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NATURAL RESOURCES AND DEVELOPMENT 216

Pathways to sustainable planning for a just energy transition in Latin America and the Caribbean

An analysis of best practices in selected countries

Antonio Levy
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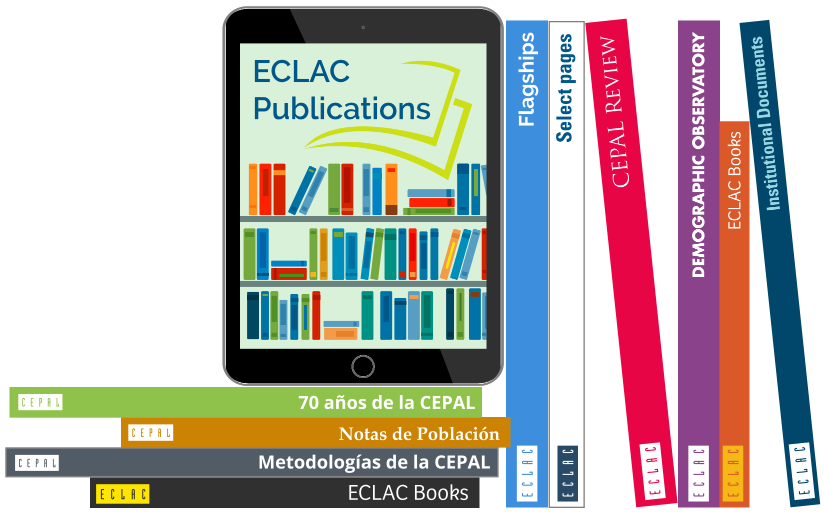

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This document was prepared and coordinated by Antonio Levy, Senior Adviser to the GET.transform programme, and Diego Messina, GET.transform programme consultant, under the supervision of Rubén Contreras Lisperguer, Economic Affairs Officer at the Water and Energy Unit of the Natural Resources Division of the Economic Commission for Latin America and the Caribbean (ECLAC) and of René Salgado from the same division. The document was prepared as part of the activities of the Regional Technical Forum of Energy Planners, which is co-organized by ECLAC and supported by the GET.transform programme under the Global Energy Transformation programme GET.pro, with support from the European Union and from Germany, Austria, the Netherlands and Sweden.

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Contents

Diagrams

List of Acronyms

ANREL	Andean Committee of Regulatory Entities and Regulating Entity for Electricity Services
CENACE	Energy Control Center of Mexico
DG	Distributed Generation
DLR	Dynamic Line Rating
FIT and FIP	Feed-in Tariff and Feed-In Premium
FOREPLEN	Regional Forum for Energy Planners
GW	Gigawatt
KWh	Kilowatt-hour
LAC	Latin America and the Caribbean
MAERCP	Andean Short-Term Regional Energy Market
OECD	Organization for Economic Cooperation and Development
RE	Renewable Energy
RER	Renewable Energy Resources
RoCoF	Rate of Change of Frequency
SIC	Central Interconnected System of Chile
SIEPAC	Central American Electrical Interconnection System
SINEA	Andean Electrical Interconnection System
SING	Interconnected Electrical System of the North (Chile)
SO	System Operator
ToU	Time of Use Fee
TWh	Terawatt hour
USD	US Dollars
VRE	Variable Renewable Energy

Executive summary

This report is part of the activities carried out within the framework of cooperation between the GET.transform programme and ECLAC for the Regional Technical Forum of Energy Planners, with the objective of providing Forum member states with relevant findings identified after an extensive process of interviews with representatives of planning institutions from selected countries in Latin America and the Caribbean. The five chapters of the study offer elements associated with recurrent practices in energy planning. Following the systematization of the information, five categories or pillars that enable a just energy transition have been established and that encompass the aforementioned elements. It is hoped that this initiative will contribute to the common understanding of the planners in the region, in order to disseminate the necessary knowledge for energy exchange between countries and eventually regional energy integration.

Introduction

The installed capacity of renewable energy has increased across the globe since the historic Paris Climate Accords (2015), with more countries adopting tender (auction) and bidding mechanisms to support international climate goals. Latin America and the Caribbean (LAC) has also made progress in fulfilling its commitment to sustainable energy. The region increased its renewability index[1] in recent years, reaching 31% in 2020 (SIELAC-OLADE, 2022). However, solar and wind energy reached 9,3% of the total electricity generation mix of the region in 2020, despite registering approximately 39% growth between 2000 and 2020. Although the region has one of the cleanest electricity generations mixes worldwide (61% from renewable energies in 2020), it is mainly influenced by large hydroelectric energy facilities in certain countries. For example, the region's renewable energy would drop to 26% total if Brazil were excluded from the overall numbers. Furthermore, if all large hydroelectric dams were excluded, the percentage of renewable energy generation in Mexico and Argentina would drop to less than 25%.[2]

Novel renewable energy initiatives assume technical, economic, and regulatory challenges, which energy planners in the region must consider to effectively incorporate renewable energy in their demand and supply forecasting models. One of the initiatives that has contributed to promoting the necessary knowledge to plan these new generation scenarios is the Regional Technical Forum for Energy Planners (FOREPLEN, for its acronym in Spanish). FOREPLEN is an international cooperation framework founded by the UN Economic Commission of Latin America and the Caribbean (ECLAC) and is strongly supported by the GET.transform program. This platform brings together planners from countries in the region to foster transnational cooperation on regional energy planning, lessons learned from past initiatives, and current best practices to support energy transformation in member countries.

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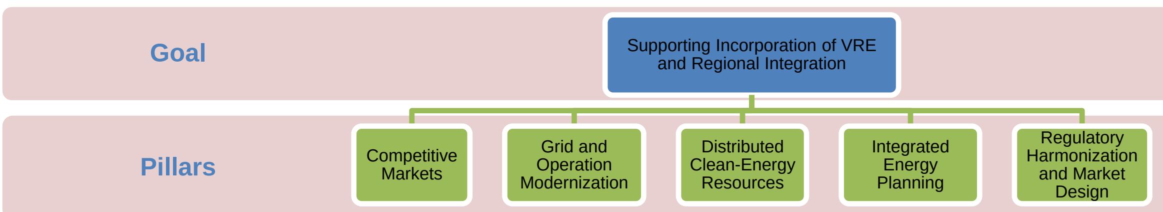
1 Defined as the percentage of the total energy supply provided by renewable primary energy.
2 Data based on statistics from the International Energy Agency (AIE, 2021) and SIELAC-OLADE, 2022).

This report presents a summary of the most relevant findings from an extensive mapping exercise of energy sector practices in the region. This report was compiled primarily through desk research and structured interviews with energy planning experts in Argentina, Brazil, Chile, El Salvador, Panama, Peru, Mexico, and Uruguay. The first goal of the study was to identify key elements of recurrent practices in energy planning. The authors analyzed strengths and opportunities for improvement and grouped them into five "macro solutions", or pillars. In sum, this document contemplates best practices grouped in five solution pillars to promote a just energy transformation in the region, as shown below: (i) fostering competitive markets to support the region's economic development; (ii) modernizing the power grid to improve power system efficiency and reliability; (iii) promoting distributed clean-energy resources to advance universal access and resilience; (iv) supporting integrated energy planning across sectors and countries to encourage renewable energies; and (v) strengthening regulatory harmonization and market design to foster regional integration.

