From the COVID-19 Crisis to Resilience: Tools for Actors in the Energy Sector in Latin America and the Caribbean

Inter-American Development Bank's Infrastructure and Energy Sector

IDB

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Abbreviations

ADMS Advanced Distribution Management System
AMI Advanced Metering Infrastructure
BESS Battery Energy Storage System
DER Distributed Energy Resources
DRM Disaster Risk Management
EDC Electrical Distribution Companies
ENS Energy Not Supplied
ERM Enterprise Risk Management
ES Energy Storage
IADB Inter-American Development Bank
LAC Latin America and the Caribbean
MV Medium Voltage
PNRRD National Policy for Disaster Risk Reduction *[Política Nacional para la Reducción del Riesgo de Desastre]*
RPG Regional Public Goods
SDG Sustainable Development Goals
SENAPRED National Disaster Prevention and Response Service *[Servicio Nacional de Prevención y Respuesta ante Desastres]*
SINAPRED National Disaster Prevention and Response System *[Sistema Nacional de Prevención y Respuesta ante Desastres]*
SMEs Small and Medium Enterprises

Acknowledgments

This report is part of the knowledge agenda developed by the Energy Division of the Inter-American Development Bank. The agenda aims to create new knowledge products and technical assistance programs for the countries of Latin America and the Caribbean. The knowledge products are designed to inform, guide, and offer a range of recommendations to policymakers and active participants in energy markets, including consumers, utilities companies, and regulators. The report was prepared under the overall direction of Marcelino Madrigal, Chief of the Energy Division. Leading the work team is José Luis Irigoyen. The main authors of the report are Juan Pablo Brichetti, Juan Carlos Cárdenas, and José Luis Irigoyen. The team would like to express their gratitude to Lenin Balza, Yuri Dalto and Gabriela Montes of the Inter-American Development Bank for their comments and review.

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Preface

Support for regional integration and cooperation are fundamental aspects of the Inter-American Development Bank's (IDB or the Bank) development mandate. Article I of the IDB Statute states that the Bank's purpose is to **"contribute to the acceleration of the process of economic and social development, both individually and collectively."**

In line with this institutional mandate, the IDB established the Initiative for the Promotion of Regional Public Goods in 2004. The RPG recognizes that LAC countries face development challenges that can be more effectively and efficiently addressed through regional collective action and cooperation. Over the course of nineteen annual public calls, the Bank has selected and funded nearly two hundred projects that fostered collaboration among countries to devise regional development solutions. As part of this process, partnerships were formed with institutions and organizations, from within and outside the region, to enhance the regional decision-making process on various social, institutional, sustainability, commercial, and regional infrastructure-related issues.

The products featured in this publication are part of a successful project financed by the Initiative. The project named **"From the COVID-19 Crisis to Resilience: A Toolkit for Actors in the Water, Sanitation, and Energy Sector in Latin America and the Caribbean"** seizes challenges such as the pandemic and transforms them into an opportunity for strengthening peer-to-peer learning. This is achieved through the exchange of good practices and lessons learned in the areas of preparedness, prevention, and risk management within the region. The collective action of the participating countries not only results in the creation of an open application toolbox that can be utilized by any interested country but also contributes to the adoption of shared standards and of quality across the involved nations.

IDB's commitment to supporting effective regional integration in LAC is demonstrated through simultaneous investments in integration software, such as policies and regulatory frameworks, and hardware, such as infrastructure. This highlights the significance of cooperation between countries as a cornerstone of integration, showcasing its benefits. It is thus both a mandate and aspiration of the Bank to continue acting as a strategic partner for cooperation among its borrowing member countries. This includes the transfer of knowledge, technology, and the collective creation of solutions to address various development issues.

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The energy sector played a crucial role in mitigating the impacts of the COVID-19 pandemic crisis. It not only ensured the provision of electricity to hospitals and households but also facilitated the operation of communication and technology services, enabling people to carry out their daily activities while adhering to social distancing measures. However, the pandemic posed significant challenges to the operation and sustainability of energy services in the region. There were changes in demand, difficulties in performing system maintenance and operational activities, and an increase in unpaid bills, leading to a decline in revenue and putting the financial sustainability of operating companies at risk.

In response, various actors in the sector, including policymakers, regulators, service providers, and users, proposed and implemented actions to ensure uninterrupted access to energy services for the population. The Regional Public Good (RPG) initiative, named **"From the COVID-19 Crisis to Resilience: A Toolbox for Actors in the Water, Sanitation and Energy Sectors in Latin America and the Caribbean (LAC),"** emerged as an opportunity to systematize best practices and lessons learned. It aimed to consolidate knowledge sharing among peers and enhance the capacity for preparation, prevention, risk management, and ultimately, improve the response capacity to disasters, of participating countries in the sector, in a more efficient and effective manner. As a result, the RPG initiative successfully consolidated the efforts of seven LAC countries, Bolivia, Chile, Costa Rica, Ecuador, Guyana, Honduras, and Panama, in the creation of the "Energy: From the Covid 19 Crisis to Resilience" Toolbox. This toolbox is available on the Energy HUB.

Resilience in the energy sector encompasses the capacity of the system to withstand and rapidly recover from various disruptions, including natural disasters, cyber-attacks, fuel supply disruptions, or equipment failures. Throughout these challenges, the energy sector must continue providing essential services to customers. The RPG has played a crucial role in conducting studies aimed at enhancing resilience in beneficiary countries, preparing them for future catastrophic events. These studies primarily focus on leveraging new technologies to diversify the energy mix, incorporating non-conventional renewable energy sources, storage solutions, digitalization of marketing activities to facilitate business operations and assessment of risk and emergency response plans.

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Executive Summary

The outbreak of the COVID-19 pandemic and the resulting containment measures presented a significant challenge to the global economy, particularly affecting sectors involved in providing public services. It became evident that these sectors lacked sufficient resilience to withstand an unforeseen and unprecedented shock of such magnitude.

The mobility restrictions and shift to remote work disrupted the usual operations of public service providers. Physical meter readings became impractical, and customers faced difficulties accessing offices for procedures and bill payments. Essential activities such as periodic inspections, service cuts, and reconnections were impacted. These disruptions, along with decreased income and increased costs, led to reduced investment and reputational damage within the sector.

The study conducted on the experiences of the energy sector in the seven beneficiary countries of the RPG project named "From the COVID-19 Crisis to Resilience: A Toolkit for Actors in the Water, Sanitation, and Energy Sector in Latin America and the Caribbean" identifies three main categories of government measures implemented in response to the pandemic shock. These categories include:

1) Measures aimed at mitigating the impact on consumers, such as suspending service disconnection due to non-payment or adjusting payment methods.
2) Measures focused on mitigating the impact on distribution companies to improve their financial situation.
3) Measures aimed at promoting the use of renewable energy to reduce dependence on conventional energy sources.

The IDB has a primary objective in the energy sector: to aid in the expansion of diversified and secure access to efficient, sustainable, reliable, and affordable energy in LAC countries. By doing so, the IDB will contribute to poverty reduction, improve the quality of life, foster competitiveness, and promote development and economic growth. Achieving these objectives requires a strong emphasis on enhancing the resilience of energy services throughout the region.

This document provides a summary of proposals derived from experiences in seven case studies across the region (Bolivia, Chile, Costa Rica, Ecuador, Guyana, Honduras, and Panama) regarding the response of the electricity sector to the COVID-19 shock. These proposals aim to enhance the resilience of public service provision and improve the sector's ability to respond to unforeseen events, focusing on three main areas:

a) Planning: This involves identifying and managing potential risks that could impact service provision. It ranges from identifying critical infrastructure to enhancing communication protocols;

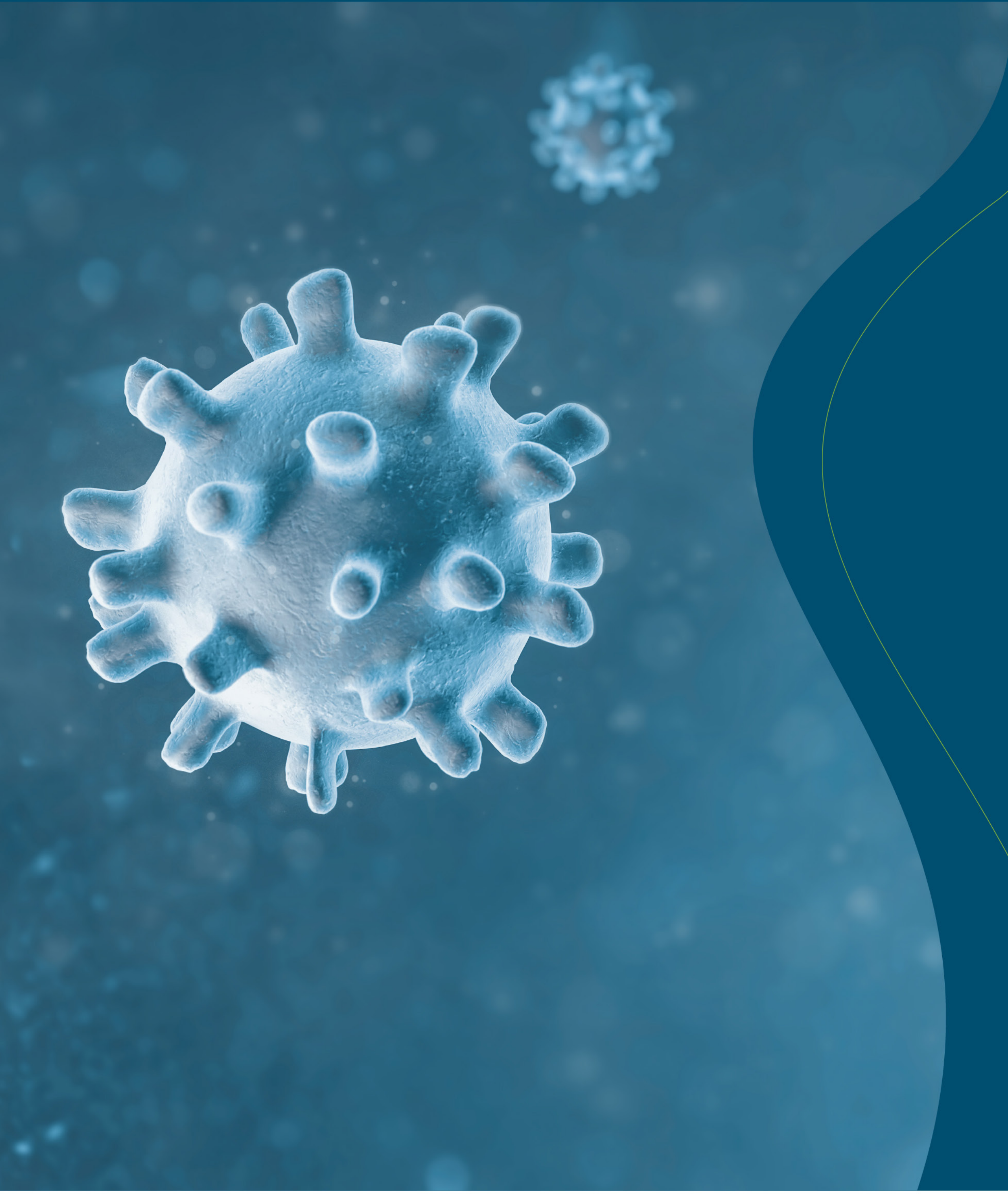
b) Digitization of services: This focuses on supporting commercial operations and management, including customer service, billing, collection, and loss control; and

