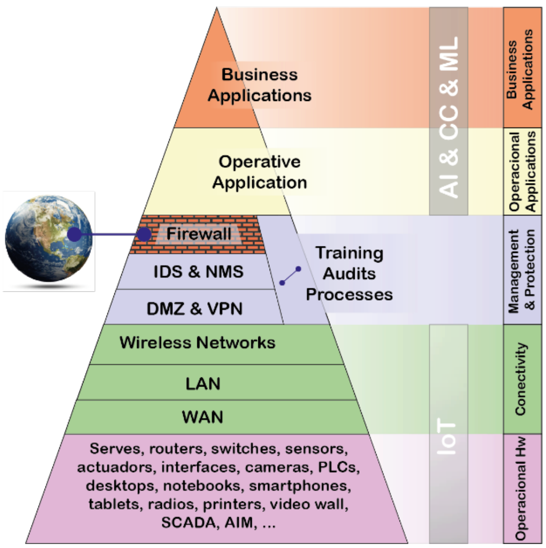

Figure1 – Architecture

Architecture in Well-Defined Layers

Systematic Layer Organization demonstrates a clear separation between different technological levels that forms the foundation of modern distribution network architecture. The base layer encompasses IoT and operational hardware representing the physical equipment that constitutes the infrastructure foundation. Connectivity requirements are addressed through comprehensive WAN, LAN, and wireless networks that guarantee seamless communication across all system components. Security and management functions operate through dedicated protection layers including DMZ configurations, VPN protocols, firewall systems, and integrated IDS/NMS monitoring capabilities. The applications layer houses operational and business management systems that effectively utilize collected data for decision-making and system optimization. This systematic separation enables more efficient and focused management at each operational level, facilitating targeted upgrades and maintenance activities without disrupting the entire system infrastructure.

Convergence of IT and OT Systems represents a fundamental shift in operational philosophy, highlighting the strategic integration of Information Technology and Operational Technology frameworks. The central implementation of Artificial Intelligence, Cloud Computing, and Machine Learning capabilities permeates both management and operational applications, creating a unified technological ecosystem. This convergence enables distributors to implement predictive analysis capabilities for network fault identification, optimize operations based on comprehensive historical data analysis, and develop intelligent planning frameworks for network expansion and maintenance scheduling.

Comprehensive Security Framework addresses critical infrastructure protection through multiple dedicated security layers including firewall protection, integrated IDS and NMS monitoring, and DMZ and VPN configurations. This multi-layered approach reflects fundamental concerns regarding critical infrastructure protection in an increasingly complex threat landscape. The strategy addresses the documented increase in cyber attacks targeting critical infrastructure, ensures comprehensive protection of consumption and operational data, and maintains operational continuity during adverse scenarios or security incidents.

Human Factors and Governance Integration recognizes that technological implementation alone cannot ensure successful digital transformation. The dedicated focus on training, audits, and processes as integral architectural components demonstrates understanding that human factors and governance frameworks are essential elements for successful digital transformation in distribution operations.

Implementation Strategy Considerations encompass multiple critical factors that determine deployment success. Scalability represents a fundamental architectural advantage, enabling modular growth that accommodates smart grid expansion and increasing numbers of connected devices. Layered architecture enhances resilience by facilitating redundancy implementation at critical operational levels, ensuring that component failures do not compromise entire system operations. Interoperability capabilities favor integration of diverse systems and equipment, which proves essential in sectors that frequently operate legacy technologies alongside modern solutions. The security-by-design approach incorporates protection mechanisms as structural elements rather than subsequent additions, following established best practices for critical infrastructure development.

Implementation Challenges and Considerations present significant factors that require careful planning and management attention. Management complexity emerges from the need to coordinate multiple technological levels, requiring robust governance frameworks and multidisciplinary team coordination. Complete strategy implementation represents substantial financial investment, necessitating comprehensive financial planning and phased deployment approaches. Regulatory compliance ensures that infrastructure development meets electricity sector regulatory requirements and maintains operational standards. Implementation timelines require gradual transition approaches that allow operational adaptation without compromising essential service delivery.

This comprehensive strategy represents a modern and integrated approach to digital transformation within the electricity distribution sector, aligning with global digitalization trends in utility operations while preparing organizations for the challenges of increasinglydynamic and complex grid environments.

Implementation Challenges and Methodology

Critical Implementation Considerations present multifaceted challenges that require strategic planning and systematic management approaches. Management complexity emerges as a primary concern, as coordinating multiple technological levels demands robust governance frameworks and effective multidisciplinary team coordination across various organizational functions. Implementation costs represent a substantial consideration, as the complete strategic transformation requires significant financial investment and necessitates comprehensive financial planning with phased deployment strategies. Regulatory compliance ensures that infrastructure development aligns with electricity sector requirements and maintains operational standards throughout the transformation process. Implementation timelines must accommodate gradual transition approaches that enable operational adaptation while preserving essential service delivery and maintaining system reliability.

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Strategic Implementation Methodology addresses the unique requirements of critical infrastructure transformation through carefully considered foundational premises. Given the critical nature of applications, inherent management complexity, and deployment requirements across multidisciplinary teams spanning various directorates and departments, the recommended approach suggests implementing a formal model structured around detailed project development with increasing levels of complexity. This methodology emphasizes comprehensive definition of requirements and interfaces at multiple organizational levels, followed by rigorous testing and validation protocols that ensure each previously defined requirement and interface undergoes specific verification procedures.

Long-term Monitoring and Validation Framework recognizes that comprehensive evaluation of high-level implementation outcomes requires extended monitoring periods to establish meaningful Key Performance Indicators and identify associated trends. This extended evaluation approach ensures that strategic objectives are achieved and maintained over time, providing organizations with concrete metrics for measuring transformation success and identifying areas for continuous improvement.

Agile Methodology Integration provides flexibility for projects that deviate from the previously established premises, particularly in situations where requirements and interfaces lack clear definition and operational criticality in terms of potential operational damage remains minimal. This dual-methodology approach enables organizations to maintain rigorous standards for critical infrastructure components while embracing adaptive approaches for less critical system elements.

Model V Framework Implementation leverages the layered infrastructure foundation to structure systematic development and validation processes. Based on the comprehensive layered architecture presented, the Model V approach provides a structured framework for managing complex infrastructure transformations while ensuring systematic validation and verification at each development stage.