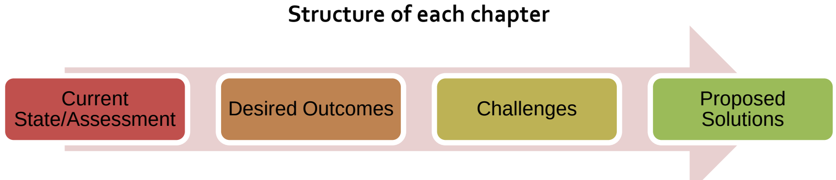
Diagram 1
Goals and pillars of this report



Source: ECLAC.

Taking into consideration these five pillars, each chapter presents and analyzes the current state of renewable energy planning in the respective country. Then, the authors consider the country's unique goals and potential challenges in furthering sustainable energy. The chapters conclude with a discussion of the linkages between current practices and the desired state and offer insight into the potential impacts of these macro solutions, as shown in diagram 2.

Diagram 2
Structure of each chapter



Source: ECLAC.

I. Fostering competitive markets that support economic development in the region

The region's economic development prospects have been affected by the global pandemic since 2020. However, RE could play an important role in resuming sustainable economic growth and aiding in a post-COVID recovery. In order to tap into the potential of RE, the region must foster an environment in which renewable energy can thrive. In other words, investment in RE will be drawn in by offering a suitable business environment where appropriate market mechanisms and remuneration play a key role in creating a competitive market. By investing in RE generation and infrastructure, there will be more efficient use of renewable resources throughout the region. At the same time, electricity systems will operate with higher levels of VRE thanks to the complementarity of different resources and geographical locations.

The projected economic growth of the region will lead to greater demand for electricity to fulfill production activities. With this in mind, countries will need to plan and finance infrastructure projects in the next 15 to 20 years to supply the expected growth in energy demand. According to the Atlas method, which classifies countries according to their income level, per capita electricity consumption in LAC is only 25% of the average consumption of high-income countries: 2,158 kWh vs 8,929 kWh,[3] respectively. Hence, if the region experiences a rise in electricity demand following the trend in higher-income countries, important changes to the energy sector will be needed. According to estimates by the Inter-American Development Bank, power needs are projected to increase and reach 2,874 TWh by 2040 (in 2018 they were 1,600TWh), which means an additional demand of almost 1,300 TWh.[4] This projection accounts for about 18 times the production of the largest hydroelectric plant in the region and the second largest worldwide, the Itaipú dam in Brazil and Paraguay (Balza, Espinasa, & Serebrisky).

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3 From the energy and balance statistics of non-OECD countries of the International Energy Agency (AIE, 2021).

4 It is estimated that by 2040, 41% of the energy will come from water sources, 32% from non-renewable thermal (mineral carbon, diesel-fuel, and natural gas), 24% NCRE and 3% nuclear (OLADE, 2020).

Renewable generation resources are widely dispersed throughout the region, with generation centers spanning large territories often located in low-population density areas. These conditions require high investment in transmission infrastructure installed over long distances, which, in turn, leads to greater transmission losses. It is worth noting that the region has exceptional renewable resources in multiple areas which could be used more efficiently if system integrity is strengthened, and a power market is promoted at the regional or subregional level.

The complementarity of resources among countries in the region and the possibility of balancing higher levels of VRE over vast geographical areas would contribute to more efficient distribution, transmission, and generation infrastructure. It would also contribute to the potential development of an electricity market at regional or local level. Creating such a market would relieve countries from making large investments in energy infrastructure. For example, the Andean region has high rates of solar radiation, Patagonia in the Southern Cone has strong wind potential, while the Amazon rainforest and Central America have large watercourses. This diversity in resources could complement each other naturally, satisfying daily power supply and demand.

Another relevant precedent to consider for improving renewable energy development in the region are high electricity costs and the high cost of subsidies.[5] LAC invests almost fifteen times more in energy subsidies than developed countries (0.7% vs 0.04% of regional GDP, respectively),[6] demonstrating that keeping energy prices low comes at a high cost for individual countries. Although subsidies can be an effective redistribution tool, if poorly designed they can lead to the excessive and inefficient use of resources and disincentivize RE initiatives.

Meanwhile, there are countries in the region that have very high tariff rates compared to other. An Osinergmin study on electricity rates from 14 countries in the region revealed that the residential tariff in Uruguay was similar to the European average, but 8.5 times higher than that of Paraguay in the fourth quarter of 2021 (21.3 versus 2.5 USD cents) for a monthly consumption of 125 kWh.[7] Similarly, in the commercial and industrial sectors, electricity tariffs were approximately 3 times higher in Uruguay than in Paraguay where government subsidies are present (15.6 vs 4.74 USD cents commercial rate, and 10.24 vs 4.21 in industrial tariff,[8] respectively). For this reason, the industrial sector is fundamental to creating the conditions conducive to investment. Chile, for example, allows customers to negotiate tariffs when their consumption exceeds 500kWh.[9]

Therefore, a power sector with competitive markets and regional integration that increases the technical and economic efficiency of the system will bring about more competition for commercial and industrial activities, fewer end-user costs, and lessen the need of state subsidies.

One short-term solution would be a competitive electricity market designed to increase VRE share in the power grid, thus reducing wholesale electricity prices. Diagram 3 below shows eight key elements to establishing competitive markets. These key elements have been used to identify regulatory, operational, and planning practices in each country. Indeed, they help generate competitive RE markets and economic development in the region (the definition for each of the elements is outlined in "Definiciones del Sector Eléctrico para la Incorporación de las ERV y la Integración Regional en América Latina y el Caribe").[10]

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5 Based on data from the International Monetary Fund (IMF, 2015).

6 Idem.

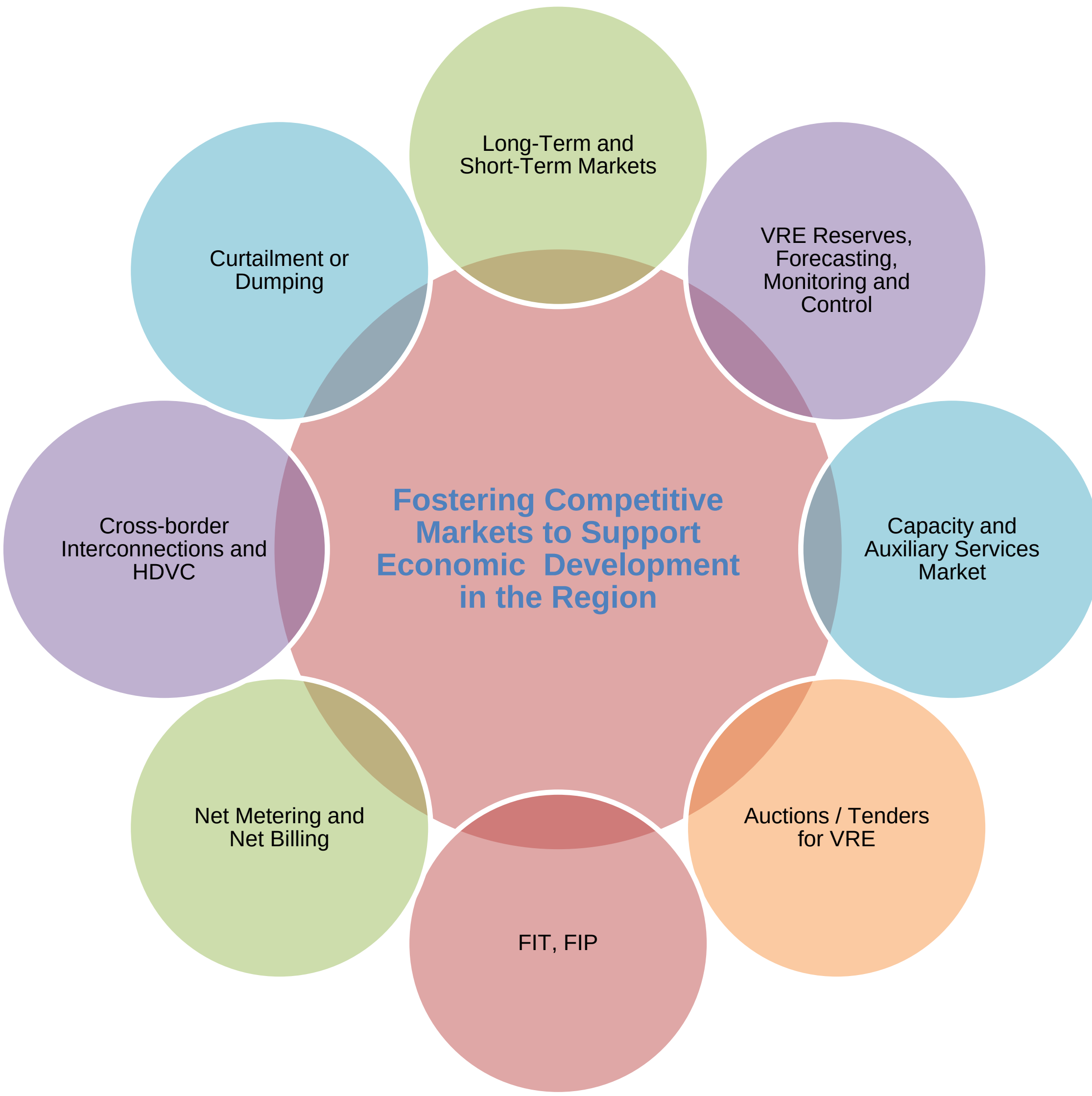
7 Based on data from Eurostat and OSINERGMIN (eurostat, 2020) (OSINERGMIN, 2022).