c) Improvements in energy system capabilities in the region: This considers aspects such as generating new energy sources and incorporating technologies to enhance service provision.

The importance of **risk planning** is emphasized, as it involves anticipating and analyzing events that could potentially impact the organization's objectives. By being proactive and prepared, a more reliable electricity supply can be ensured, even in adverse situations. It is essential to have a well-defined risk management strategy that assigns responsibilities, promotes coordination among stakeholders, and monitors crisis situations effectively.

Additionally, greater **digitization of services** can contribute to sustaining business operations and management in relation to new mobility restrictions, not only during a pandemic but also in the face of natural disasters or other shocks. Simplifying client interactions would be a significant advancement in this area. Implementing platforms that facilitate procedures such as contract signing, claims, and requests, as well as establishing new forms of virtual interaction with users, and streamline processes with reduced response times. It is also essential to provide effective mechanisms for timely monthly bill payments. Digital meters offer advantages such as lower error margins, easy disconnections (to incentivize payment), faster reconnections, and prevention of tampering. While the cost-effectiveness of such measures must be evaluated on a case-by-case basis, less burdensome advancements can be promoted, such as allowing users to submit readings by uploading a photo.

Lastly, **improving the capacities of electric power systems in the region** focuses on achieving greater source diversification, environmental commitment, distribution stability, and the adoption of new technologies to mitigate unforeseen shocks and enhance resilience. The analyzed cases demonstrate the potential for certain regions to generate new renewable sources, making recommendations for their utilization. Furthermore, incorporating emerging technologies, such as ever-developing energy storage solutions, presents favorable options that include not only economic considerations but also technical and social factors.



1

Introduction

The COVID-19 pandemic, officially declared by the World Health Organization in March 2020, had an unparalleled global impact across various sectors. From a social standpoint, the pandemic triggered a health crisis that affected millions of people, leading to the implementation of confinement and social distancing measures to curb its spread. These measures significantly disrupted people's lives, altering their routines and adversely impacting their well-being. Notably, the impact was not evenly distributed, but disproportionately affected the most vulnerable populations.

Economically, the pandemic caused a worldwide recession, bringing numerous economic activities to a standstill and resulting in increased unemployment rates and reduced production and consumption. In LAC specifically, the GDP contracted by 7.4% in 2020. This decline was more than three times greater than the drop experienced during the 2009 Great Recession and more than double the decline witnessed during the 1983 Debt Crisis. The economic downturn in LAC surpassed that of other emerging economies and most high-income countries (IMF, 2021). Governments worldwide responded to this crisis by implementing economic stimulus measures. However, in LAC and other developing regions, the negative impact was exacerbated by limited fiscal space, making it challenging to implement countercyclical policies effectively.

The energy sector was not immune to these circumstances but faced distinct challenges linked to its unique characteristics. On the demand side, the implementation of lockdown and social distancing measures worldwide led to business closures and a reduction in industrial production, resulting in decreased energy demand from industries. However, residential demand increased significantly since more individuals started working from home and spending more time indoors. A recent report from the IDB Energy Division (Sánchez Úbeda et al., 2021) highlights that, on average, the maximum monthly reduction in electricity demand among the analyzed countries in the region was 15%. Throughout a typical modeled year, the weekly impacts ranged from 8% to 34%. During the most critical moments of the pandemic, such as April 2020, countries like Peru experienced a reduction in electricity consumption of one-third of their usual levels. On the supply side, the existing energy production capacity and electrical infrastructure were only partially equipped to handle this shift in consumption patterns. Additionally, the pandemic disrupted the energy supply chain, causing delays in the construction of new power plants and the installation of electrical infrastructure. Maintenance and repair efforts for existing infrastructure were also hindered, increasing the risk of power supply interruptions.

On a positive note, the pandemic has accelerated the transition to renewable energy sources such as solar and wind. These forms of energy have proven to be viable options in reducing dependence on oil. Governments have also implemented stimulus measures to boost renewable energy production capacity globally.

In the energy sector, the IDB aims to enhance access to efficient, sustainable, reliable, and affordable energy in LAC. This is achieved through diversified and secure approaches while contributing to poverty reduction, improving quality of life, fostering competitiveness, and promoting development and economic growth. The unprecedented shock of the pandemic has provided valuable lessons that need to be identified and organized, which will contribute to the development of tools that can effectively address future disruptive events and build more resilient energy systems. Resilient power systems are designed and managed to withstand, absorb, adapt to, and recover from potential disruptions such as system failures, natural disasters, cyberattacks, or changes in demand, quickly and efficiently. Despite adverse challenges, these systems continue to provide electricity services, minimizing disruptions to consumers and critical infrastructure. Achieving resilience in a power system requires a combination of robust design, adaptive operations, redundancy, and rapid emergency response plans. Furthermore, resilience can be enhanced by diversifying energy sources and decentralizing electricity generation. Renewable energy and decentralized generation solutions play a significant role in achieving these objectives.

In line with the goal of improving the resilience of the electricity sector in LAC based on the takeaways from the COVID-19 crisis, the IDB has undertaken the task of gathering information on the experiences of the energy sector in seven countries: Bolivia, Chile, Costa Rica, Ecuador, Guyana, Honduras, and Panama. These countries were beneficiaries of the RPG initiative titled "From the COVID-19 crisis to Resilience: A Toolkit for Actors in the Water, Sanitation, and Energy Sector in LAC." The purpose of this document is to record the actions taken under these exceptional circumstances and explore how the region can better prepare for future shocks.

The structure of this document is as follows: Chapter 2 examines the experiences of the beneficiary countries in response to the pandemic shock, identifying and categorizing the main measures implemented to mitigate its impact. Chapter 3 focuses on the key areas of impact from the pandemic and provides a summary of policy recommendations related to planning, digitization, and technological advancements in the electricity system. These recommendations aim to enhance the sector's resilience in the face of potential future disruptions. Lastly, Chapter 4 presents the main conclusions derived from the analysis.

2

The COVID-19 Crisis in the Electricity Sector in LAC: Public Policies to Sustain Service During the Pandemic

One of the greatest challenges faced by governments and public and private actors in the energy sector during the COVID-19 pandemic was ensuring access to energy. This task proved to be particularly complex due to the impact of the health crisis on sector companies and the challenging economic situation faced by families and businesses. These factors threatened the payment chain, thereby jeopardizing the financial stability of energy companies and the overall sustainability of the system. The measures implemented by governments can be categorized based on their focus: mitigating the impact on consumers, companies, or promoting the energy transition.

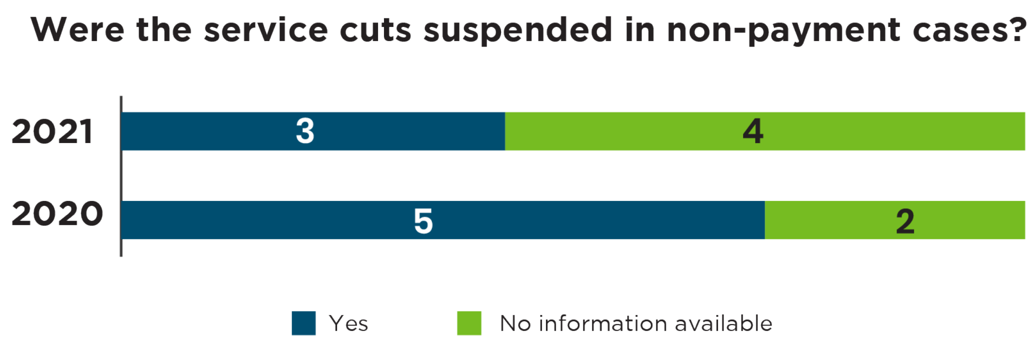
The information presented in the following subsections has been compiled using the toolkit to face future disruptive events and develop more resilient energy systems, available at the IDB Energy Hub: https://hubenergia.org/es/indicators/la-energia-de-la-crisis-del-covid19-laresiliencia. This platform provides key data that offers insights into the impact of the pandemic on the regional energy sector and the primary measures taken to mitigate its effects. Through collaboration between the IDB, the Latin American Energy Organization (OLADE by its acronym in Spanish), and the representatives of the seven countries, this work has compiled and structured relevant information regarding energy consumers, energy companies, and the consequences of this unique context on the energy transition process. The compilation was based solely on official and publicly available open data sources.

Actions to mitigate the impact on consumers

The economic crisis resulting from the COVID-19 pandemic left many consumers, including small and medium-sized enterprises (SMEs) and residential customers, struggling to cover their energy bills. To prevent power cuts and disruptions in the payment chain, several countries implemented measures to provide temporary relief. These measures included the suspension of power cuts due to non-payment, adjustments in payment mechanisms, and/or reductions in energy prices.