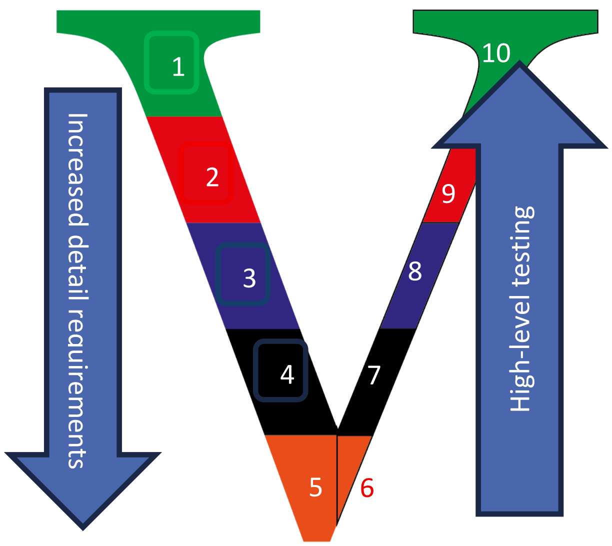

Figure 2 - model V

V-Model Implementation Framework for Distribution Systems

Introduction to the V-Model Approach

The V-Model methodology provides a systematic framework specifically designed for complex, mission-critical infrastructure implementations where comprehensive validation and verification are essential. In the context of electricity distribution system digitalization, this approach addresses the unique challenges of integrating advanced technologies while maintaining operational reliability and regulatory compliance.

The V-Model's structured progression from high-level business requirements through detailed technical implementation, followed by corresponding validation phases, ensures that each development stage has a corresponding verification component. This methodology proves particularly valuable for distribution system modernization projects due to their inherent complexity, safety requirements, and the critical nature of continuous service delivery. The model's emphasis on early requirement definition and systematic validation helps mitigate risks associated with large-scale infrastructure transformation while ensuring that strategic objectives are measurably achieved.

Left Side: Specification and Development (1 - 5)

Business Requirements (1) establish the foundational framework through comprehensive definition of the distributor's strategic objectives and identification of critical performance indicators including DEC/FEC metrics and technical loss reduction targets. This phase encompasses determination of regulatory requirements mandated by ANEEL and other governing bodies, ensuring compliance frameworks are embedded from the project inception.

System Requirements (2) translate strategic objectives into functional specifications for management and operational applications, defining comprehensive data analysis and artificial intelligence capabilities requirements. This stage establishes service level agreements for each architectural layer, creating measurable performance standards that guide subsequent development phases.

System Architecture (3) focuses on designing seamless integration between all operational layers including IoT infrastructure, connectivity frameworks, security protocols, and application systems. This phase defines comprehensive data architecture and information flow patterns while planning the underlying computing and storage infrastructure necessary to support the complete system ecosystem.

Detailed Design (4) provides technical specifications for field equipment including sensors and actuators, comprehensive design of communication interfaces and protocols, and detailed security frameworks with granular access control rules. This stage ensures that all technical components are precisely defined before implementation begins.

Implementation (5) encompasses application development and customization activities, equipment and network configuration processes, and comprehensive implementation of security controls across all system layers. This phase represents the actual deployment of all previously designed components into operational environments.

Right Side (6-10): Verification and Validation

Unit Tests (6) provide individual validation of each implemented component through comprehensive testing of IoT devices, network elements, and software modules. This phase ensures compliance with technical specifications at the component level, establishing confidence in individual system elements before integration.

Integration Tests (7) verify communication capabilities between components and conduct comprehensive interoperability assessments between legacy and new systems. This phase validates data flows between architectural layers, ensuring seamless information exchange across the complete system infrastructure.

System Testing (8) validates complete architecture within controlled environments through comprehensive load and performance evaluations. This phase examines system response capabilities across various operational scenarios, ensuring robust performance under diverse operating conditions.

Acceptance Tests (9) validate compliance with functional requirements and verify adherence to regulatory standards through comprehensive assessment protocols. This phase includes usability testing with actual operators, ensuring that implemented systems meet practical operational needs and user experience requirements.

Operational Validation (10) evaluates system performance during actual operational deployment, verifying achievement of performance indicators and confirming compliance with strategic objectives. This final phase provides comprehensive assessment of real-world system effectiveness and validates successful completion of transformation objectives.

Benefits of Model V for Energy Distributors

The V-Model methodology delivers substantial advantages specifically tailored to the unique requirements of energy distribution organizations. Complete traceability ensures that each requirement maintains direct linkage to its corresponding verification process, guaranteeing that no component is implemented without comprehensive testing and no testing occurs without clearly defined requirements. Early problem detection capabilities emerge through simultaneous planning of testing protocols alongside requirement definition, enabling identification of design flaws before they impact implementation timelines or operational effectiveness.

Structured governance frameworks provide clear control points essential for project management within regulated environments such as the electricity sector, ensuring compliance with oversight requirements and maintaining accountability throughout the transformation process. Risk management capabilities address the critical nature of distribution systems through early identification and mitigation of potential operational risks, facilitated by the systematic structure inherent in the V-Model approach. Quality assurance mechanisms ensure that every infrastructure component meets stringent standards required for reliable operation in mission-critical environments.

Contextual Adaptations for Distribution Environments

The V-Model framework requires specific adaptations to address the unique operational requirements of distribution system environments. Security testing enhancements incorporate dedicated testing layers for cybersecurity assessment, including comprehensive vulnerability analysis and penetration testing protocols that address the increasing threat landscape facing critical infrastructure. Regulatory validation processes include explicit verification steps to ensure compliance with ANEEL[1] requirements and other regulatory agency mandates, embedding compliance verification throughout the development lifecycle.

Resilience testing protocols add specific verification procedures for contingency and disaster recovery scenarios, ensuring that systems maintain operational capability during adverse conditions. Field validation components include comprehensive testing under real operating conditions, accounting for the diverse characteristics of urban and rural environments and their unique operational challenges.

The V-Model methodology offers a structured and rigorous implementation approach that aligns perfectly with the requirements for secure and reliable deployment in critical infrastructures such as power distribution networks. This framework ensures that each component of the layered architecture undergoes proper specification, implementation, and validation, creating a foundation for successful digital transformation that maintains operational reliability while achieving strategic modernization objectives.