8 Commercial tariffs corresponding to monthly consumption up to 50,000 kWh, while industrial tariffs correspond to consumption between 50,000 kWh and up to 500,000 kWh.

9 Based on data from OSINERGMIN in Peru (OSINERGMIN, 2022) and the International Monetary Fund (IMF, 2015) .

10 "Definitions from the Power Sector for the Incorporation of Variable Renewable Energy and Regional Integration in Latin America and the Caribbean" (Levy, Antonio, et al., 2021) – editor's translation. Herein referred to as the "Definitions Document".

Diagram 3
Elements to promote competitive renewable energy markets and regional integration



Source: ECLAC.

In the long-term, both contracts and tender operations have been widely implemented throughout the region to stabilize prices and promote investment in new capacity by ensuring energy supply. Meanwhile, the **short-term market** helps respond to the inherent variability of VRE sources. One solution to consider is shortening the time period known as "gate closure time", which would allow for more accurate generation forecasts, take maximum advantage of existing generators in the system, and reduce the need to implement **reserves**. An example of a short-term market in the region is the SIEPAC regional electricity market in Central America. The remaining markets in the region are limited to the participation of certain agents, or they have declared an intention of integrating them in the future. Finally, as VRE participation grows, the VRE **capacity credit** will ensure a more efficient sizing of the system's firm capacity needs. Likewise, the **capacity market** will ensure the adequacy and viability of resources, contributing to firm capacity. Argentina, Uruguay, Panama, and Mexico have experience with this type of market, where generators receive capacity payments. Peru and Brazil are weighing the possibility of introducing this market. Experts recommend that countries in the region continue to promote this type of market and review its payment structures to ensure viability. In the same vein, **ancillary services markets** help manage the uncertainty and variability of the VRE.

The introduction of VRE requires adequate remuneration mechanisms for their generation particularities, depending on local conditions and desired level of engagement. Countries can apply different economic remuneration instruments to this end. These instruments are described below, according to selected elements from the Definitions document.

Tenders (auctions) and/or biddings are effective instruments for large-scale incorporation of VRE because they limit participation to specific technologies, timeframe blocks, or certain areas of difficult access. The region demonstrates global leadership in developing renewable energy auctions. Examples include Brazil's Incentive to Alternative Sources Program (PROINFA)[11] and RER bidding calls in Peru, uniquely developed for biddings in isolated areas. In Chile, experts have designed conditions to direct or guide the tenders towards fulfilling goals such as greater competition and diversification. The 2013/03 tender introduced the concept of "hourly blocks" in which days are divided into three eight-hour blocks, thereby directed at incorporating VRE's in the tenders (CNE, 2017).

At medium scale, the **Feed-In Tariff** (FIT) is often used to promote VRE by offering a stable income guarantee to potential developers. The **Feed-In Premium** (FIP) arises as an alternative to the FIT that encourages production growth, but also exposes renewable electricity producers to market risks. For example, Peru defines FIP solely for power generated from Renewable Energy Resources (RER). Recommendations for the design of an appropriate FIT or FIP are mentioned in the Definitions document along with some examples of its application in different countries of the region.

At the end-user level, there are mechanisms for trading in renewable electricity such as **net metering** or **net billing**, both of which are present in the region. For example, net metering is used in Brazil and Panama for distributed renewable generation, and in Peru for distributed microgenerators. Beyond these country-specific mechanisms, their design considers local circumstances and incentivize distributed generation development in a safe and sustainable manner for the system and its participants.

Regional integration, through **interconnections** between countries/markets, would increase interest in the development of the sector as it would enable **cross-border commercial energy exchange**, optimize generation costs, avoid VRE curtailment, and/or provide reserves at critical times for the system, within the context of VRE growth and development of competitive markets. To achieve greater regional integration, countries need infrastructure development to facilitate energy transfer. One of the main technological solutions to this last point is the development of **HVDC** transmission lines and converter stations.

A good example is Brazil, a country that has an electrical system with one of the highest incorporations of HVDC technology, with the three longest HVDC transmission lines in the world. One of these lines is the XRTE (Xingu – River Energy Transmitter) with the capacity to transmit 4,000MW along a 2,540km stretch between Belo Monte and Rio de Janeiro.[12] Chile, on the other hand, has managed to install renewable energy production in the north of the country with an HVDC interconnection between the former Norte Grande Integrated System (SING) and the Central Integrated System (SIC),[13] which are now integrated as one. In addition, HVDC technology allows the interconnection between asynchronous systems such as Uruguay or Brazil's.

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[11] Program created by Law 10,438/2002.

[12] Published in the EFE Agency about official information of the State Grid Brazil Holding (EFE, 2019).

[13] Published by Comisión Nacional de Energía (Chile, 2017).

Another relevant factor for interconnections is the development of regulatory, legal, technical, and commercial frameworks that facilitate the import/export flow between countries at the regional level. In this area, the MER-SIEPAC and MAER markets have extensive experience in terms of regulations, framework agreements, and mechanisms for trading valuation, which could be applied in other areas in the region if appropriate frameworks are in place. However, it is important to carry out preliminary analyses of how incorporating new interconnections may affect the system in the country or countries integrating the grid.

The intermittency and variability associated with VRE generation, as well as its greater level of decentralization, are among the fundamental aspects to be addressed in modern electrical systems so as to achieve high penetration of VRE technologies in the generation mix. There are different actions that the SO (system operator) and different participating agents can carry out to mitigate the effects of the VRE's intrinsic characteristics, such as **VRE monitoring, forecasting, prediction,** and curtailment control. Each of these measures is outlined in detail in the Synthesis Document.