During the strictest period of confinement in 2020, at least five out of the seven analyzed LAC countries, Chile, Bolivia, Panama, Costa Rica, and Honduras, information was unavailable for the others, restricted distribution companies from disconnecting the power supply in cases of non-payment or delays. By 2021, as the crisis began to ease, the number of countries maintaining such measures decreased to three: Chile, Panama, and Ecuador.

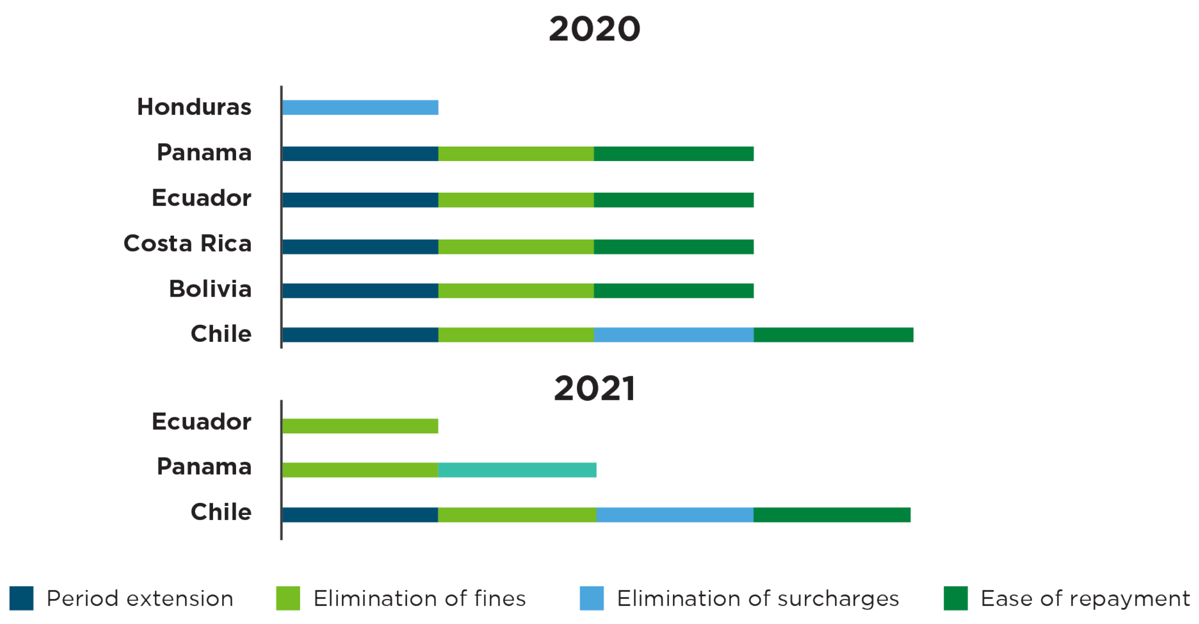
Graph 1. Suspension of power cuts due to non-payment



Source: https://hubenergia.org/es/indicators/la-energia-de-la-crisis-del-covid-19-la-resiliencia

Additionally, to address the delays in invoice payments all countries except Guyana, for which not public information is available, implemented measures to adjust payment mechanisms during 2020. These measures included extending payment deadlines, waiving fines, and implementing repayment facilities in Chile, Bolivia, Costa Rica, Ecuador, Panama. Some countries also eliminated surcharges, such as Chile, and Honduras. However, by 2021, only three out of the six countries continued with these measures, Chile, Panama, and Ecuador, with Chile being particularly noteworthy for maintaining all of them consistently.

Graph 2. Adjustment measures for payment mechanisms



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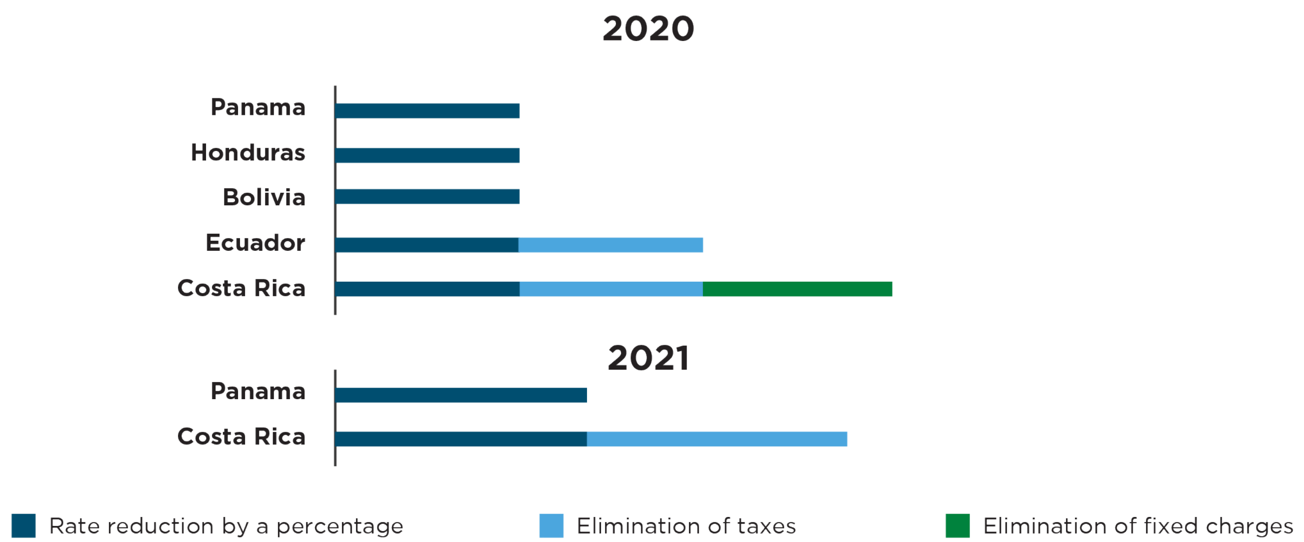
Lastly, five out of the seven countries, Costa Rica, Ecuador, Bolivia, Honduras, and Panama, analyzed implemented measures regarding the reduction in energy prices, in 2020. All of them reduced rates, and some countries also eliminated taxes, Costa Rica and Ecuador, and/or fixed charges, Costa Rica. However, by 2021, only two out of the seven countries maintained these measures, Costa Rica and Panama.
These findings demonstrate the swift response and recognition of the problem by the countries in the region, with widespread implementation of measures to mitigate the impact of the pandemic.

Graph 3. Measures to reduce energy prices



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Actions to mitigate the impact on companies

The impact on consumers, both small and large, had a ripple effect on distributors, leading to negative implications for their economic and financial well-being caused by the reduction or non-payment by many clients.

Table No1. shows that across all the countries analyzed, except for Costa Rica, there was a noticeable increase in accounts receivable (at constant 2017 prices) in 2020 compared to the pre-pandemic average, 2017-2019. Some countries experienced substantial increases of over 50%, as observed in the cases of Guyana, Honduras, and Bolivia. In contrast, Table No. 2 shows that the total income of companies (at constant 2017 prices) witnessed an average decline of nearly 5% for the same period, with Panama being particularly affected with a contraction of over 10%, while Guyana stood out as an exception increasing 6.7%.

Table 1 and 2. Variation of accounts receivable and total income of the aggregate of surveyed companies (at constant 2017 prices)

Accounts receivable

2020 vs 2017 - 2019 average

Countries	Variation
Guyana	75,0%
Honduras	65,0%
Bolivia	59,7%
Ecuador	48,5%
Panama	18,6%
Chile	2,5%
Costa Rica	-5,1%

Total income

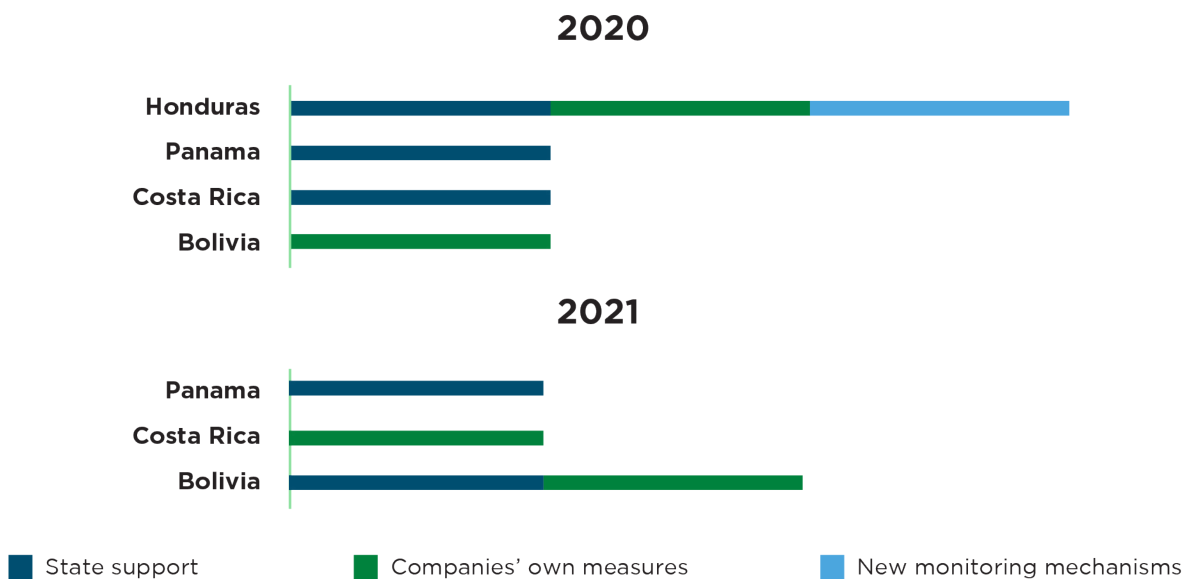
2020 vs 2017 - 2019 average

Contries	Variation
Panama	-11,1%
Ecuador	-6,5%
Chike	-5,2%
Honduras	-4,8%
Costa Rica	-0,8%
Bolivia	-0,5%
Guyana	6,7%

Source: https://hubenergia.org/es/indicators/la-energia-de-la-crisis-del-covid-19-la-resiliencia

In this context, four out of the seven countries implemented measures to support the financial stability of energy distributors. These measures included state support to restore balance in Honduras, Costa Rica, and Panama, independent actions taken by the companies to rebuild their financial position in Honduras and Bolivia, and the implementation of new monitoring mechanisms in Honduras. As of 2021, three of these countries, Bolivia, Costa Rica, and Panama, continued to maintain these measures, ensuring ongoing state support and implementing specific measures tailored to the needs of the companies. See Graph No. 4.