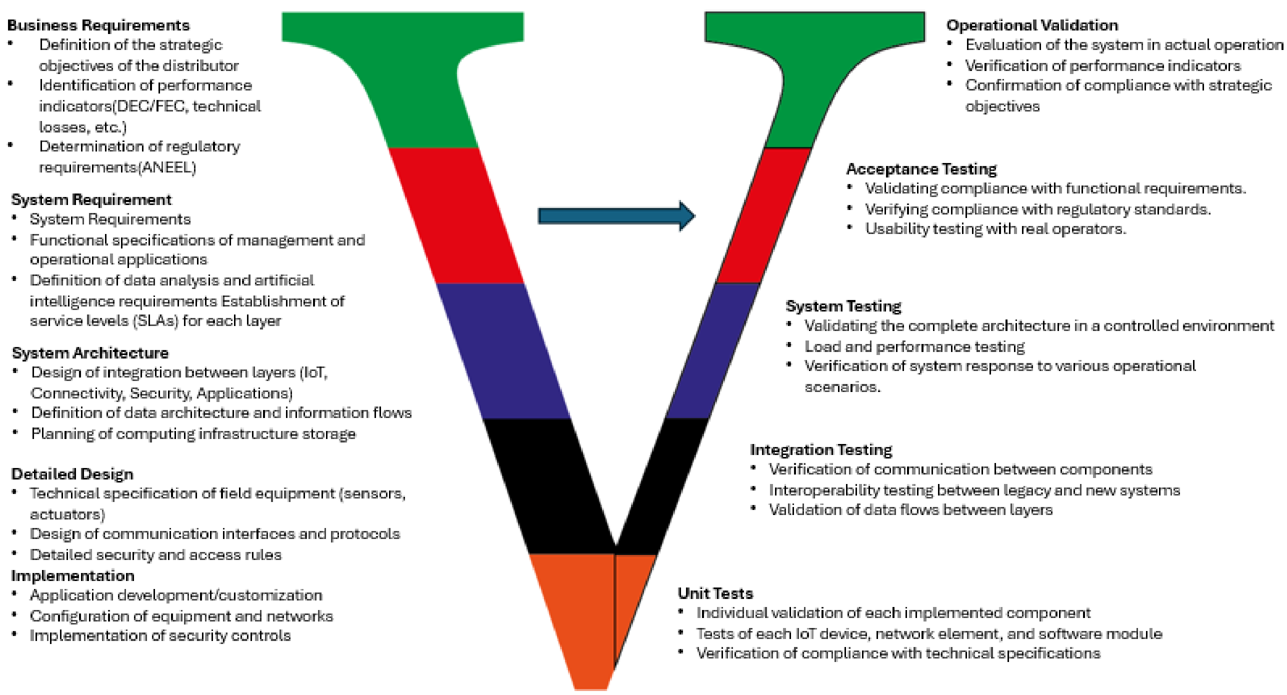

Figure1 - Model V – phases

[1] ANEEL – Brazilian Regulatory Agency. This study was prepared for the Brazilian Market

Roadmap

This strategic roadmap describes the evolution in **three phases of digital maturity - short term (1-2 years)**, **medium term (3-5 years)** and **long term (6-10 years**) - detailing technological initiatives, organizational changes and regulatory aspects at each stage. Real examples (international and national) are also provided to serve as a reference for each phase of this evolutionary path.

Short Term (1-2 years) - Digitization Fundamentals

In the short term, the concessionaire must focus on **technological and organizational foundations** that will prepare the ground for more advanced initiatives in the following years. This is a phase of **pilots, investments in basic infrastructure and initial organizational adjustments**.

Priority Technologies and Solutions:

Advanced Metering Infrastructure (AMI) - Initial deployment of smart meters for remote metering and remote control. This enables remote reading of consumption, detection of commercial losses (fraud) and remote disconnection/reconnection. For example, AES Eletropaulo (SP) launched a pilot with 35,000 smart meters in 2007, enabling *remote disconnection* functionalities and identification of energy detour. International experience confirms the priority of AMI: Italy was a pioneer in installing around **36.7 million** smart meters between 2001 and 2011 fsr.eui.eu, laying the groundwork for hourly tariffs and loss reduction.

SCADA/OMS Systems and Initial Automation - Modernization of the supervisory control systems (SCADA) and the outage management system (OMS). Integrating the new meters and sensors into the OMS makes it possible to detect faults and restore service more quickly. It is important to remotely update/control field equipment (reclosers, disconnectors) to implement basic *FLISR* (Fault Location, Isolation and Service Restoration), starting **network automation** for automatic isolation of faulty sections.

GIS Systems and Network Modeling - Consolidation of a **Geographic Information System (GIS)** integrated with distribution network assets. The GIS will serve as a reliable source of topological data for other applications (such as ADMS in the future) and is key to building digital twins of the network. Ensuring that the technical cadaster is up-to-date and integrated is a **fundamental short-term program**.

Sensing and IoT - Installation of **IoT sensors** at critical points (transformers, switches, feeders) for real-time monitoring of operating conditions (voltage, current, temperature, etc.). Even on a pilot basis, this IoT infrastructure is starting to feed the company with real-time data. IoT technologies, together with smart meters and AI, are already proving their worth by making it easier to identify fraud and non-technical losses - an immediate benefit in terms of reducing energy losses.

Initial Analytics and Data Management - Implementation of basic metering **data management (MDM)** and **analytics** systems. In the short term, this involves consolidating the data collected (from meters, sensors, legacy systems) in a central repository and developing *dashboards* and initial analytical reports. For example, implementing reports on technical and non-technical losses by region, identifying critical feeders, etc. This initial analytical capacity will support the prioritization of investments and demonstrate *quick wins* from the use of data.

Organizational and Process Changes:

Team Training and Change Management - Start a **training** program for operational, technical and IT teams to develop skills in new technologies (use of AMI systems, data analysis, smart grid concepts). At the same time, invest in **change management** to engage employees in the digital transformation vision. Experience shows that staff training and cultural change are **key** elements of any modernization plan.

Creation of Innovation and Data Centers - Structure a small **cross-functional digital innovation team** or a **Data Center of Excellence in** the short term. This initial nucleus - albeit lean - will be responsible for coordinating technology pilots (e.g. smart meter pilot project), analyzing the data collected and supporting the business areas in adopting the solutions. International organizations recommend establishing clear governance for data right from the start, defining **those responsible for the quality and use of data** in the company.

IT/OT (Information Technology and Operation) integration - Bringing IT and Operation (OT) teams closer together to work collaboratively on smart grid projects. For example, involve IT analysts in network automation initiatives and involve operations engineers in defining data system requirements. In the short term, you could create committees or *squads* focused on pilot projects, promoting knowledge exchange between these traditionally isolated areas.

Governance and Planning - Update the distribution company's strategic planning, incorporating digital transformation as a pillar. Define an **executive sponsor** (e.g. a director leading the digital agenda) and set measurable short-term targets (e.g. % of meters installed, number of teams trained, etc.). This signals the priority of the topic internally and creates accountability for the first digital deliverables.