Although the easiest systems to implement have decentralized forecasting, which are therefore the most common, centralized forecasting for electrical systems with multiple VRE generators has important advantages as it offers greater consistency and robustness by mitigating uncertainty and the need to schedule reserves. In Latin America and the Caribbean, most of the electrical systems are decentralized (Mexico, Brazil, Panama, Peru, and El Salvador), but there are also centralized systems such as in Uruguay, Chile, and Argentina. One of the best practices for centralized systems is to validate the forecast with more than one model to lessen the chance of bias by a single forecast.

Besides validating the forecast with more than one model, the region is conducting **VRE monitoring and control**. However, its application and demand vary between countries according to the plant size. As distributed generation increases, it would be important to review the size of power plants from which monitoring and controllability is performed in order to reduce **curtailment** in the grid.

Table 1 offers a summary of strengths which include enabling conditions for achieving competitive renewable energy markets, along with an assessment of aspects to improve upon at the country-specific level.

Table 1
Strengths and weaknesses identified at the regional level

Strengths (highlights from individual countries)	Weaknesses and assessment (at the regional level)
Long-term market widely disseminated in the region	Inexistence of market for ancillary services
The most developed short-term market in the region is the SIEPAC market	Need to develop a regional regulatory, legal, technical, and commercial framework to promote and make electricity exchanges (imports and exports) smoother between countries
LAC has experience in capacity markets	VRE forecasting is mostly carried out through decentralized systems
Global leadership in renewable-energy bids in Brazil with the Incentive for Alternative Sources Program or Peru with bids in isolated areas	
Brazil has the longest HVDC transmission lines in the world	
With HVDC SING-SIC interconnection, 99% of renewable production can be injected placed into the system	

Source: ECLAC.

II. Modernizing the power grid and its operation to improve power system efficiency and reliability

Inefficient and obsolete electricity infrastructure poses a challenge for the expected increase in demand for a clean energy transition. Modernizing the grid, along with greater integration of distributed resources and **demand integration**, are key to make efficient use of electrical resources, because it could mitigate the costs associated with the required transformations.

Losses in electricity transmission and distribution systems are due to technical inefficiencies, physical issues, and non-technical factors, such as administrative errors, measurement anomalies, self-connected customers, or energy thefts in distribution grids. During 2019, the average electricity loss in the region was approximately 15%, considerably higher than the global estimated average of 8%.[14] This leads to a decrease in effective technology and development (T&D) capacity and reduced revenue from unbilled consumption, which ultimately means an increase in energy supply costs. If distribution systems accounted for and identified the origin of losses through intelligent systems, operators could put measures in place to mitigate such losses.

Without modern and efficiently-operated infrastructure, coping with the increase in electricity demand and integrating greater sources of VRE will not be possible. To meet the demand, the region's electrical systems will have to install approximately 230 GW of additional power and 15 GW in transmission capacity. Much of this generation capacity (power) is expected to be generated by VREs, either at a large scale or through **distributed resources**. Therefore, the region faces the challenge of renewing its electrical infrastructure, modernizing its operation to enable these transformations, and maintaining, or even improving the quality and reliability of the electricity supply.

Diagram 4 indicates key elements that contribute to achieving greater efficiency and reliability in managing electrical resources.

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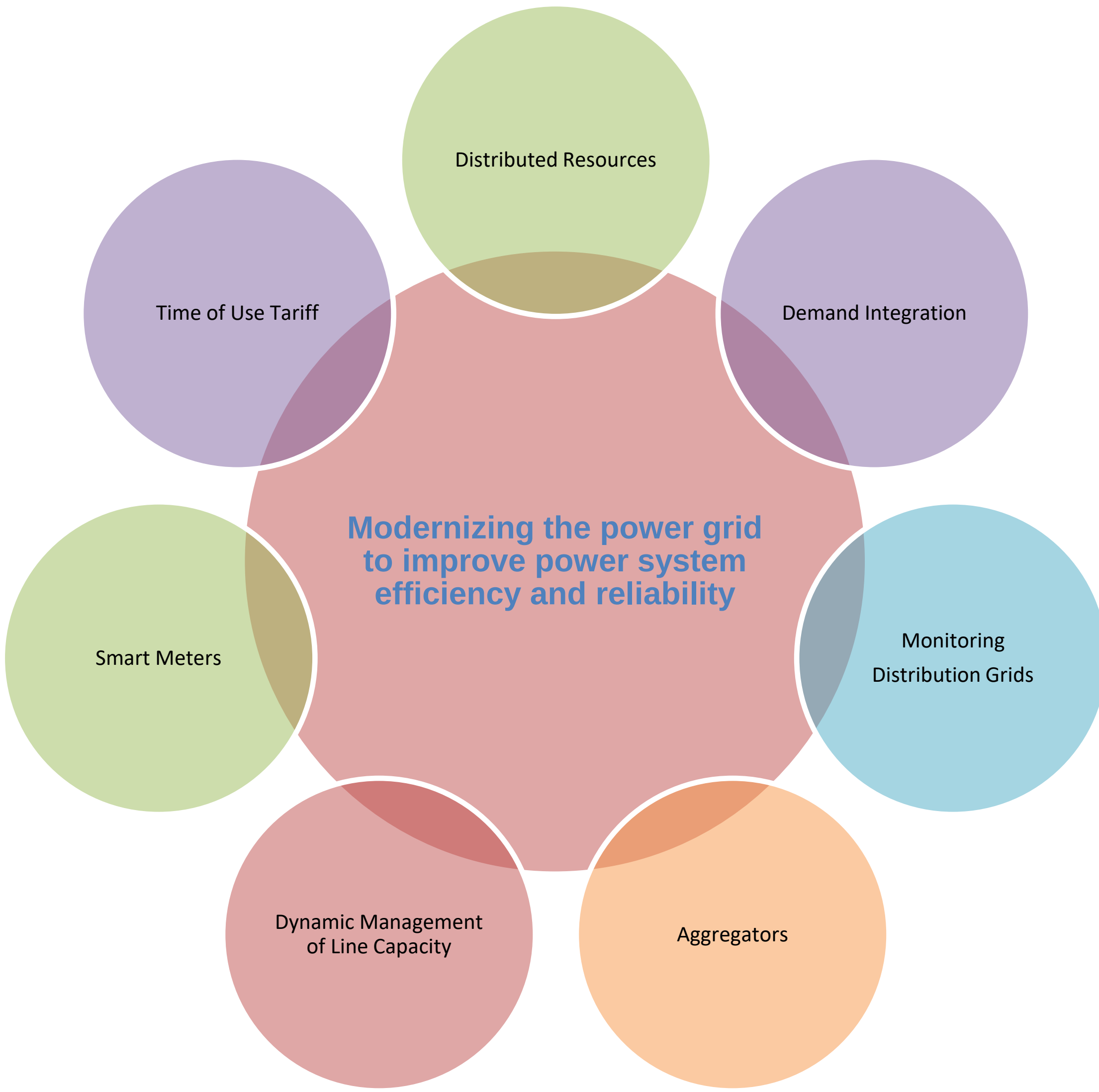
[14] Dato based on statistics from the International Energy Agency(AIE, 2021).

Diagram 4
Elements that modernize the power grid and improve its efficiency and reliability



Source: ECLAC.

The elements indicated in Diagram 4 contribute to improving the efficiency, flexibility, and reliability in managing electrical resources. One of these is **monitoring distribution grids** to locate and evaluate non-technical electrical losses. The first step towards improving this is the installation of **smart meters**, which allow better observation of the distribution grid through their monitoring capacity, giving the operator the ability to measure and communicate remotely in real time with the entity in charge of the system.