Graph 4. Types of measures to mitigate impact on distributors



Source: https://hubenergia.org/es/indicators/la-energia-de-la-crisis-del-covid-19-la-resiliencia

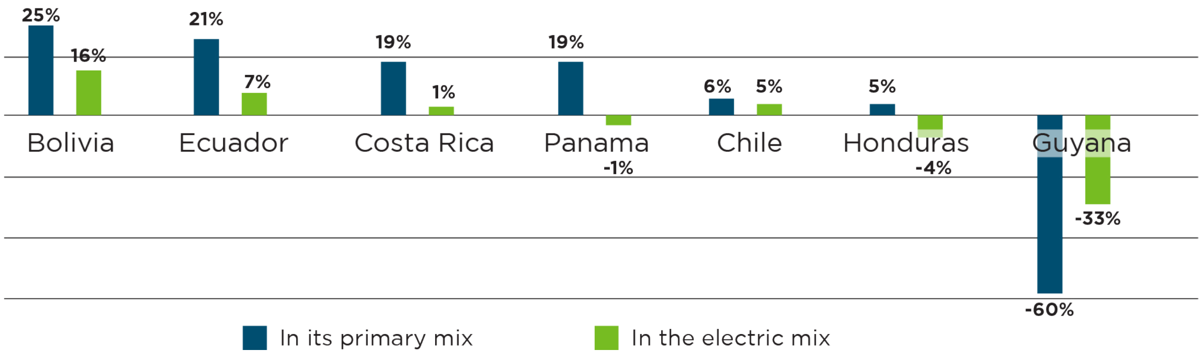
Impact of the energy transition

The COVID-19 pandemic had a positive impact on the energy transition, as it accelerated efforts to reduce reliance on conventional energy sources. There was a notable increase in the participation of renewable sources in both the overall primary energy mix and the electricity mix.

In 2020, all the countries surveyed, except for Guyana on the downside, experienced a substantial increase in their renewability index compared to the previous years, 2017-2019. This index represents the percentage of renewable sources in the global primary energy mix or electricity mix of a country.

On average, the countries witnessed a 16% increase in the participation of renewable energies in their primary energy mix, with Bolivia and Ecuador leading in relative terms. When considering the electricity mix, the average increase was 4%, with Bolivia and Ecuador demonstrating the largest relative increases, and Honduras and Panamá experiencing a setback in this regard. See Graph No. 5

Graph 5. Changes in the participation of renewable energies: 2020 vs 2017-2019 average



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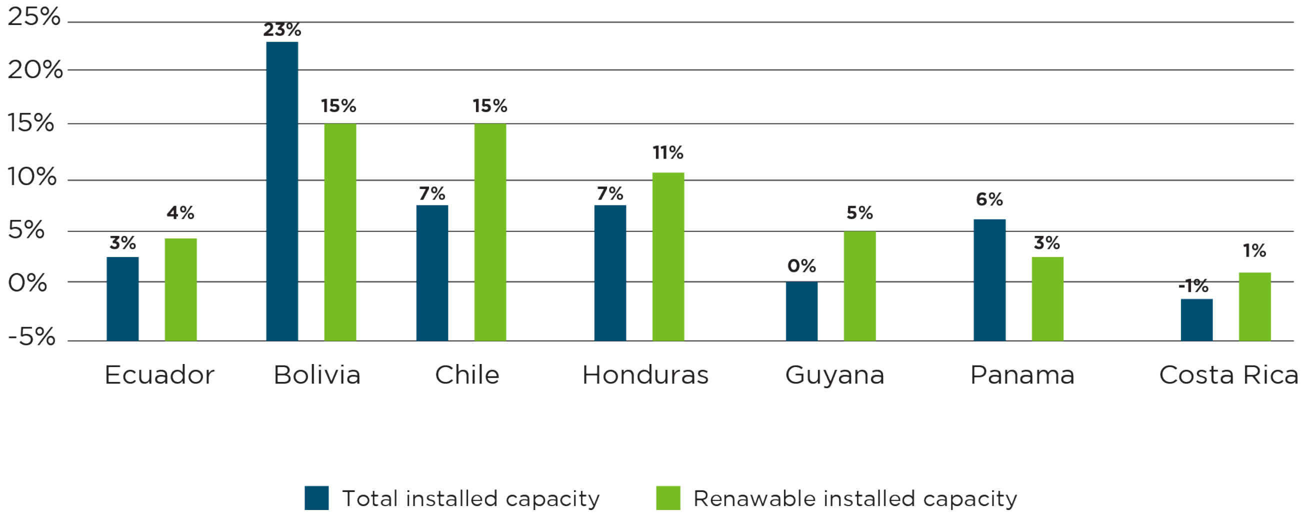
In this context, the installed capacity of both total and renewable electricity generation serves as an indicator of progress in the energy transition, and the trends align with this transition, as seen in Graph No. 6.

While Costa Rica, known for its exceptionally renewable electricity mix, maintained its installed capacity unchanged, all the other countries experienced an increase in the capacity of renewable sources. Moreover, apart from Bolivia and Panama, the growth in installed renewable capacity outpaced that of total installed capacity.

Graph 6. Changes in the installed capacity of electric power: 2020 vs 2017-2019 average in MW



Source: https://hubenergia.org/es/indicators/la-energia-de-la-crisis-del-covid-19-la-resiliencia

Finally, another important indicator that reflects the progress of the energy transition is the number of renewable generation contracts signed annually. This indicator provides insights into the changes induced by the pandemic. For instance, in Chile, which is the only country with publicly reported data, there was a notable increase in the number of contracts, with 69 contracts in 2019, rising to 82 at the beginning of the pandemic, which represents a 19% increase. The growth continued towards 2021, with a further 6% increase.

3

From the COVID-19 Crisis to Resilience in the Electricity Sector in LAC

The COVID-19 pandemic exposed the vulnerabilities of the energy sector, as it was ill-prepared to handle an unprecedented shock and its wide-ranging implications. However, this crisis serves as just one example of the various unforeseen shocks that the electricity services may encounter in the near future, including those associated with climate change and commodity price fluctuations, among other disruptive events.

The experiences of the energy sector in the seven participating countries of the "RPG: From the COVID-19 Crisis to Resilience: A Toolkit for Actors in the Water, Sanitation, and energy sector in LAC" highlight three key areas where specific measures can enhance the resilience of electricity services in the region: (a) risk planning, (b) digitization of services, and (c) improvements in the capacities of electrical energy systems, including technological advancements and the promotion of renewable energies. The following section will delve into the main lessons learned in these areas, aiming to identify potential improvements that can mitigate the impact of future shocks on electricity services in the region.

3.1. Risk Planning as a Key Element to Guarantee Service Continuity

The pandemic served as a clear demonstration of how unexpected shocks can disrupt electricity services, impacting both demand and the conditions under which these services are provided.

Risk planning plays a crucial role in addressing such challenges. It involves identifying, analyzing, and managing potential risks that could affect the provision of electricity services. This includes identifying threats like natural disasters, technological infrastructure failures, supply interruptions, and more. By anticipating these risks, providers and other relevant institutions can develop preventive strategies and measures to minimize their impact. This entails creating contingency plans, defining clear responsibilities, implementing early warning systems, and conducting emergency drills. Robust planning for various risk scenarios is vital to prevent disruptions and enhance the resilience of services in the face of shocks.

The case of Chile: "Support for updating emergency communication protocols for fuel and electricity"

Chile, with its constant tectonic activity, coastal exposure, and susceptibility to climatic events, is a country that faces significant vulnerability to natural disasters. The COVID-19 pandemic highlighted the limitations in the existing preparation to handle such a shock, underscoring the need to enhance emergency protocols and integrated Disaster Risk Management (DRM) plans, particularly concerning the provision of fuels and electricity.

To address this, a comprehensive proposal was developed to improve the protocols, necessitating a detailed examination of the regulations and the existing institutional framework. This diagnostic process was conducted meticulously. First, the review focused on the mother law (Law No. 21,364) that establishes the National System for Disaster Prevention and Response (SINAPRED by its acronym in Spanish) and the National Service for Disaster Prevention and Response (SENAPRED by its acronym in Spanish). The objective was to transform the system from an emergency-oriented approach to a preventive one. This involved forming a national and regional committee with decentralized participation from various ministries throughout the DRM cycle, including the mitigation, preparation, response, and recovery phases.

The regulatory framework analysis highlights the National Policy for Disaster Risk Reduction (PNRRD by its acronym in Spanish) developed by SENAPRED. In line with the comprehensive approach of DRM, the proposed reforms aim to provide guidance for political actions and decisions, setting short, medium, and long-term goals. These goals are designed to:

- Enhance national governance of DRM, aligning it with international standards.
- Promote prevention by improving access to information.
- Invest in risk reduction through comprehensive planning, with a focus on minimizing the impacts of disasters.
- Strengthen the coordination and collaboration among different entities involved in emergency scenarios to ensure effective responses.
- Enhance research and early warning capabilities relating to DRM.
- Plan for sustainable recovery that mitigates the creation of new disaster risks.

Furthermore, within the framework of the PNRRD, Chile has established the National Strategic Plan for the 2020-2030 period. This plan outlines the strategic actions, goals, and key actors necessary to achieve the established objectives. Additionally, the country has developed a dedicated National Emergency Plan for the energy sector, which outlines response actions for different operational phases during emergency situations. The plan aims to ensure the continuous supply of national energy through public-private coordination, based on valid sector-specific protocols. Some of the anticipated emergency scenarios include (1) events that impact the supply of liquid fuels, liquefied petroleum gas, liquefied natural gas, and network gas, (2) events that disrupt the electricity supply, and (3) emergencies that may affect the governance of the energy sector, overseen by the Ministry of Energy and the Superintendence of Electricity and Fuels.