Regulatory and Legal Aspects:

Adherence to Current Rules - Ensure that pilots and new technologies comply with current regulations. For example, ensuring that the smart meters installed are approved by the metrological regulator and that the remote cut-off functionalities comply with the agency's resolutions (notifying customers in advance, etc.). In Brazil, the **PRODIST** (Distribution Procedures) **standards** must be followed in pilot projects, and any exception or non-standard experiment requires dialogue with ANEEL via R&D projects or specific authorizations.

Initial Differentiated Tariff - Prepare for **initial dynamic tariffs**. One example is the **White Tariff**, an hourly tariff modality introduced in Brazil from 2018, in which energy consumed outside peak hours is cheaper. In the short term, the distributor must adapt its billing and service systems to offer this option to eligible customers and carry out awareness campaigns. According to the original schedule, consumers with high consumption were able to migrate to the White Tariff in 2018, extending to the rest in 2019 and 2020 - so the systems already need to accommodate this tariff complexity.

Integration of Prosumers (Distributed Generation) - Implement internal processes to connect and manage distributed micro and mini generators (such as residential solar panels) in accordance with regulations. This includes adapting billing systems to account for energy injected vs. consumed (energy compensation system), creating specific service channels for prosumers and training technicians to evaluate grid access studies. The **legal framework for distributed generation (Brazilian Law 14.300/2022)** established clear rules, guaranteeing microgenerators already connected by 2022 the right to compensation in the current form for 25 years . In the short term, the distributor must be able to **comply with this law**, processing connection requests on time and keeping records of prosumer energy credits.

Cybersecurity and Privacy - Since the start of the digital transformation, it is crucial to observe **information security and data protection** requirements. Smart meters and sensors collect detailed consumption data, which requires compliance with the General Data Protection Act (LGPD) in the Brazilian context. In addition, the operational infrastructure becomes more connected, increasing the cyber attack surface - so security standards (such as ISO 27001, IEC 62443 for industrial systems) must already be incorporated into pilots (e.g. ensuring authentication and encryption in meter communication).

Reference Examples (Short Term):

International: As mentioned, **Italy** completed the massive installation of smart meters in just over 10 years, making it possible to migrate all residential consumers to hourly prices (peak, intermediate and off-peak) by 2010. This case illustrates the value of prioritizing AMI in the short term to enable regulatory and operational benefits later on. Another reference is the **Sacramento Municipal Utility District (SMUD)** in the USA, which started an ADMS/DERMS plan years ago and highlighted the importance of smart metering and robust communication as the first step to support active customer participation in the future smud.org.

National: In Brazil, several *smart grid* pilots have been carried out over the last decade. AES Eletropaulo (now Enel SP) implemented a project in Barueri with tens of thousands of smart meters and network automation, a pioneer in telemetering and fraud detection. **Cemig (MG)**, for its part, invested in 2019 in an intelligent communication system for complete automation in the metropolitan region of Belo Horizonte, with the aim of improving the quality of the service and reducing the duration of faults - an example of a focus on SCADA/telecom systems in the short term. These experiences show initial gains in terms of reducing losses and fault response times, reinforcing the value of short-term investments.

Medium Term (3-5 years) - Integration and Expansion of Capacities

In the medium term, the distributor will have accumulated experience with the pilots and foundations implemented previously. This phase focuses on **scalability and integration**: expanding solutions to the entire concession area, integrating different technologies into unified platforms and consolidating organizational changes. This is when the company makes the leap from one-off initiatives to a **significantly digitized operation**.

Priority Technologies and Solutions:

Expanded AMI Coverage - After successful pilots, **smart meters** are going mainstream, covering a large portion (or 100%) of consumers. This enables universal remote reading, the elimination of manual reading and making consumption data available almost in real time to customers (via apps) and to the distribution company's own operations. The international **National Grid (UK)**, for example, plans to complete the deployment of millions of smart meters during the regulatory period until 2028, in line with the regulator's requirements. In Brazil, an ambitious project announced in 2025 foresees the modernization **of 1.6 million meters** by CPFL Energia by 2029, in order to proactively meet regulatory requirements and improve energy management for customers.

Advanced Distribution Management System (ADMS) - Implementation of ADMS as a central operational control platform. ADMS integrates SCADA, OMS, GIS and field automation, offering advanced tools: *real-time load flow*, network-wide automatic restoration (FLISR), voltage and reactive optimization (*Volt/VAR Optimization*), load forecasting and operator decision support. Many global utilities consider ADMS a key technology to be implemented in the medium term: in New York (USA), distributors plan to develop a centralized ADMS model around 2025-2026, incorporating DER forecasting and control functionalities. It is expected that by 2027 these companies will have a fully operational ADMS, the basis for later integrating a comprehensive DERMS. In the national context, companies such as Enel Distribuição São Paulo have already started implementing ADMS, integrating legacy systems into a digital operation center.

Distributed Energy Resource Management Systems (DERMS) - In the medium term, **DERMS** platforms will begin to operate to manage *DERs* (Distributed Energy Resources) in a coordinated manner. Initially, DERMS can be focused on monitoring and dispatching resources such as distributed solar generation, stationary batteries and controllable loads (e.g. boilers, electric vehicles) participating in demand response programs. **ADMS-DERMS integration** allows the operator to have unified visibility of distributed loads and sources, moving from a purely passive model to a **bidirectional control** model **of the network**. An example is SMUD itself, which in 2022-2023 put into production a combined ADMS/DERMS platform to support the transition from a unidirectional radial system to a dynamic, decentralized system, optimizing resources such as rooftop solar, electric vehicles, batteries and smart thermostats. In the medium term, DERMS will operate in a limited way (for example, only in peak events or microgrid pilot projects), but it will already lay the foundations for large-scale DER integration in the long term.

Expansion of Automation and Real-Time Control - Network automation, which began in the short term, has now reached a large part of the feeders. Large-scale installation of **intelligent reclosers, motorized disconnecting switches and sensors** on practically all the main circuits, all integrated into the ADMS. This enables a "self-restoring" network in a large part of the concession area, significantly reducing the DEC and FEC indicators (duration and frequency of interruptions). In addition, the communication of field devices (via radio, fiber or private LTE networks) is integrated with the control systems. *Cases*: In the US, utilities plan that *"in the long term (from 2026) AMI communication will be integrated into the automation network to support VVO, FLISR and other ADMS applications*" **-** i.e. using the meter communication network to also control network devices, increasing distributed intelligence.