To maximize the potential of these devices, they have to be installed with the appropriate communication infrastructure and methodologies that allow processing, analysis, and real-time decision-making based on large volumes of collected information. Although most of the countries examined in this report have implemented pilot projects that include smart meters in their distribution grids, regional penetration or prevalence of smart devices is very low, at around 4% (northeast group LLC 2020). In contrast, market penetration of these devices is nearly 100% in Italy, Finland, and Sweden, whereas market penetration is expected to reach 80% by in this decade in France and Spain. In the US, the percentage of smart meters is between 30 and 40% (IOT Analytics 2019). There is still much to be done at the regional level in order to reach significant levels of installations that make this type of device and the benefits it offers widely available.

Another aspect that contributes to improving the monitoring of the grids is **dynamic line rating**, or DLR. This technology allows the user to dynamically determine the ampacity, or the line's maximum current capacity, by observing environmental conditions and evaluating the thermal dissipation capacity of the conductor. Additionally, DLR reduces congestion and curtailment of renewable generation, relieves restrictions in electrical transmission, and lessens the need to install reinforcements. The latter of these benefits could reduce the need to implement costly expansions to power grids as demand increases, along with an increase in renewable generation. In Germany and Denmark, planning studies for the potential development of 20 GW of offshore wind generation until 2030 (Institut für Elektrische Anlagen und Energiewirtschaft 2020) suggest that the use of DLR could, on its own, reduce congestion management costs through reduced curtailment by 6.8 TWh per year and VRE generation curtailment by 2.5 TWh per year, reductions of 27% and 50%, respectively. Within the region, Uruguay is an exceptional case because they use DLR technology in the operation of the SIN and have effectively reduced wind generation discharges. Currently, the Electrical Coordinator of Chile is urging investors to join the grid with this technology, especially in the south, to take advantage of the correlation between line capacity and wind power in that area.

Furthermore, countries should consider demand response **(demand integration)** to make more efficient use of generation and T&D resources and improve the overall operation of electricity infrastructure. In traditional power system operation, demand often has a passive and unmanaged role. Part of these demand resources could add flexibility and more actively contribute to the operation. For example, by transferring resources to time periods with cheaper electricity generation and/or less congested grids, the system uses such resources more efficiently.

Using variable electricity prices, **time of use tariffs** (ToU) are meant to incentivize usage in times of lower generations costs and electricity demand. The simplest version of this is known as "Static ToU" in which prices are set in advance (a priori) for different time blocks. The cheapest rate is during off-peak hours because of the low demand for electricity, while the most expensive would be in hours of high demand and less availability of generation resources, which would be peak hours (afternoon and evenings). This kind of tariff is only possible if advanced measurement infrastructure (i.e., smart meters) is available, allowing power companies to measure consumption on an hourly basis. The study carried out for this publication shows that at the regional level there are different examples of static ToU, but most are for industrial users. However, even within this sector, its use is still far from widespread. The spread of this mechanism is still limited in Latin America and the Caribbean because of the low penetration or prevalence of smart meters. An applicable case of static ToU at the small-user level is the White Tariff in Brazil, which has only been available since 2020.

A more advanced type of ToU is dynamic ToU, where price points vary depending on the prices of wholesale electricity markets, such as intraday or real-time markets, or potentially other services like ancillary services. Dynamic ToU can generate a greater and more dynamic demand response to the needs of the electricity system, providing greater flexibility. With real-time pricing, variations in VRE generation can be balanced by shifting demand to lower consumption schedules, thus avoiding grid overloads. At a global level there are examples of this type of tariff in power systems such as in Finland, Illinois (USA), or Arizona (USA). In Latin America and the Caribbean, countries still need to improve market design by introducing mechanisms or models that bring operation closer to programming (intraday or real-time markets), or technological ones, such as increasing the percentage of smart meters that measure commercial or domestic consumption, to implement this kind of ToU.

Another measure that would contribute to efficient resource management is the combination and aggregation of distributed resources. A more active, integrated, and specifically distributed use of demand can form part of the transformation towards non-centralized systems. That is, systems where distribution grids and resources play a key and active role in their operation. As discussed in more detail in Chapter III, the combination, aggregation, and management of such resources (distributed generation, storage, or demand integration) through innovative entities such as **aggregators** increases the efficiency and penetration of VRE and mitigates the need to expand upon existing infrastructure.

To conclude, the measures/solutions presented above mainly aim to modernize the infrastructure and operation of the power grid to use electrical resources more efficiently. However, part of the solution to the growth and decarbonization challenges the region currently faces unequivocally lies within the expansion of its electricity infrastructure. This is not only to meet the increased demand, but to also make use of new generation resources far from the load centers, or to interconnect different systems in the region to move towards a more unified use of regional resources. For this reason, **HVDC** technology is destined to play a fundamental role since it allows for the transmission of large volumes of energy over long distances, and for the efficient connection of asynchronous systems. At both regional and global levels, Brazil uses this technology exceptionally well, with some of the longest HVDC lines in operation worldwide.

Table 2 summarizes the strengths and weaknesses identified in this chapter for the modernization of the electricity grid and improvement of efficiency.

Table 2
Strengths and weaknesses identified at the regional level

Strengths (individual examples from the countries)	**Weaknesses and assessment (at the regional level)**
DLR is being used in Uruguay and more recently in the SING of Chile	Slow movement for installing smart meters
ToU: White Tariff in Brazil has been available since 2020	Lack of strategies on demand integration and few examples of ToU
HVDC transmission lines in Brazil	

Source: ECLAC.

III. Promoting distributed clean-energy resources to achieve universal access and resilience

The impacts of natural disasters and climate change have shown that power systems in Latin America and the Caribbean are still vulnerable and require greater resilience.[15] This is exacerbated by the fact that more than 733 million people do not have access to clean cooking systems or lack access to basic electrical services[16] in the world. However, today we can address this challenge with distributed energy resources like **micro-grids**,[17] **distributed generation**, and new alternatives like **aggregators**, **storage**, or **P2P**.[18]

The lack of access to electricity continues to pose a problem for the region, especially in isolated communities that lack infrastructure. According to ECLAC data, as of 2022 approximately 17 million people lacked access to electricity in the Latin America and the Caribbean, and more than 70 million lacked access to clean cooking systems.[19] This figure is mostly representative of urban-marginal, peri-urban, and rural areas. Lack of access to basic electric services is one of the main impediments to the development of these areas.

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15 In the power sector, resilience can be defined as a power system's capacity to tolerate disruptions and continue supplying energy to consumers. A resilient power system is one that can recover quickly from large shocks and incorporates alternative energy supplies to cover changes in the external circumstances. (HRudnick, s.f.).

16 Tracking SDG7 Report, 2022. The International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), the United Nations Statistics Division (UNSD), the World Bank, and the World Health Organization (WHO). https://trackingsdg7.esmap.org/downloads.

17 We defer to the US Department of Energy (DOE) for the definition of micro-grid. According to some experts in the field, the term "micro-grid" is more specific and includes systems that are typically connected to a larger central system but can operate on its own. The term "mini grid", however, generally uses the same definition, but assumes that the system will not be connected to a larger central grid. The definition by the DOE is based on a general concept of microgrid that would also include the mini grid.