Once the regulatory and institutional frameworks governing DRM in Chile were established, the next stage of the project involved studying international experiences in energy markets. Specifically, the focus was on the United Kingdom, Japan, the Philippines, India, and Australia, seeking to analyze their energy supply strategies, operational adjustments, tariff considerations, and adaptations to regulatory and institutional frameworks during the pandemic. This task was conducted through a documental review of plans and protocols, and interviews with key stakeholders responsible for managing energy emergencies associated with the COVID-19 crisis.

Building upon the examination of the national legislative framework and international experiences, as well as the collaborative efforts testing the protocols with the Ministry of Energy, a set of recommendations was developed for the plans and protocols to ensure the continuity of energy supply to end users during times of crisis. Some of the proposed measures include:

- **Develop a DRM plan aimed at ensuring service continuity, promoting continuous coordination among stakeholders, and implementing effective monitoring during crisis situations.**
- **Assess the response capacity of the relevant authority based on the specific situation at hand and engage collaboration from associated institutions.**
- **Establish thresholds for potential events that trigger proactive reporting by energy companies to the competent authority, ensuring the timely notification of situations that may impact energy supply.**
- **Formalize the inclusion of all communication channels used, such as WhatsApp or other messaging services, within the emergency protocols.**
- **Foster awareness among all involved parties regarding the main threats they may face and establish clear communication channels and roles for each official, ensuring that everyone understands their responsibilities in crisis scenarios. The Ministry of Energy or the designated competent authority should act as the central coordinator to facilitate an effective response.**
- **Facilitate public-private coordination to enhance governance within the sector. Encourage the participation of private sector entities in disseminating and testing the emergency plan.**
- **Update protocol sheets that assess the potential impact on other essential services, such as public schools, public transportation, and hospitals. These sheets should also evaluate the company's response capacity to determine if it can handle the crisis internally or if external support is required. Additionally, emphasize the importance of coordination with other relevant institutions.**

- **Establish strategies and investment plans in DRM that prioritize strengthening governance through infrastructure improvements, professional development, equipment upgrades, and other relevant measures.**

- **Implement mechanisms for timely and continuous monitoring of critical infrastructure, maintaining an updated georeferenced database. This database will inform the development of plans that encourage continuous private sector investment in critical infrastructure to enhance emergency response capabilities and increase the overall resilience of the national energy mix.**

- **Incorporate public and private investment plans that outline methods for maintaining future energy supply, with a focus on updating the national energy mix considering, for example, the transition to renewable energy sources.**

- **Consider the unique characteristics of different geographical areas within the country. Recognizing that threats and challenges vary across regions in Chile, it is important to promote the decentralization of plans, which should grant autonomy to regional entities to adapt the plan according to their specific realities and needs, thus ensuring effectiveness.**

- **Conduct training sessions on the plan on predefined dates and conduct regular tests to evaluate it.**

- **Conduct a post-crisis analysis to assess the takeaways, quantifying the losses and damages to the infrastructure incurred during the crisis, prioritizing the recovery of critical infrastructure elements essential to the energy system.**

By implementing these recommendations, the electricity service can be better prepared to respond to potential future shocks, minimizing their impact on the provision of electricity.

The Guyana case: "Guyana Power and Light Incorporated (GPL) – Enterprise Risk Management Policy & Framework"

GPL, the leading electricity provider in Guyana, operates in the three counties of Demerara, Berbice, and Essequibo. The company's voltage distribution system is relatively new, providing electric power with voltages in 120/220 volts and cycles of 60 Hz. With over 1,200 employees nationwide, GPL serves approximately 220,000 residential, commercial, and industrial customers.

Initially known as the Guyana Electricity Corporation, the company was entirely owned by the Guyanese government until 1999. Later, an equity partnership was established with the UK Commonwealth Development Corporation and the International Electricity Supply Board of Ireland, with ownership divided equally between the state and the partnering companies. However, this partnership did not yield the desired results, leading to its dissolution in 2003 and GPL's return to full state ownership.

Driven by an unwavering commitment to continuous improvement, GPL remains dedicated to enhancing the quality of electricity supply in Guyana, despite the inherent complexities involved in its operations. The company's background is a testament to its ability to adapt and grow, starting from the era when electricity provision in Guyana was managed by various private and community entities. Following the nation's independence in 1966, power was nationalized, eventually evolving into the modern-day GPL.

Driven by its commitment to uninterrupted service and operational efficiency, GPL works tirelessly to minimize disruptions and enhance the electricity grid's performance. The organization holds a forward-thinking vision, actively seeking to incorporate cutting-edge technologies and embrace sustainable practices. With this approach, GPL stands prepared to tackle the challenges arising from the escalating energy demand, ensuring the longevity of its operations and the satisfaction of its customers.

In collaboration with the IDB, GPL has established a new institutional framework for enterprise risk management (ERM). This framework entails the systematic application of policies and procedures to identify, analyze, evaluate, mitigate, and communicate risks associated with service provision. By adopting this framework, GPL strengthens the resilience of its services, enhancing its ability to plan and respond effectively to various operational, commercial, and reputational shocks. The newly established ERM at GPL specifically examines the protocols governing measures taken in strategy, reputation, operations, finance, health and safety, environment, and compliance with standards, assessing GPL performance.

The enterprise risk management framework focuses on four key pillars:

1

Risk strategy.
This encompasses risk appetite and risk tolerance, determining the level of each the company is willing to assume and the method employed to evaluate them. The higher the risk rating, the quicker the company will act on it. In some cases, risk acceptance may be recommended as the most suitable response.

2

Risk infrastructure.
This refers to the governance structure, which provides board-level oversight of company-wide risk management, and the operational structure, at the management level, which integrates ERM into strategic planning. This ensures that the roles and responsibilities of risk management and that appropriate technologies supporting the ERM process are well-defined. The framework can be viewed as a three-line defense system: the first line consists of management, responsible for identifying, evaluating, and monitoring risks within the organization; the second line involves officers who collaborate with the first line to ensure that the business operates within the established risk appetite, and the third line comprises internal auditors who independently verify adherence to risk management policies and procedures. Robust lines of defense are vital to facilitate the effective execution of daily risk management responsibilities throughout the company.

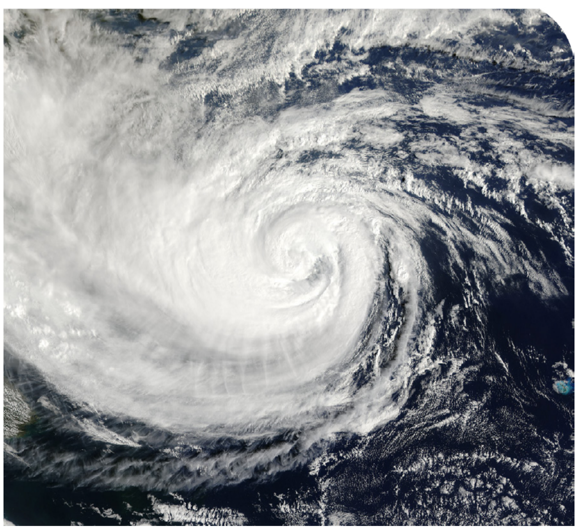
3

Risk analysis.
This refers to the processes of risk identification, assessment, response, and monitoring. Risks are identified at various levels, including the strategic level (related to strategic initiatives and objectives) and within specific departments and business processes. To ensure comprehensive coverage, the risks faced by the company are classified into six categories: 1. Strategic; 2. Financial; 3. Operational; 4. Compliance; 5. Reputational; 6. Health, Safety, and Environment. Once identified, the risks are evaluated to prioritize them based on their significance. The company assesses the probability of each risk occurring in the coming months and evaluates the potential impact if they were to occur within that timeframe. A qualitative assessment of the risks' impact on the business should be conducted at a minimum.

4

Risk culture.
This is understood as the attitudes and behaviors towards risk that are necessary to ensure adherence to the risk management policy. It involves establishing a sense of "ownership" over risks, where executive directors, department heads, and their respective teams are the ultimate owners of the risks they assume. They are held accountable for the outcomes, whether they are successes or failures, resulting from the decisions and actions taken within the company. To foster a proactive risk management approach, all staff members are encouraged to promptly report any identified risks to their supervisors. A governance system will be in place to ensure that risk information is discussed at the highest levels of the organization. Whenever possible, the company will integrate individual risk responsibilities into its performance management systems. This way, individuals will be recognized or held accountable based on how effectively they fulfill their risk management duties.

The case of Honduras: "Assessment of Vulnerability and Effects Associated with the Supply of Electric Power"



Due to its geographic position, Honduras is prone to tropical storms and hurricanes,[1] which have caused significant damage to the power generation, transmission, and distribution systems, particularly in the northeastern and southeastern regions. The growing concern of climate change, which is expected to exacerbate these challenges in the coming years, further complicates matters.

Given this context, an in-depth analysis was conducted to assess the vulnerability and risks associated with the supply and utilization of electrical energy. The objective was to develop comprehensive guidelines and adaptation measures for a climate risk management strategy moving forward.

Risk was defined as the outcome of vulnerability (the susceptibility of an element to adverse impacts), exposure to threats over time, and the likelihood of occurrence. This risk assessment considers the potential impacts of climate change, which arise from the dynamic interactions between climate-related hazards and the vulnerability of the exposed human or ecological systems. Additionally, it acknowledges the influence of human responses, considering the possibility that these responses may not achieve the intended objectives or may have unintended consequences and negative impacts on other social objectives.

1 Notably, the 2020 Atlantic hurricane season was the most active on record and the fifth in a row to exceed average activity.