Partial Digital Twins - Development of **digital models of the network (Digital Twins)** to improve planning and operation. In the medium term, the digital twin can be applied to critical subsystems: for example, a digital twin of an entire substation or a major urban feeder, integrating GIS data, real-time measurements and maintenance history. These models make it possible to simulate scenarios ("*study mode*" in ADMS) before applying changes in the real world. Components of the digital twin will already be in use within ADMS and DERMS - for example, to test demand response actions or DER dispatch before executing them. In addition, the digital twin supports *asset management*: by consolidating inspection, measurement and historical data, it can predict failures and asset replacement needs. Internationally, the creation of accurate digital twins is seen as a critical factor in the safe operation of the grid as it becomes more complex.

Artificial Intelligence and Advanced Analytics - The use of **AI** in the medium term will deepen, thanks to the availability of more data (from meters, IoT sensors, digital twins). Use cases include: **predictive maintenance**, with ML algorithms identifying patterns that precede transformer or cable failures; more accurate **load forecasting and distributed generation**, feeding into operational and commercial decisions; **advanced loss detection** (technical and non-technical) combining data from multiple sources (consumption, weather, satellite images, etc.) to target anti-fraud actions. For example, an AI tool developed in partnership with the IDB and tested at CEEE (RS) analyzes customers' monthly consumption to pinpoint which meters are most likely to be fraudulent, increasing the identification of irregularities in the field by 5%**. Chatbots and virtual assistants** can also be implemented to improve customer service in the medium term, resolving common issues in an automated way and integrating with new systems (providing hourly consumption data to the customer via WhatsApp, for example).

Modernized Business Management Systems - Along with specific network innovations, in the medium term we expect to modernize *back-office* systems. This includes integrated ERPs, **asset management systems (EAM)** with modules aimed at intelligent assets, **field team management platforms (Mobile Workforce)** to optimize the dispatch of service orders considering real-time data, and customer **relationship portals** redesigned for the digital age (allowing prosumers to track their energy credits, consumers to monitor their hourly consumption profile and respond to price signals, etc.).

Organizational and Process Changes:

Data Analytics Center of Excellence - The data hub created in the short term evolves into a mature **Analytics Center of Excellence**. Dedicated teams of data scientists, data engineers and energy experts work together to extract value from the large volumes of data collected. This CoE meets the demands of several areas: maintenance (failure prediction models), commercial (customer segmentation for efficiency programs), planning (electric vehicle adoption projections and distributed generation), among others. It also institutionalizes good **data governance** practices, guaranteeing data quality, security and accessibility for those who need it. According to experts, a well-structured analytics CoE unifies the data vision and accelerates the journey to becoming a data-driven organization.

New Structures and Profiles - The organization undergoes major adaptations. **New departments** or directorates may emerge, such as a Digital Transformation or Innovation directorate. The IT and Telecom areas take on a more strategic role, often integrating with network automation. The need arises for **new professional profiles**: data engineers, cybersecurity specialists, electrical engineers with knowledge of software/IA, etc. The human resources area must actively recruit and train for these positions, as well as upskilling current staff to reduce skills gaps.

Agile Processes and Culture of Innovation - In the medium term, the company is adopting more **agile** and iterative project management methodologies, suited to the technological environment. Multidisciplinary squads can be formed to develop, for example, an automatic outage response solution or a new customer portal, delivering increments in short sprints. Organizational culture becomes more conducive to continuous innovation: incentives for internal ideas, partnerships with *startups* in the electricity sector (via open innovation programs) and participation in collaborative R&D projects become commonplace. In short, the utility begins to operate less like a traditional electricity company and more like a technology company.

Governance and Data-Based Decisions - With integrated systems and analytics available, decision-making becomes more **data-driven**. Operations and planning meetings now take into account real-time *dashboards* of indicators (e.g. voltage levels at various points in the network, peak load forecasts for the day, etc.). Senior management monitors digital metrics (number of interruptions avoided by automation, savings achieved by detecting losses, customer satisfaction with new digital services). IT/OT governance is strengthened to ensure alignment between technological strategies and business objectives. **Cybersecurity** also gains dedicated committees and frequent reports to leadership, given the increase in digital criticality.

Regulatory and Legal Aspects:

Regulatory Evolution for Smart Grids - In the medium term, it is expected that **regulatory frameworks will begin to be updated** to accommodate innovations. The distributor should actively engage with the regulator to contribute to standards on: **interoperability of systems**, **sharing of sector data**, **participation of distributed resources in energy markets**, among others. In the UK, for example, the regulator (Ofgem) has already included in the 2023-2028 regulations obligations for distributors to publish digitalization strategies and implement intelligent system optimization platforms - demonstrating that regulators value ambitious digital plans. In Brazil, it is possible that resolutions on smart meter standards, specific quality of service requirements for automated networks, etc. will emerge in the medium term, and the company must be ready to comply with them.

Dynamic Tariffs and Price Signaling - With extensive hourly metering infrastructure, it becomes feasible to introduce **dynamic pricing** for more consumers. Regulators can move from static tariffs (peak/off-peak) to more dynamic models, such as **daily variable hourly tariffs according to the market price** or *critical* peak pricing schemes. In the medium term, the distributor can pilot **Demand Response** programs - for example, offering discounts or credits to customers who reduce consumption at critical times, something that depends on smart metering and consumer communication systems. Internationally, there are already examples: in the US, some utilities offer hourly tariffs linked to the spot price in real time; in Europe, Spain has adopted an hourly market-indexed tariff for small consumers. Successful implementation requires not only technology, but also regulatory change to allow these tariffs and ensure that the distributor's remuneration structure remains adequate.

Regulation for DERs and Aggregators - As DERs proliferate, the regulator will have to create or adjust rules for their efficient integration. In the medium term, regulations are expected on **technical standards for connecting DERs** (e.g. mandatory smart inverters with frequency/voltage response capability), **models for** distributed resource **aggregators** (companies that group together small generations and loads to provide services to the system), **standards for microgrids** connected to distribution networks, etc. The distributor should get ahead of these discussions, perhaps by taking part in regulatory pilot projects (such as regulatory *sandboxes*) to test DER control schemes via DERMS. A clear objective is to prevent the high penetration of distributed resources from negatively affecting the quality of service - and this can be addressed with new rules and with systems such as ADMS/DERMS that the company implements.

Adaptation of Tariff Models - With digitalization, the distributor's cost and investment structure changes (investments in IT, communication, cybersecurity, etc.). The company must talk to the regulator to ensure that the **tariff/remuneration models** take these new investments and benefits into account. For example, justify the efficiency gains made in the tariff review processes (reduction of losses, optimization of staff) and propose sharing these benefits with consumers, while guaranteeing resources to continue investing. Regulators around the world have adopted mechanisms to encourage innovation - *output-based regulation* - by remunerating utilities for achieving performance targets (e.g. reducing the duration of outages, integrating X MW of distributed renewables) rather than just remunerating assets. In the medium term, the company must be prepared for a more performance and innovation-oriented regulatory environment.