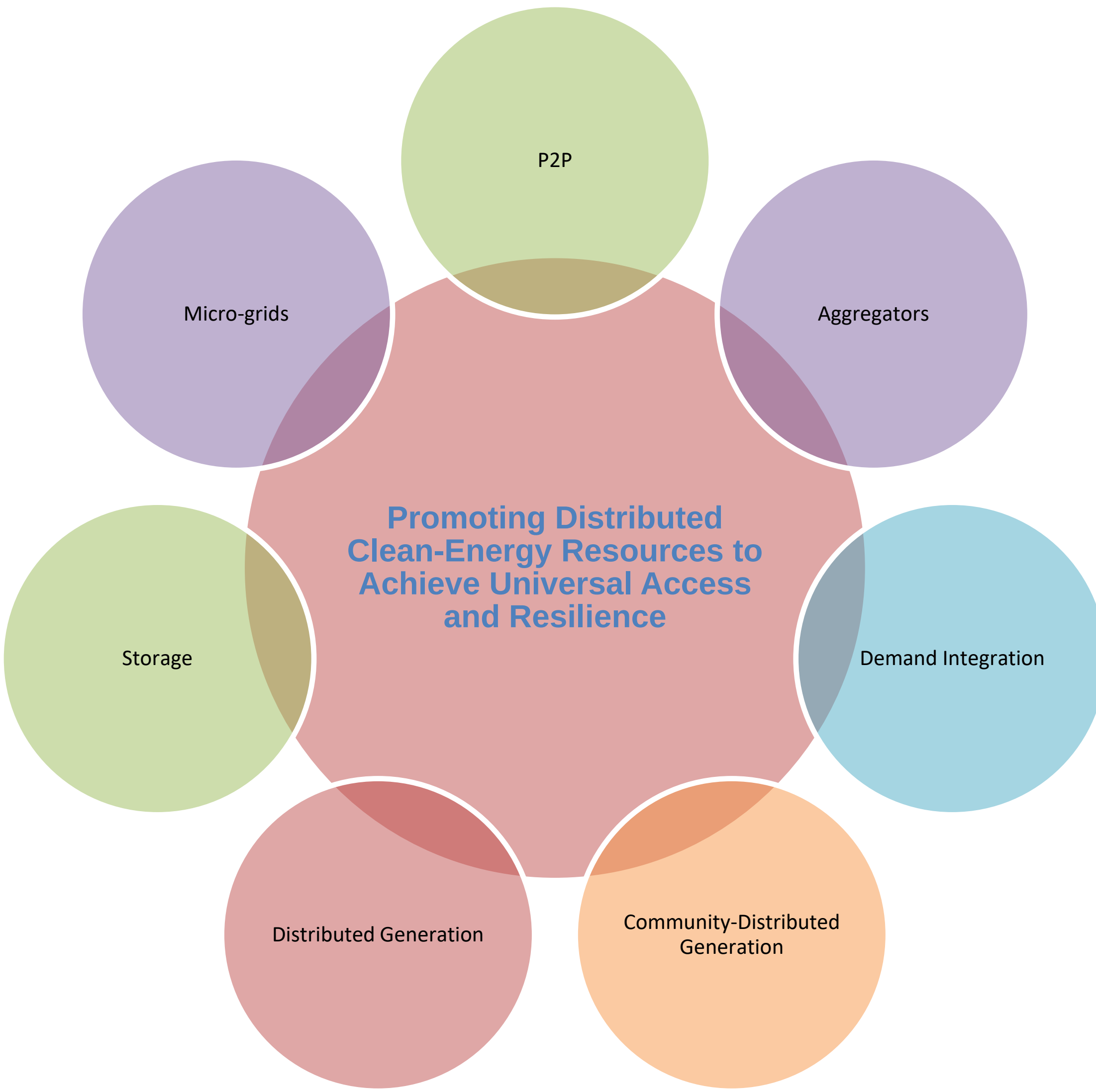
18 The P2P (peer to peer) model creates a market where "prosumers" and consumers can trade electricity without an agent (IRENA, 2020).

19 Boletín de Recursos Naturales en América Latina y el Caribe, N04, Los servicios básicos de agua potable electricidad como sectores clave para la recuperación transformadora en América Latina y el Caribe, CEPAL, septiembre 2022. https://www.cepal.org/es/publicaciones/tipo/recursos-naturales-america-latina-caribe/4.

Moreover, LAC's electrical systems are increasingly exposed to climate change and extreme weather events. Perhaps the most recent events that best exemplify this are the 2014-2015 drought in Brazil and category-5 hurricanes Dorian (2019) and Irma (2017) that wreaked havoc in the Caribbean. These recurring weather phenomena have a direct impact on the respective countries' power systems. During the 2014-2015 drought in Brazil, there was no water available to generate hydroelectric power or to cool thermal plants. Category-5 hurricanes Dorian (2019) and Irma (2017) in the Caribbean subregion devastated electrical infrastructure and caused prolonged blackouts in Puerto Rico and other islands.

Diagram 5 shows elements that would promote the use of distributed resources, help solve access issues, and make electrical systems more resilient.

Diagram 5
Elements that incorporate distributed clean energy resources to achieve universal access and resilience



Source: ECLAC.

As mentioned earlier, centralized resources can prevent isolated communities from accessing energy due to the high cost of developing and implementing the required infrastructure. In these situations, modern electrical systems must begin distributing their operations to create other generation models (distributed generation, DG, based on RE) and incorporate storage technologies. Some of the benefits of this transformation include: (1) greater efficiency, sine DG can meet the demand of consumption, reducing transport costs; (2) better security and resilience resulting from the decentralization of the system and lower dependence on energy and the grid; and (3) increased sustainability, since primarily RE-based distributed generation helps decarbonize the electricity generation mix and the energy grid. These and other benefits can be strengthened by combining different resources, other technological developments (digitization, connectivity etc.), and innovative business models (aggregators, P2P etc.). Combining these into a micro-grid may be a more efficient way to make sure isolated communities, especially islands, have access to the central electric grid. These benefits, described in greater detail in the Definitions Document, can be implemented in both short and long-term solutions to some of the challenges of LAC's electrical systems.

Isolated systems based on VREs such as solar roofs or micro-grids are considered in many cases to be the most economical and sustainable alternative when it comes to ensuring access to clean, safe, and resilient electricity for isolated communities. The abundance of VRE resources in different areas of LAC, lower costs, and maturity reached by these technologies make micro-grids an especially attractive solution in the short-term to improve access levels in rural areas that are currently around 93%. There are only a few examples of micro-grids with VRE in Argentina and Uruguay, so there is still plenty of potential in the region for these systems.

The use of VRE micro-grids embedded within systems such as those of an island can enable certain parts of the system to continue operating autonomously with local generation resources in case of a main system blackout, thus providing supply in times of emergency. In addition to maximizing the use of solar resources and reducing discharges, storage technologies can operate on 100% renewable energy, replacing synchronous generators. This solution could also provide more resilience for critical loads in the region such as hospitals, schools, or shelters. There aren't any noteworthy examples of this type of configuration in the region at present.

Among the aspects of clean energy technology that could benefit the region is the potential for the transition to assist in the regional decarbonization process. By combining distributed resources such as demand (**demand integration**) or storage, countries can make more efficient use of infrastructure and therefore delay the need for upgrades, reducing the loss of electricity in transport. In addition, encouraging the use of regulatory models such as **community-distributed generation** can dig deeper into the access universalization process and benefit the development of regional economies, especially in isolated areas or where the price of energy is high. Brazil is an impressive regional example when it comes to the development of this model. Community-distributed generation also allows active participation by consumers, since it provides RE access to people who cannot install it on their property, which results in more efficient investments due to economies of scale. Brazil's current shared generation model has a total of 637 plants and a total installed capacity of 35.5 MW.

In the long-term, the role of these resources is destined to become more instrumental because of other developments such as digitalization and modernization of grids, or the creation of business models like aggregators (of supply). For example, by creating virtual generation plants that add multiple distributed resources managed by aggregators, similar services currently provided by large generation centers could be supplemented by clean energy, in turn adding flexibility to electrical systems. This could also increase energy independence of the continent's large cities, and the supply resilience with embedded micro-grids. Another paradigm shift, which the ubiquity of these resources would drive in the region, would be user participation. Besides the inclusion of innovations such as the earlier-mentioned aggregators, new business models such as peer-to-peer networks and implementation of new technologies such as blockchain would enable direct participation of users in energy trading. This would work for both generators and consumers, eliminating vertical and, in many cases, inflexible and inefficient models still predominant in the region.