After conducting the vulnerability and risk analysis, the next step is to formulate action plans aimed at preventing, correcting, and mitigating the underlying conditions that contribute to these risks. This planning process takes into consideration available resources, limitations, and the political-institutional capacity to implement the proposed measures. A set of ten initial general guidelines for action was therefore developed, which will be subjected to review and evaluation by a panel of experts in the field:

1. **Establish an effective knowledge and information management system for the electricity subsector: to enhance the planning process, promptly access information for decision-making, integrate data, and facilitate access, updating and offering reliable data.**
2. **Articulate an institutional framework for sustainable and resilient development of electrical energy: allow a unified strategy and action among all stakeholders, maximizing synergies and aligning with State policies and plans.**
3. **Risk of disasters and critical infrastructure: it is crucial to identify the elements of the national electric system infrastructure that are at risk and incorporate them into plans.**
4. **Modernize and refurbish existing infrastructure: strengthening and adapting subsector facilities, especially in high-risk areas.**
5. **Expansion of climate-resilient infrastructure: it is still necessary to integrate disaster risk considerations into expansion plans and conduct a comprehensive review of the project portfolio.**
6. **Management instruments for sustainable and resilient development within the subsector: matters pertaining to climate adaptation and disaster risk have been inadequately addressed. Therefore, it is essential to develop legislation, plans, and mechanisms that align with the requirements of climate resilience.**
7. **Financial instruments for sustainable and resilient development of the subsector: they should be flexible and adapt to the evolving financial needs of the subsector.**
8. **Integration of flexible energy measures into the climate change adaptation strategy: increased generation capacity with firm power, loss reduction, implementation of smart grids, distributed generation, renewable energy sources, and storage.**
9. **Training on sustainable management, risk management, resilient development, and climate change adaptation: offer continuous, systematic and formal training on cross-cutting issues for sustainable and resilient development of the subsector.**
10. **Research, development, and innovation: for the subsector's adaptation to disaster risks.**

Finally, alongside the prioritized general guidelines for action, a shared condition was identified among all of them: the necessity of technical, financial, and technological capacity within the electricity subsector to effectively implement these measures. To address this specific weakness and ensure it doesn't impede the achievement of other objectives, additional actions have been incorporated.

3.2.
The digitization of services as a way to increase operational resilience

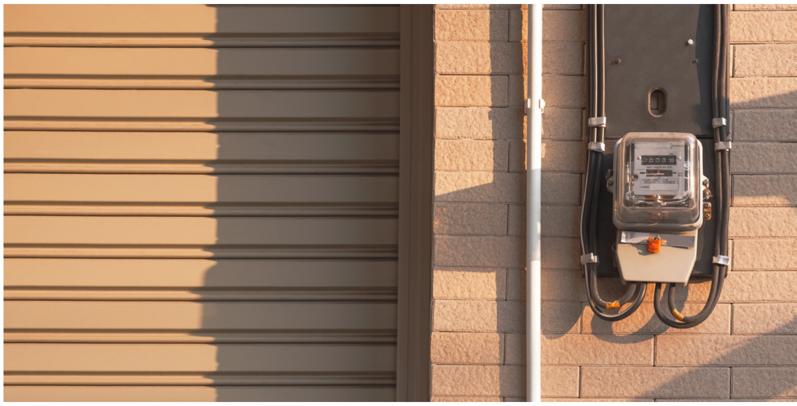
As highlighted in the DIA2020 report (Cavallo et al., 2020), the digitization of energy services has the potential to bring about transformative changes in the way these services are delivered, offering various benefits such as improved demand management and cost reductions through enhanced operational and commercial management.

The COVID-19 pandemic and associated disruptions in mobility demonstrated the significance of digital services. In countries where service digitization was sufficiently implemented, operations were sustained through remote meter readings, enabling commercial efforts such as claims handling and facilitating collection through digital invoices and payments, which otherwise would not have been possible to conduct physically.

Implementing a digitization agenda in electrical services is crucial for enhancing their resilience to unforeseen events. This digital transformation would facilitate real-time data collection and analysis, enabling early detection of failures and a swift response to service disruptions. Moreover, a digitized electrical grid can adapt more effectively to fluctuations in demand and supply, enhancing the overall efficiency of the system. This advancement also paves the way for leveraging renewable energy sources, micro-grids, and energy storage systems, all of which are vital components of a flexible and resilient electricity system. In essence, a digitalization agenda offers a solid pathway to bolster the resilience of electric services, yielding significant benefits in terms of streamlined operations, reliable service provision, and environmental sustainability.

The case of Ecuador: "Study to Modernize and Automate the Commercial Management of the Electric Distribution Companies of Ecuador"

Effective business management processes play a crucial role in enhancing service quality and building resilience against disruptions, including those caused by natural disasters that affect mobility. Commercial management involves various processes such as customer service, invoice issuance (which involves meter reading and validating the readings), and timely collection.



In countries like Ecuador, and in Latin America in general,[2] where digitalization is not widely adopted, the impact of mobility restrictions during the pandemic was particularly significant. Traditional operations that relied on face to face interactions, such as taking meter readings, conducting customer transactions for new services, claims or payments, and performing inspections by electrical distribution companies (EEDs), became impossible under the circumstances. This led to increased job stress, infections among EEDs workers, and customer dissatisfaction due to service disruptions. Remote meter readings and automated processes could have alleviated these challenges by providing alternative solutions.

2 For example, AMI penetration rates are below 10% in the region (IEA, 2022)

Furthermore, the reduced demand and collection posed additional challenges for EEDs. Many clients lost their jobs or faced difficulties in running their businesses, leading to cash flow constraints and supply chain management issues for EEDs.

The document highlights four key areas that require attention to ensure distribution companies can maintain and enhance service quality and reliability, and the financial sustainability of the electricity sector:

Customer Support

The EEDs play a crucial role in handling customer concerns, such as requests for information or new service, relocation or change of meter, suspension of service, errors in readings, etc. The greater the number of satisfied customers, the greater the collection. The document suggests implementing simple, efficient procedures with minimal requirements and response times. Transparency should also be prioritized, allowing customers to track the status of their requests through web or mobile applications. To enhance user satisfaction, specific suggestions related to digital services emerged from the Ecuadorian case:

- **Promote the adoption of Advanced Metering Infrastructure (AMI), which enables two-way communication with electricity service users.**
- **Utilize electronic platforms, such as WhatsApp and web portals, for interactive communication with users. This includes electronically signing supply contracts, eliminating the need for manual signatures.**
- **Provide an expedited repair service to address power cuts or interruptions, and proactively inform users about scheduled interruptions through digital channels.**
- **In countries with widespread smart metering, encourage the implementation of consumption schemes for smart home appliances using Internet of Things (IoT) technologies.**

Billing

During the pandemic, the suspension of meter readings and the reliance on consumption estimates posed challenges in ensuring accurate billing for customers. To address claims associated with this issue and enhance the reading-taking process, the study proposes the following recommendations:

- **Have technological tools that enable comprehensive management control of user information and business process outcomes.**
- **Strengthen monitoring and oversight of reading contractors, ensuring adherence to schedules, routes, equipment, and the competence of personnel involved. Digital technologies can greatly assist in this regard.**

- **Establish a detailed and rigorous digital procedure that encompasses the entire process of meter reading and invoice delivery.**
- **Assess the quality of billing by examining the number of invoices adjusted as a result of reading errors and issues in the billing process. Additionally, propose an indicator to measure the percentage of billing errors.**

Collection

In order to ensure payment for the energy consumed, the distribution company established collection centers and employs personnel dedicated to this task, among other measures. However, the lack of payment discipline among many users has turned the collection process into a significant challenge that needs to be addressed. This issue was further aggravated during the pandemic due to growing delays in payments, which were influenced by the inability to disconnect service, given its essential nature. The difficulties arising from collections that fail to cover the costs associated with providing the service can create financial imbalances for the distribution company, impacting other stages within the electrical service chain.

During the pandemic, the effectiveness of collection methods was hindered by the inability to enforce service disconnections and the limitations on mobility for both users and distribution company personnel. These circumstances made it challenging to prompt debtors to make payments or negotiate revised payment terms.

To improve the collection process for distributors, several key recommendations have been proposed, primarily focused on digitizing services:

- **Reducing the transaction costs associated with external payment points.**
- **Allowing readings to be conducted by either company personnel or users themselves through a simple photo upload.**
- **Promoting the adoption of digital meters, which offer a smaller margin of error compared to analog meters. Digital meters can be disconnected from the building's network, enable alarm scheduling, provide detailed parameter visualization, facilitate reconnections within a matter of hours, expedite response to failures, and eliminate the possibility of readings manipulation.**
- **Remote consumption readings are facilitated by the presence of data concentrators, which aid in the management of meters from a distance. This enables seamless communication with the central system, providing greater flexibility. The recorded data is then processed within this system, where analysis is conducted on some cases to avoid any potential inconsistencies.**
- **Offer a variety of payment methods to ensure convenient and hassle-free bill settlements for customers.**
- **Encourage the prompt delivery of digital receipts, free of charge, so that customers can receive this information electronically every month. •Proporcionar diferentes métodos de pago para facilitar a los clientes la cancelación de las facturas de servicio eléctrico.**

Control of non-technical losses

There are numerous alternatives available that leverage digital operations to effectively minimize non-technical losses, such as breakdowns or irregularities in the electricity supply to customers. These alternatives consider many aspects, including measurement, secondary systems, and information systems of distribution companies. The study conducted for Ecuador highlighted some noteworthy examples:

- **Installation of prepaid meters, enabling customers to purchase the equivalent amount of energy they anticipate consuming in advance. These meters provide consumers with timely information about their energy consumption, alerting them when a significant portion of the purchased energy has been used. Consequently, customers can then choose to acquire additional energy as needed. This approach has proven successful in reducing non-technical losses arising from commercial and billing irregularities (Frost & Sullivan, 2022). To implement this proposal effectively, it is crucial to establish multiple collection points for the prepaid system within distribution companies.**

- **The installation of macrometers enables a comparison between the total energy delivered and the energy billed. This approach empowers distributors to identify and control non-technical losses. In their study titled "Control of non-technical losses through totalizing meters," Acosta and Gámez (2006) observed an 8% reduction in non-technical losses in Venezuela following the implementation of a totalizing meter project.**