Data Protection and Privacy - With millions of pieces of data being collected (each customer's hourly consumption profile, for example), **privacy** issues become even more relevant. Strict customer data protection policies must be in place, communicated transparently to regulators and consumers. In addition, compliance with future national cybersecurity regulations for critical infrastructures may be required, something that is already being outlined in European countries and the US, imposing minimum security standards that the distributor will need to follow.

Reference Examples (Medium Term):

International: Several utilities in the US and Europe are currently implementing plans for this 3-5 year phase. In **New York (USA)**, the distribution companies (Avangrid, ConEd, National Grid, etc.) have presented plans to implement advanced systems: **ADMS in operation around 2025-2026** and **DERMS thereafter by 2028**. Similarly, **SMUD (California)**, after years of preparation, has put its ADMS and DERMS into integrated operation, and is already seeing the transition to bidirectional operation, with customers providing services to the grid (reduction of consumption on notice, use of electric vehicles as a resource, etc.) - maximizing the value of these distributed resources for all consumers. In the UK, **UK Power Networks** and other distribution operators are investing heavily in flexibility platforms and digitalization as required by the new regulatory cycle, and by 2028 a largely digitally sensed and controlled infrastructure is expected on UK networks .

National: **CPFL Energia**, one of the largest private groups in Brazil, is already signaling steps corresponding to the medium term: the partnership with Siemens foresees, in addition to the replacement of 1.6 million meters, the use of advanced *Meter Data Management* software and other solutions by 2029. This means that, according to its plans, by the end of this decade CPFL will have a large part of its customer base remotely controlled and ready for differentiated tariffs. **Elektro (SP)** and **Light (RJ)** are examples of utilities that have started network automation and ADMS projects in recent years, aiming to complete full deployments in the next 5 years. ANEEL[2]'s R&D projects, such as the smart cities pilot in Balneário Camboriú (CELESC) and the modernization of the Manaus network (then Manaus Energia), have brought important lessons that are now being converted into the expansion of real systems. Thus, in the medium term, we will see Brazilian distributors with integrated digital operation centers (SCADA/ADMS) and various digital services for consumers (consumption information via the app, proactive warnings of power outages, etc.), in line with practices already common in leading utilities.

Long Term (6-10 years) - Consolidation and Continuous Innovation

On the horizon of 6 to 10 years, the vision is to have a **highly digitalized dealership**, effectively operating as a **"Utility 4.0"**. Almost all key processes will be supported by integrated digital technologies. In this phase, the company will largely reap the rewards of previous investments in the form of greater reliability, operational efficiency, new services and business models, and the ability to adapt to future challenges (regulatory changes, environmental demands, etc.). At the same time, it is a phase of **continuous innovation**, as technologies emerging today could be mainstream in 10 years' time, requiring the distributor to constantly learn and reinvent itself.

Priority Technologies and Solutions:

[2] ANEEL – Brazilian Regulatory Agency

100% Sensorized and Automated Network - Achieve practically **100% coverage of** smart metering and automation in the network. All consumers have state-of-the-art smart meters (possibly already **second generation**, replacing those installed in the previous cycle), enabling near real-time measurements and full remote control. The utility's **telecommunications infrastructure** is robust and ubiquitous, combining dedicated long-distance networks, private 5G, low-power IoT, etc., connecting **thousands of sensors and actuators** in the field. As a result, the system is operated in a **complete** and current *real-time* **digital framework**, with full visibility of the state of the network in each transformer and branch. Automatic control algorithms (many embedded in the field devices themselves - *edge computing*) manage voltage, redirect power flows and isolate faults in seconds without human intervention.

Optimized Large-Scale DER Management - With the massification of distributed resources (rooftop solar generation, residential and commercial batteries, electric vehicles with *vehicle-to-grid*, demand response for smart appliances, etc.), **DERMS** becomes a central part of the operation. In the long term, the DERMS will be fully integrated into the ADMS, functioning almost like a distributed "brain" that coordinates **tens of thousands of resources** for the mutual benefit of the grid and customers. For example, on a peak load day, DERMS can command hundreds of vehicle batteries to inject power into the grid or adjust thousands of thermostats via price signals, relieving critical substations. These distributed resources, now numerous, effectively operate as **extensions of the infrastructure -** customers and utility interact dynamically. SMUD has described this transformation as moving from a unidirectional system to a fully active bidirectional one, where **ADMS + DERMS maximize the value of connected distributed resources**. In Brazil, distributed generation is expected to reach dozens of GW installed over the next decade, so in the long term, the distributor acts almost like an **orchestrator of a large "virtual power plant"** spread across roofs, batteries and vehicles in its area.

Integral Digital Twin and Autonomous AI - The grid's digital twin reaches its peak: a **unified digital model of the entire distribution system**, updated in real time and connected to decision-support AI systems. Everything that happens in the field is reflected in the digital twin immediately, and **continuous predictive simulations** take place - for example, predicting the impact of connecting too many EV chargers in a given neighborhood, or assessing the best reconfiguration of the network in the face of a storm forecast. AI evolves from auxiliary to **autonomous** in many cases: intelligent agents can take operational actions without needing direct human command, within defined limits and policies. For example, an AI agent can identify degradation in a voltage regulator through the digital twin (by analyzing historical and operational data) and **autonomously open a work order** for preventive maintenance, scheduling it in the best possible time window. This vision of **cognitive automation** is what many utilities are aiming for at the end of the digital transformation - a highly optimized, predictive and proactive operation thanks to digital twins and AI.

Digital Platforms and New Services - The distribution company, with its core mission already digitized, can expand its operations **by** offering **new services enabled by technology**. In the long term, the utility can operate a **local energy market platform**, where prosumers and consumers trade surplus energy or flexibility services (for example, a consumer can contract a neighbor's surplus solar energy through a system managed by the distributor, using blockchain or other secure technology to record the transactions). It can also provide intelligence services: for example, providing aggregated consumption data to help cities with public policies (while respecting privacy) or helping the national operator (ONS) with granular data to improve load forecasts. In addition, the company can work on **electric vehicle charging infrastructure**, taking advantage of its network experience to implement and manage smart charging stations integrated into the system. In short, in the long term the boundary between distribution utility and energy service provider becomes blurred - adjacent business models flourish because of the available technological base.