Table 3 summarizes the strengths and weaknesses of distributed clean energy resources that would allow greater access to electricity in the region.

Table 3
Strengths and weaknesses identified at the regional level

Strengths (individual examples from the countries)	Weaknesses and assessment (at the regional level)
Community-distributed generation in Brazil (637 shared generation plants)	Not many instances of energy storage
Experience with micro-grids incorporating VRE: - Uruguay: Cerra de Veda (52 kWp Solar, 308 kWh BESS and back-up diesel generators) and the Arerunguá II projects - Argentina: the PERMER project, which aims to install up to 5 systems in Puna areas in the northeast	Distributed generation is currently not very popular Few cases of micro-grids: there is a lot of potential for better access with this type of solution Lack of knowledge and awareness in society regarding the benefits and possibilities of DG Lack of regulations and good practices in DG by countries in the region

Source: ECLAC.

IV. Integrated planning and greater incorporation of renewable energies

Currently, energy planning practices in the region mainly consider factors at the national level, with little or no consideration of other energy sectors or neighboring power systems. This disintegrated planning is suboptimal from techno-economic, environmental, and safety aspects. The introduction and adaptation of integrated regional planning methods that include new technologies and sectors are key to achieving optimal solutions that make sustainable development goals attainable.

Regional power planning exercises generally don't include analysis of the potential access to clean energy and electricity sources by non-electrified sectors. This lack of comprehensive planning can cause supply problems in the future, as various sectors compete for limited energy resources, but **coupling** the electricity sector with other sectors is one of the main vectors for achieving sustainable development goals and combating climate change. Therefore, the planning process should be accompanied by increasing VRE in the power grid, so that the supply of both traditional demand and newly added demand comes from cleaner sources. In the last five years, participation of the electricity sector in the LAC power grid was estimated at 18%[20] (sieLAC-OLADE, 2022), which highlights the region's limited effort towards decarbonization if it is only focused on current electricity demand. It also calls attention to the importance of coupling with the power sector as a main focus for decarbonization. Therefore, the lack of coupled planning is a huge disadvantage of the widespread planning practices in the region in the context of sustainable development and climate change.

There isn't any collaboration in energy planning within the region currently, which means that energy complementarity between countries has not been considered. This limits the ability to explore the potential benefits of trading and macro-exploitation of present and future resources, as well as the demands of different systems.

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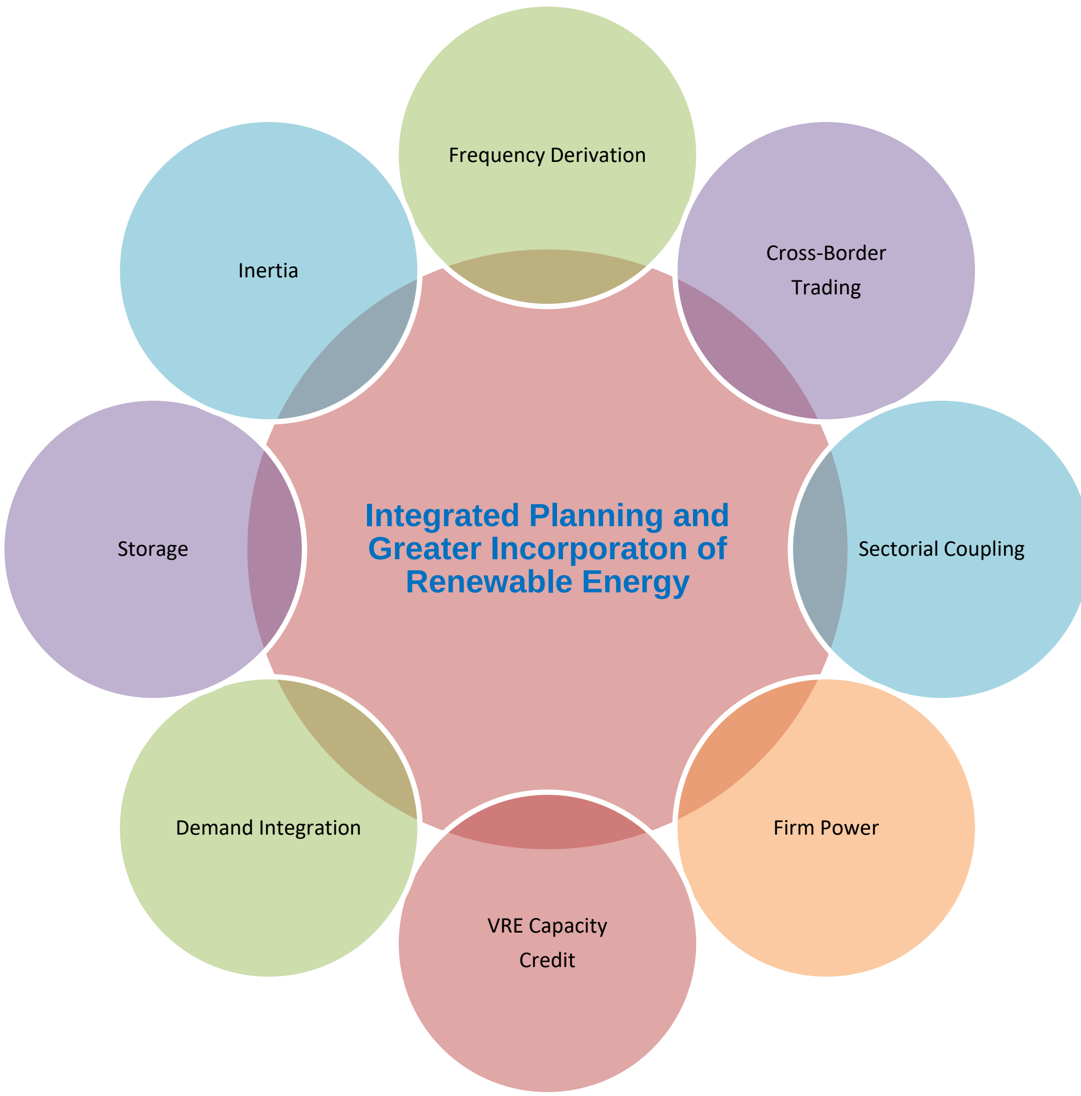
[20] This is slightly lower than in the USA, where 21% of the energy demand was supplied through electrical supply in 2019, or Germany, where it was around 19.7% in 2017 (International Energy Agency 2022).

Diagram 6 shows various elements conducive to comprehensive planning and incorporation of renewable energies.

Diagram 6
Elements to consider for comprehensive regional planning with greater penetration of renewable energies



Source: ECLAC.

Technological developments may limit planning resources and reduce their accuracy. Although VRE representation in the planning process is an established practice in all cases analyzed in this study, there are still a wide margin for improvement in methodologies and information to reach international best practices. Relevant aspects such as the **VRE capacity credit**, the impact of VRE on the flexibility requirements of the system, the co-optimization of generation and transmission, or creating stability analyses of the systems' dynamic response to increase VRE share are some of the best international practices that are still to be implemented in regional planning practices. This complicates the feasibility of developing VRE projects. Technologies that play a key role in facilitating the integration of VRE are storage and demand integration. Storage has a moderate participation in regional planning (in the case of the former), while demand integration is seldom considered, which poses a roadblock to achieving sustainable development and decarbonization goals.