- **Implementation of AMI systems, which establish a network connecting smart meters to distributor systems. This integration allows for remote reading, disconnection of overdue accounts, tampering detection, outage notifications, and other advanced functionalities, including demand response. When combined with macrometering, AMI systems facilitate the detection of excessive demand and unmetered consumption, enabling remote identification of energy theft. Furthermore, the data provided by AMI systems enables the profiling of electricity usage, with smart meter readings analyzed to identify any irregular consumption patterns.**

- **Use of information systems. By utilizing georeferencing systems, distributors can establish a geographical connection between each customer and their corresponding secondary system, distribution transformer, feeder, and distribution substation. Simultaneously, customer information systems manage energy consumption and billing data, enabling precise energy balance calculations and the monitoring and identification of system losses. Distributors are increasingly embracing systems like AMI, which collect valuable data that aids in estimating and pinpointing non-technical losses.**

- **Across various countries in the region, distribution companies have adopted electronic channels or portals to report energy theft activities. These applications provide individuals with the ability to report such acts anonymously and through a user-friendly interface.**

3.3.
Improvements in the capacities of electric power systems in the region to increase resilience

The COVID-19 pandemic had an unprecedented impact on electricity generation, transmission, and distribution services worldwide, and poses formidable challenges to the sustainability of the sector. This crisis has brought about radical transformations in energy demand, not only in terms of consumption but also in its composition and variability. Furthermore, the disruption of global supply chains has resulted in significant delays in constructing new energy infrastructure and acquiring essential equipment and components necessary for maintaining and repairing existing electricity networks. The sector's labor force has also been profoundly affected, impacting efficiency and the ability to respond to these new dynamics. Collectively, these challenges have highlighted the vulnerability of energy systems in the face of large-scale disruptive events.

Within this context, the pandemic underscored the significance of resilience in electrical systems. Countries and power companies alike recognized the imperative to enhance the flexibility and resilience of power grids to effectively navigate crisis situations like the one experienced. A fundamental element in achieving this objective lies in the adoption of new technologies for energy generation, transmission, distribution, and storage. In the LAC region, two areas show particular promise in advancing both resilience and environmental sustainability: the integration of renewable energy sources and energy storage systems.

New sources of generation to increase the resilience of electrical systems

The adoption of renewable energy sources holds a myriad of valuable benefits for countries in the region. First, it strengthens environmental sustainability by diminishing the regional carbon footprint, combatting climate change, and safeguarding biodiversity and natural resources. Additionally, it contributes to energy diversification, reducing the reliance on imported fossil fuels and mitigating the risks associated with price volatility and availability. From a socioeconomic perspective, the growth of renewable energies fosters job creation across multiple sectors, ranging from equipment manufacturing and component production to research and technological development, thereby stimulating economic advancement. Moreover, renewable energy offers greater price stability and the potential for long-term cost reduction, thanks to its low operating expenses and cost predictability in comparison to fossil fuels. All in all, renewable energy represents a strategic pathway towards a greener, more resilient, and prosperous future.

Despite LAC boasting one of the world's most environmentally friendly generation matrices, achieving the Sustainable Development Goals requires a concerted effort to facilitate a well-planned and inclusive energy transition.
This transition entails incorporating renewable generation sources like wind, solar, and geothermal power. By embracing an orderly energy transition, the resilience of electricity services can be significantly enhanced. This is achieved by reducing exposition to energy commodity cycles, particularly relevant for countries in Central America and the Caribbean, where oil and gas prices play a pivotal role. The impacts of the pandemic and the Russian invasion of Ukraine serve as examples of how disruptive events can amplify the volatility of essential input prices for power generation. By progressively integrating alternative generation sources into energy matrices, reliance on thermal sources is diminished, thus reducing exposure to fluctuations in input costs. Consequently, this safeguards the economies of the region and shields the most vulnerable users from the adverse impacts of such price volatility.

Nonetheless, the journey towards a higher share of renewables is not without its hurdles. First, the intermittent nature of many renewable energy sources, like solar and wind, presents challenges in terms of grid stability and reliability. Addressing this requires the development of efficient and affordable energy storage solutions, the implementation of electricity demand management mechanisms to enhance flexibility, and the adaptation of regulatory frameworks to facilitate the deployment of these solutions. Secondly, existing infrastructure may require substantial upgrades or even the establishment of new grids to accommodate distributed generation and the transition to renewables. Additionally, regulatory and policy adjustments are indispensable to incentivize investment in renewables and ensure a fair playing field for all stakeholders. Last but not least, economic and financial challenges, including high initial costs and investor concerns regarding perceived risks, can pose obstacles to the transition towards a greater share of renewables in the electricity mix.

The case of Bolivia: "Data Gathering for the Start of the Solar Cadaster in Bolivian Cities to Promote Distributed Generation as a Resilience Measure of the Electric Power Service"

To attain a higher penetration of renewable energies in the electricity grid, it is crucial to assess the potential of various available technologies. In this regard, the IDB has collaborated in the development of a solar cadaster in Bolivia's four major cities: La Paz, El Alto, Cochabamva y Santa Cruz. The primary objective of this initiative is to encourage distributed generation to enhance the resilience of the electrical power service.

Solar cadasters serve as valuable tools that enable the assessment of the photovoltaic potential of individual homes or buildings. They rely on four key variables: solar radiation, effective roof area, climate variability, and roof inclination. Conducting these studies yields significant benefits, such as an improved capacity to evaluate the local renewable energy sources available, ultimately fostering the promotion and expansion of their use.

In the case of Bolivia, the study enabled the acquisition of valuable geographic information to:

- Determine the **average annual solar radiation** received by each roof.
- Identify **areas with exploitable energy potential.**
- Provide **decision-making support for urban planning,** considering energy inputs in construction or rehabilitation areas.
- **Raise awareness among property owners and investors** about the solar potential of their roofs for installing photovoltaic panels.
- Plan innovative schemes for the implementation of new projects that allow for the greater penetration of distributed generation in the main cities of Bolivia, with the aim of encouraging self-consumption and the displacement of fossil fuels.


The solar cadaster in the main cities of Bolivia (La Paz, El Alto, Cochabamba and Santa Cruz) shows that these cities have great potential to generate electricity from photovoltaic panels. The results of the study were based on the average annual solar irradiation measured in each city, which was 4.77 kWh/m2/day for Santa Cruz, 5.66 kWh/m2/day for Cochabamba, 6.29 kWh/m2/day for La Paz, and 6.52 kWh/m2/day for El Alto.

Considering the geometry and orientation of the cities' roofs, as well as other standard assumptions such as the efficiency of the solar panels used, the potential for distributed solar electricity generation in these cities is estimated to be significant. The study estimates generation capacity of 97,534.30 MWh/year in Santa Cruz de la Sierra, 148,048.43 MWh/year in Cochabamba and 274,736.61 MWh/year in El Alto and La Paz.

This solar generation potential represents a new alternative for Bolivia in terms of diversifying its energy matrix and improving the resilience and quality of the electrical system. However, to realize this potential, it is necessary to establish adequate incentives that encourage investment in solar energy projects, both from the public and private sectors.

In addition, it is essential to adapt existing regulations and regulatory frameworks, to ensure that the solar energy adoption process is carried out efficiently and maximizes potential benefits. This may involve the implementation of policies that encourage the installation of solar systems in residential, commercial and industrial buildings, as well as the simplification of administrative procedures and the creation of fiscal and financial incentives to promote investment in solar energy.

New storage technologies play a pivotal role in enhancing the resilience of electrical systems

Not only are the use of storage technologies vital for achieving higher generation levels using intermittent renewable energy sources, but they also have the potential to reduce investments required in electricity transmission and distribution networks, make decentralized systems viable and bolster the resilience of critical services, such as hospitals and drinking water pumping, by mitigating interruptions in electrical service.

However, integrating storage technologies in an economically viable manner remains a challenge. Case studies from Costa Rica and Panama prove to be valuable exercises in planning that incorporate the potential of these technologies and assesses their economic and financial viability. By doing so, these studies strengthen the resilience of essential services, especially in the face of climatic events and other disruptive circumstances.

Both Costa Rica and Panama have undertaken studies focusing on the implementation of decentralized energy storage systems. This approach emphasizes storing energy in locations near the point of consumption or generation, as opposed to relying solely on large, centralized facilities situated far from end-users. Decentralized storage enables a shift from relying solely on power transmission infrastructure for electricity delivery. Instead, it empowers power consumers and producers to possess energy storage capacity on a more local scale.

In the realm of renewable energy, decentralized storage serves as a means to optimize the utilization of renewable energy generation, including solar and wind power, which can be intermittent or subject to fluctuations due to weather conditions. It enables the storage of excess energy produced during periods of low demand and facilitates its utilization during times of high demand or when renewable generation is unavailable.

Decentralized energy storage can be achieved through various technologies, such as batteries (as observed in the aforementioned studies), thermal storage systems, supercapacitors, hydraulic storage, or even chemical storage systems. These systems have the flexibility to be installed in homes, commercial buildings, industries, or local communities. By doing so, they empower these entities to manage their energy generation and consumption more efficiently and potentially at a lower cost.

The case of Costa Rica: "Design of a pilot project to improve the resilience of the electrical distribution network through the installation of energy storage systems in Costa Rica"

The results presented in Section 2 of this report show that Costa Rica's efforts to maintain a renewable and diversified electricity matrix, added to the policies adopted and implemented through reasonable regulation, managed to mitigate the negative effects caused by COVID-19 crisis. To further progress in the transition towards clean energy sources,[3] while enhancing operational efficiency and ensuring competitive prices in the electricity supply, Costa Rica conducted a pilot design aimed at assessing the advantages associated with technological innovation and the development of distributed energy resources (DER), such as energy storage.

The study conducted outlines a pilot project profile for distribution companies interested in implementing Battery Energy Storage Systems (BESS) within one or multiple circuits. The objective is to enhance the resilience and reliability of the electrical energy supply, both in day-to-day operations and in the face of external disruptions.