Emerging Technologies - In 6-10 years, some technologies that are emerging today may be mature. The distributor should evaluate and incorporate those that add value. Examples: **blockchain** for reliable records of energy transactions between peers; **quantum computing** for complex optimization of networks in real time; **advanced storage technologies** (new generation batteries, supercapacitors) connected at strategic points for flow control; **adaptive response via advanced IoT**, with domestic appliances (fridges, air conditioners, boilers) adjusting consumption dynamically according to network signals without the consumer's perception, etc. The long term is therefore a phase in which the already digitally consolidated company continues to innovate and **absorb new technological waves** in order to remain on the frontier.

Organizational and Process Changes:

Digital and Multidisciplinary Workforce - By now, practically all employees are **highly digitally proficient**. Repetitive or dangerous activities are largely automated, and people's roles are focused on analysis, supervision of automated systems and customer relations. Professional profiles blend together: a field engineer uses **augmented reality** to repair equipment guided by information from the digital twin; a data analyst has a deep understanding of electrical systems, and an electrical engineer understands AI so he can train models together with the data team. The **organizational culture** values continuous learning - frequent refresher and training programs keep skills up to date with new tools. Change management becomes a continuous and natural process, as the company incorporates technological adaptation into its DNA.

Customer and Service Oriented Organization - The organizational structure can be redesigned to be **more customer and service oriented** than internally siloed. For example, cells can emerge dedicated to customer segments (residential, commercial, industrial) that bring together technical, IT and service skills to develop tailor-made solutions (such as energy efficiency projects, demand management for industries, etc.). Customer experience is central: the distributor uses data and technology to provide excellent quality of service, proactive and personalized communication with consumers (e.g. automatically alerting a customer to a consumption anomaly that indicates a possible problem in their installation). In short, in the long term the company consolidates itself not just as an energy supplier, but as an **energy partner for its customers**, taking advantage of the digital transformation to deliver added value.

Governance and Partnerships - Corporate governance incorporates permanent **innovation committees** that assess trends and direct R&D investments. The company works in strong collaboration with **external partners**: universities, startups, suppliers and other utilities globally (sharing digital best practices). **Public-private partnership** models can emerge for specific projects - for example, developing smart electricity grids in isolated rural communities, integrating local renewable generation with government support. The distributor of the future acts as part of a wider energy and technology ecosystem.

Integrated Sustainability and ESG - Over the next 10 years, environmental sustainability and social responsibility objectives are expected to be fully integrated into daily operations, facilitated by technology. The company uses its digital arsenal to optimize technical losses (reducing energy waste), integrate increasing volumes of renewable sources and contribute to carbon reduction targets. ESG indicators (Environmental, Social and Governance) are monitored and reported transparently, many of them extracted from digital systems (e.g. reduction of emissions through low burning of diesel oil in generators thanks to automation of load transfers, inclusion of low-income communities in solar generation programs thanks to digital platforms, etc.). Digital transformation therefore empowers the utility to also achieve public policy and sustainability objectives in the long term.

Regulatory and Legal Aspects:

Redefined Regulatory Business Model - In 6-10 years, the regulation of the distribution sector may undergo significant reforms to adapt to the new reality. There is a possibility of a transition from the traditional model of pure distribution to that of **"Distribution System Operator (DSO)"**, in which the company not only delivers energy, but actively manages bidirectional flows and local markets. European regulators are already moving in this direction. This would imply new responsibilities and new revenues for the distributor, for example for operating flexibility auctions or providing local ancillary services. **Performance-based remuneration** should be consolidated: quality, renewable integration and efficiency targets will be strongly linked to revenue. The company, equipped with digital systems, will be able to **meet strict quality targets** (e.g. DEC and FEC close to zero in urban areas thanks to the self-healing network) and thus avoid penalties and even earn incentives for exceptional performance.

Full Hourly Pricing and Signaling - In the long term, most consumers are expected to be on **dynamic hourly pricing** schemes. With universal smart metering, there is nothing to stop offering all customers different prices per hour (or even per half hour), possibly linked to the wholesale market or the situation of the network. There could be **nodal tariffs** (different according to location, reflecting congestion in the distribution network) or bilateral contracts between consumers and nearby producers. The distributor will have to manage this tariff complexity via advanced billing systems and with a lot of automation to ensure correct billing. In Brazil, the White Tariff is likely to evolve into an even more dynamic model as the penetration of smart meters increases. Therefore, the company will need to technically support and legally adhere to these modalities, while also ensuring that consumers understand and benefit from them.

Regulatory Integration of Prosumers - With the full consolidation of prosumers, the regulatory framework will be mature. Law 14.300/2022 will have completed its transition phase: after 2030, new microgenerators will gradually bear the costs of using the grid, and by 2045 everyone will contribute proportionally. This guarantees the financial sustainability of the distributor even with high self-generation by customers. In the long term, the company must be fully compliant with this model - for example, by charging the network tariff components on the energy injected according to the rules for each transition year, and by adapting its metering systems to record bidirectional flows with the necessary accuracy. In addition, new **aggregation services** can be regulated: a customer with battery and solar can sell capacity services to the distributor or participate in paid demand response programs - all within contracts or tariffs established by regulation. The distributor will act as a facilitator and guarantor of last resort that these resources do not harm the network and follow technical standards, reporting the results to the regulator.

Strict Cybersecurity Regulations - Given the criticality of such a digitized infrastructure, it is likely that specific cybersecurity laws and regulations for the electricity sector will be instituted by then. The distributor will have to comply with high standards of cyber protection (e.g. periodic system certifications, independent security audits, 24/7 security operation centers monitoring possible attacks). Failure to comply with cybersecurity requirements could lead to heavy penalties, since a cyber incident could cause widespread blackouts. Therefore, in the long term, the company must have **security "by design"** in all solutions - from the meter in the customer's home to the data cloud - and demonstrate continuous compliance to regulators.

Harmonization with Environmental and Energy Transition Policies - Finally, long-term regulation will align distributors' operations with national energy and environmental policy objectives. For example, if the country adopts robust emission reduction or transportation electrification targets, distributors may be called upon to contribute - either by facilitating EV charger connections, or by investing in end-use efficiency projects, etc. There will possibly be **regulatory incentives for carbon-neutral networks**, or for sustainability initiatives (such as reducing technical losses equivalent to so many tons of CO_2 avoided). The digitalized utility will be able to meet these demands thanks to the refined control of its system that technology provides.