Energy storage systems offer a range of services that bring benefits to both the distribution stage and end users. In the distribution stage, the following advantages are notable:

- **Decongestion of Critical Components:** discharging energy during peak periods, to prevent equipment overload.
- **Postponement of Network Investments:** when there are sudden increases in demand over short periods, the system can mitigate the problem.
- **Energy Arbitrage at the Distribution Level:** the purchase of inexpensive energy during off-peak periods, which can then be utilized during peak periods.
- **Reduction and Shifting of Demand Peaks:** flatten demand peaks by utilizing energy stored during off-peak periods.
- **Power Quality:** operational technology to regulate output reactive power based on terminal voltage, resulting in reduced voltage fluctuations.
- **Combination with Distributed Generation:** reduce the fluctuations of renewable energies connected at the distribution level and releasing part of the energy produced during peak hours.
- **Microgrids:** provide voltage and frequency regulation services, facilitate the integration of DERs into the microgrid, and ensure a reliable supply of energy within the microgrid system.

3 The electricity sector in Costa Rica has achieved a high level of participation of renewable energy sources in the generation of electricity.

For end users, the services are the following:

- **Energy Arbitrage:** End users can capitalize on variations in kWh costs throughout the day, enabling them to achieve economic savings.
- **Demand Spike Trimming and Shifting:** trimming and shifting demand spikes results in a flattened load profile and reduces demand charges for end users.
- **Participation in Demand Management and Response Programs:** conscious and voluntary actions to optimize energy usage, while response actions involve adjusting electricity demand in short periods of time to support the efficient operation of the electrical system.
- **Maximization of Own Generation:** with an energy storage system, end users can optimize the consumption of energy produced by their distributed generator. This ensures that all or most of the generated energy is consumed on-site, but at a more suitable and convenient time.
- **Backup during Electric Service Interruptions:** energy storage systems safeguard critical loads from being affected by power outages or service interruptions.

Considering these benefits, a financial analysis of the pilot project in Costa Rica was conducted. The evaluation involved assessing six different sizes of BESS based on parameters such as energy demand, BESS and maintenance expenses, current tariff data, and a 20-year timeframe. In all cases, the Net Present Value (NPV) was negative.

Subsequently, a sensitivity analysis was performed, revealing positive valuation scenarios under the following circumstances: a) simulating scenarios with a decrease in BESS kWh price[4] (2 viable scenarios); and b) simulating annual increases in the cost of electricity[5] (1 viable scenario).

Nevertheless, it is important to note that this case study emphasizes the significance of not solely relying on financial considerations when assessing a pilot project. It underscores the value of gaining insights into the technology and its capabilities to determine the technical and economic feasibility of larger-scale storage projects in the future.

Within this framework, while a pilot project provides valuable firsthand experience of the economic benefits and associated costs of the services offered, it is crucial to recognize that these costs and capacities of energy storage systems are subject to constant change. Factors such as the discovery of new materials or manufacturing methods can impact costs, and assumptions regarding income and expenses may not necessarily align with reality.

4 It is assumed that the price starts at USD 500/kWh and is reduced in steps of USD 50/kWh until a minimum value of USD 100/kWh. Two scenarios become economically viable when prices per kWh are below USD 200 and USD 150.
5 As the annual increase in the cost of electricity increases, the NPV tends to improve. An annual increase of 3% is assumed initially and when this rises to more than 12% another viable case appears.

Furthermore, from a technical standpoint, it is essential to comprehend and evaluate various operational modes, limitations, enhancements in network operations, service restoration, performance monitoring, and system degradation.

In conclusion, the results of these pilot projects offer several recommendations on various significant aspects to consider when contemplating the installation of a BESS:

A

Selection of the distribution circuit, will be influenced by factors such as energy consumption levels, demand and minimum ratio, presence of distributed generation, surplus energy, and the presence of critical loads.

B

Sizing and selection of BESS, should focus on factors such as maximum power, storage capacity, degradation rates, and battery technology. Each option comes with different costs and benefits

C

Location of the BESS, to minimize the risks associated with flooding, landslides, also avoid potential hurricane-prone areas and areas near active tectonic faults.

In the case of Panama: "Consultancy to assess the integration of decentralized energy storage for bolstering the resilience and reliability of Panama's electrical system"

The primary objective of this consultancy was to evaluate the integration of decentralized stationary energy storage systems to enhance the resilience and reliability of Panama's electrical distribution system. The motivation behind this initiative stems from the challenges posed by service interruptions experienced by end customers, primarily resulting from failures in the distribution networks.

Technological advancements in BESS have enabled their use in distribution networks, making significant contributions to the overall reliability and resilience of these networks and playing a crucial role in preventing MV networks from reaching their thermal limits, which in turn helps to defer investments in network assets. Additionally, they offer the capability to operate independently from events occurring within the distribution network, known as Dynamic Island Operation, which is a key focus of this evaluation.

Furthermore, the study conducted a comprehensive review of the legal and regulatory norms governing Panama's electrical sector. Based on this analysis, a proposal was formulated to establish regulatory measures that facilitate the viable incorporation of BESS systems, with the aim of enhancing the reliability and resilience of distribution networks, as valuable assets for distribution companies.

During the bibliographic review and analysis of international experiences concerning the implementation of BESS with batteries, several pertinent questions arise:

- **BESSs play a crucial role in promoting the environmental sustainability of electricity supply by integrating non-conventional renewable generation sources into isolated systems.**
- **The size and configuration of BESSs depend on their intended usage requirements.**
- **BESSs are primarily employed at the wholesale and distribution levels.**
- **When it comes to reliability, BESSs are primarily utilized to defer investments and reduce restoration times in case of failures.**
- **Several countries in the region, being the leaders Chile, Puerto Rico, Brazil, Suriname, and French Guyana, have made significant advancements in BESS, while others have lagged.**

Through a case analysis conducted in two distribution company circuits in Panama,[6] various scenarios were explored to evaluate the technical and economic feasibility, taking into account the eventual legal and regulatory framework. The analysis revealed the following key findings:

- **Under the assumptions analyzed, it is not technically justified to install BESS to cover an entire feeder. Instead, it is more viable to install near the load or, if feasible, in conjunction near a group of loads. This approach is justified by the infrequent utilization of a BESS at the feeder level, whereas located near specific loads or groups of loads they are used multiple times throughout the year.**
- **Considering a cost of Energy Not Supplied (ENS) at 1,875 USD/MWh[7], no BESS installation resulted financially attractive for reducing reliability costs associated with feeder interruptions, under the assumptions analyzed. However, if the ENS cost is 4.155 USD/MWh, installing BESS near the load becomes economically viable in both feeders.**
- **In both feeders, focusing on critical loads for enhanced resilience resulted in negative NPV values and a Cost/Benefit ratio greater than 1. This outcome is expected, considering the necessary storage capacity BESS requires for resilience. However, it is crucial to establish clear parameters and criteria when defining or adopting critical loads for BESS implementation. The selection process should be based on anticipated social benefits, such as ensuring healthcare services during critical moments, as demonstrated by relevant studies.**

6 ENSA 210 feeder (it is one of the longest feeders in the MV network, powered by isolated generation systems) and ENSA GAT-9 feeder (one of the longest feeders in the ENSA network. It has backup system plants at the time the protections open on the feeder)
7 Value governing in Panama.

- **Implementing BESS as an independent activity requires legal modifications. However, existing legislation and regulations in Panama do not impose limitations on the utilization of technology to enhance the continuity of electrical service.**
- **It is crucial to establish regulatory accounts to determine the expected useful life, amortization schedules, and equipment considerations for these types of systems.**

The analysis carried out in Panama only considered SAEBs as an element to increase reliability and resilience. Other services that the systems could provide were not included in the analysis, such as facilitating the incorporation of distributed generation, or reducing demand peaks, elements that could increase their financial and economic viability.

In conclusion, it can be inferred that the use of storage systems can prove cost-effective in specific scenarios. However, it is essential to reiterate, as seen in the case of Costa Rica, that economic evaluations should not be the sole determining factor. Projects with negative net present values may generate positive added benefits in the future, taking into account social considerations. Furthermore, it is important to note that the costs associated with these new technologies are continually evolving.

4

Final Considerations

During the unprecedented global crisis caused by the COVID-19 outbreak, numerous measures were implemented to alleviate the impact of the shock and ensure the continued provision of high-quality services. Following this urgent response, the realization of the need to enhance the resilience of the energy sector to better cope with potential future disruptive events became apparent. The analysis of relevant documents provides valuable guidance and recommendations that pave the way for progress in this direction.

First and foremost, the significance of **risk planning** is emphasized, wherein risks are defined as events that have the potential to impact an organization's objectives. By anticipating and identifying these risks and analyzing the shocks that could affect service provision, it becomes possible to prepare and effectively confront them, ultimately resulting in a more robust electricity supply in the face of adverse situations. It is crucial to establish a well-defined risk management strategy that assigns responsibilities, fosters coordination among relevant stakeholders, and closely monitors crisis situations.

Moreover, increased **digitization of services** can contribute to sustaining business operations and management during periods of restricted mobility, whether due to a pandemic or other unforeseen events like natural disasters. Streamlining client interactions would be a significant advancement in this regard. Implementing platforms that facilitate procedures such as contract signing, claims, and requests as well as establishing new forms of virtual interaction with users, and reduced requirements, ensuring minimum response times. Additionally, providing effective mechanisms for timely monthly bill payments is crucial. Digital meters offer advantages, including lower error margins, easy disconnections (as an incentive for payment), faster reconnections, and protection against tampering. While cost-effectiveness should be evaluated on a case-by-case basis, less burdensome advancements can be promoted, such as allowing users to submit readings by uploading a photo.

Lastly, the **enhancements in the capabilities of electric power systems in the region** are geared towards achieving a broader range of energy sources, a stronger commitment to the environment, increased distribution stability, and the adoption of new technologies to mitigate unforeseen shocks and bolster resilience. The analyzed cases highlight the potential of specific regions for generating renewable energy, warranting their utilization. Additionally, the incorporation of new technologies, which are continually evolving and experiencing significant improvements in terms of efficiency and costs, presents a favorable option. It is crucial to consider factors beyond strict economic considerations, such as technical and social aspects, when making decisions in this regard.

5

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