Reference Examples (Long Term):

International: Countries with advanced smart grid programs are already painting a picture of what the long term will be like. In **Italy**, after completing the first generation of meters, the **second generation of smart meters** is already underway, with more communication capacity and support for prosumers - and the goal is to remain a leader in the adoption of hourly charging and the full integration of renewables into the distribution network. In the **UK**, it is expected that by 2030 distribution companies will have fully assumed the role of **DSOs**, operating local flexibility platforms and interacting in real time with the Transmission System Operator to optimize energy flows at all levels. In the US, states such as California and Hawaii project that, by the end of the decade, most homes will have solar + battery + EV, requiring a **maximum** degree of **automation and distributed intelligence** to manage stability - utilities in these locations (e.g. Hawaiian Electric) are already operating "100% renewable grid" pilots in some areas. **Edge computing** technologies **and on-device intelligence** (such as photovoltaic inverters that respond autonomously to grid signals) are increasingly the norm. In short, out there the long term is already envisioned as a reality where *"every home, vehicle and appliance can be an active part of the electricity grid*" - and companies will be equipped with ADMS/DERMS, analytics and teams prepared to orchestrate this complex ecosystem

National: In Brazil, looking 10 years ahead, we should see many distributors reaching similar levels. **Enel Distribuição Ceará**, for example, has plans underway (via regulatory programs) to fully automate its networks by 2030. **Neoenergia** and **Equatorial** should significantly expand their investments in smart grids, given that both groups have already carried out fruitful pilots (at Celpe/PE and Cemar/MA, respectively) and have ambitious loss reduction and DEC/FEC improvement targets - only possible with comprehensive digital solutions. Regulations such as distributed generation and white tariffs will have been consolidated, and we will possibly have **local energy markets** in pilot operation in some regions, with distributors acting as operators of these platforms. Academics and research institutions (CEPEL, universities) in collaboration with utilities can develop **national digital twins** that integrate data from many companies, creating large-scale simulations for planning the entire Brazilian electricity system. Thus, in the long term, the digitalized Brazilian utility will be an integral part of a modernized electricity sector, supporting universalization, efficiency and sustainability policies with the help of the technologies implemented in recent decades.

Conclusion

The digital transformation of a distribution utility is a complex journey that requires long-term planning but decisive action in the short term. Divided into phases **- short, medium and long term -** it is clear that there is a logical sequence of building **foundations**, then **scaling integrations**, and finally **reaping results and innovating continuously**. Technologies such as AMI, ADMS, IoT, GIS, digital twins, AI and DERMS form the core of this transformation, but their success also depends on evolutions in the **internal organization** and a **favourable regulatory environment**.

Ultimately, the digitally mature utility will be able to offer energy with higher quality and reliability, enable active consumer participation in energy management and operate efficiently in a rapidly changing sector. Each phase of the roadmap aims to bring the utility closer to this ultimate goal: **an energy company centered on data and technology, focused on the customer and prepared for the sustainable future of energy**.

The availability of diverse and reliable energy sources serves as a fundamental catalyst for economic progress and global competitiveness, which modern societies build their industrial capabilities and technological advancement. Nations with sustainable energy resources consistently demonstrate superior economic performance enabling energy-intensive industries to flourish competitively in global markets. Access to reliable energy infrastructure directly correlates with manufacturing productivity, digital transformation capabilities, and the development of knowledge-based economies.

Sources and References:

The information and examples cited were based on studies and real cases of network modernization, including industry reports and specialized news, as indicated throughout the text, among others. This roadmap combines these references with an adaptation to the Brazilian regulatory context, aiming to offer a robust strategic guide for different levels of digital maturity of energy distributors.

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Consolidated View by Phase

To summarize the digital transformation journey described, the following table shows the **main milestones in each phase (short, medium and long term)**, categorizing them into Technology, Organization and Regulation:

Table1 - Consolidated view by phase

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Dimension	Short Term (12 years)	Medium term (3-5 years)	Long term (6-10 years)
Technology Initiatives	**AMI** pilots (smart meters in selected areas)	Massive **AMI** (most customers with smart meter)	100% **AMI** coverage (2nd generation of smart meters)
	SCADA/OMS upgrade, first automatic reclosers	Complete implementation of **ADMS** (advanced network control)	Fully **automated** and sensed network (ubiquitous self-healing)
	Consolidated **GIS** and unified databases	Introducing DERMS to manage distributed resources (pilot/limited)	**Integral DERMS** coordinating thousands of DERs and demand programs
	IoT sensors at critical points (pilot)	Automation (FLISR, VVO) on most of the feeders	**Digital twin of** the entire network. Integrated in real time
	Start of **analytics** (loss reports, etc.)	Development of feeder/substation digital twins	**Autonomous AI** assisting in many operational decisions
		AI in production (load forecasting, predictive maintenance, etc.)	New services: local energy markets, V2G, etc. operational
Organization Processes	Intensive team training in new technologies	**Data/Analytics** center of excellence established	Highly digitally skilled workforce (**converged IT/TA**)
	Creation of a **digital/data hub**	New teams and positions (data scientists, automation engineers) engineers) integrated into the structure	**Flexible**, customer-oriented **organization** and energy services
	IT-Operation Committees for Integrated Projects	Widespread innovative and agile culture (use of agile methodologies, partnerships with startups)	Continuous innovation: permanent R&D, adaptation to new technologies (e.g. blockchain, edge computing)
	First data governance and security policies defined	Decision-making guided by *dashboards* and digital KPIs	Culture of **constant learning**, frequent upskilling programs
	Executive sponsorship and clear communication of the digital vision	Field teams using mobile and integrated tools (automatic work orders)	Organizational structure possibly adjusted to the role of **DSO** (local market management, etc.)
Market regulation	Compliance with current regulations (PRODIST, etc.) in pilots	Evolution of rules to include digitization (e.g. requirement for digitization plans)	Possible transition to the **Pay for Performance** model (SAIDI/SAIFI close to zero = bonuses, for example)
	White Tariff support and first steps in hourly rates	Pilot dynamic tariffs (demand events, CPP etc), and expansion of the White Tariff	**Full hourly** pricing for all; exploration of real-time pricing model
	Processes for connecting microgeneration (net metering in force)	Structuring regulated demand response programs	Integrated Prosumers under a new regime (paying for network use in accordance with post-2029 law 14.300)
	Attention to **LGPD** and emerging cybersecurity standards	Technical standards for smart inverters and DER aggregators taking shape	Distributor acting as **local market operator** (if authorized):
	Interaction with the **Regulator** via **R&D** projects and public consultations on smart grids	Tariff model adjusted to remunerate investments in technology and share efficiency gains with consumers	Strict **cybersecurity** regulations in place, mandatory compliance
			Alignment with electrification policies (e.g. EV infrastructure, renewables targets)