Adapting planning methodologies for more detailed and realistic representation of VREs and other new technologies can help improve estimations of the technical and economic impact on systems and determine what measures should be taken to ensure optimal and safe integration. In this sense, the VRE capacity credit is a good practice for verifying the contribution in terms of **firm power** and ensuring optimal adequacy of generation resources. At the regional level, Brazil, Argentina, and Mexico are some of the countries that already consider capacity credits in their systems and prioritize improving the methodologies to determine them.[21] Flexibility is another key element in electrical systems in order to integrate high levels of VRE, so incorporating the appropriate technologies for their supply, such as storage or demand integration, is a good practice. While several countries in the region include storage (e.g., Uruguay, or Chile in its first phase), none of the countries reported that they consider demand integration in their planning practices (IRENA 2017).

Dynamic stability analysis is an essential part of planning because the replacement of synchronous generation by inverter-based generation reduces the **inertia** of electrical systems, impacting their inertial response. In line with international best practices, countries in the region should include dynamic stability analysis with high levels of VRE in planning, so that they can study response and explore solutions to improve it. This analysis should pay attention to legacy system response characteristics such as the inertia minimum (minimum inertia that guarantees operation stability), rate of change of **frequency (RoCoF)** in low inertia scenarios, and their impact on generation or protections. Countries should later explore possible solutions that improve inertia response without limiting the instantaneous penetration of VRE, such as the provision of fast frequency response (FFR) and/or synthetic inertia by generation assets. Once the technical solutions have been identified and analyzed from a stability point of view, they could be fed back into the process to optimize the expansion of generation and transmission resources, paving the way for evaluation of their costs, and ultimately determining the most appropriate techno-economic solution. Of all the countries in the region, only Argentina reports using dynamic stability studies in their planning processes.

Another recommendation is to include sectoral coupling with the electricity sector as the main focus in planning, integrating sectors such as transport or industry resulting from electrification of end uses such as heat, electromobility, or hydrogen. There is now a broad consensus that sectoral coupling is necessary and beneficial to achieving sustainable development goals. By coupling gas, heat, and transportation sectors with the electricity sector, progress is made towards decarbonization. In addition, integrating other sectors into the electricity system can introduce new flexibilities to the grid which would consequently contribute to VRE integration. The possibilities offered by coupling are many, as are the questions surrounding its development, such as what sectors to prioritize, what levels of sectoral electrification are feasible, what the costs and benefits will be, and what type of VRE and other technologies are the most appropriate to facilitate coupling and decarbonize new demand.

Planning is a key tool in answering many of these questions and in determining the action plan, led by the electricity sector, that will enable the region to move closer towards achieving development and sustainability goals. Coupled planning exercises in the electricity sector will require collaboration between planning actors from different sectors, which implies harmonization and coordination in the information used to obtain consistent results that will be compatible with the action plans of each sector. The flow of information centred around the electric sector planner is fundamental, as it involves drawing up a detailed model of all sectors including information, evaluation methodologies, and analysis of results. Calculation

[21] For more information, please refer to the Definitions Document that describes the calculation methodologies more extensively.

tools and methodologies used in electricity sector planning also require the capacity to model other sectors. In the regional mapping of this report, no planning practices were reported that systematically consider sectoral coupling. Furthermore, in cases where some type of communication was identified with planning agents in other sectors, they were treated as one-off incidents.

Including various electrical systems and resources, especially those of neighboring countries, would help identify optimal solutions to lower the cost of supply, improve reliability and resilience of power systems, and contribute to the region's development and decarbonization goals. Complementarity between electricity demand and VRE from different sources and locations mitigates VRE variability, one of the main challenges confronting its integration. In LAC, which is rich in VRE resources, integration of these technologies depends greatly on taking advantage of this complementarity. To make this possible, regional planning exercises that include detailed depictions of neighboring electrical systems would shed light on the benefits and costs of joint exploitation of VRE resources from different jurisdictions. These exercises should also focus on aspects such as the necessary electrical infrastructure and the dynamics of electricity flows between countries. In turn, this would help elucidate the investments that still need to be made and the roles of each jurisdiction in addressing them, and the regulatory changes that would need to be implemented at the planning level (e.g., to foster **cross-border trading**). Planning exercises such as the "Grid of the Future" (Inter-American Development Bank, 2017) have laid out the potential benefits of greater integration of LAC's electricity systems and established a methodological example of how to improve the scope of intraregional planning.

Table 4 summarizes the strengths and weaknesses identified in comprehensive planning in LAC and the extent of higher levels of renewable energy.

Table 4
Strengths and weaknesses identified in the region

Strengths (individual examples from the countries)	Weaknesses and Assessment (at the regional level)
Inclusion of VRE capacity credit in planning in Brazil, Mexico, and Argentina	Limited regional scope of planning exercises
Dynamic stability studies form part of energy planning in Argentina	Lack of sectoral coupling
	Limited and improvable inclusion of new technologies and resources such as demand integration or storage

Source: ECLAC.

V. Strengthening regulatory harmonization and market design to foster regional integration

The advantages and benefits of regional electricity integration are being squandered in LAC, even though multiple studies conclude that the potential benefits far outweigh the risks (Levy Ferre, Alberto, & Di Chiara). Among the solutions to promote electricity trading is the development of harmonized regulatory and contractual frameworks, as well as the design of markets suitable for making these transactions feasible.

The region still has very low levels of energy trading and VRE participation. The opportunities for trading between countries originate partly from the difference in prices between the markets, for which there must be a diversity of power supplies. As mentioned in Chapter I, the region has several geographically dispersed energy resources. However, the share of all VRE sources in the region's electricity production only reached 9,3% of the total in 2020, despite a growth of approximately 39% in the 2000-2020 period.

There are several electricity-integration schemes in the region with differing levels of progress: very high levels of trading in Brazil and the Southern Cone, moderate levels in Central America, and very low levels in the Andean region and Chile. The amount of electricity imports and/or exports from the region is equivalent to less than 11% of those made in Europe in the same period (2018). Furthermore, while Europe has experienced annual growth rates of 2.1% in imports/exports (2000-2018), Latin America showed negative rates of -0.8% in that same period, demonstrating a lack of regional integration.[22]

The largest interconnections in the region are the result of binational hydroelectric power plants on rivers bordering Paraguay, Brazil, Argentina, and Uruguay. Brazil accounts for approximately 75% of all electricity imported in the region from 2010-2017, while the rest of the Southern Cone is the largest

[22] Energy imports of 49,100MWh in LAC versus 454,000 MWh in Europe, and exports of 48,700 MWh in LAC versus 454,000 MWh in Europe. Data based on statistics from the International Energy Agency (AIE, 2021).

exporter with 80% of electricity exported in Latin America during the same period.[23] It should be noted that Itaipú supplies about 11% of the energy consumed in Brazil and 88% of that used in Paraguay.

SIEPAC in Central America has moderate levels of trading and is the most advanced interconnection scheme in LAC because it includes regional organizations that regulate, manage, and supervise trading, as well as a company that owns the grid interconnecting the countries. El Salvador, Guatemala, Nicaragua, Costa Rica, and Honduras are among the countries with the highest rates of domestic demand covered by imported electricity, with approximately 28%, 8%, 7%, 5%, and 3%, respectively.[24]

Progress in the Andean region has been mild. Demand coverage through imports from Ecuador and Colombia were less than 0.1% in 2022,[25] even though they have a long tradition of trading (since Decision 536 of the Andean Community of 2002).[26] In 2012, the Andean Committee of Normative Entities and Regulatory Entities for Electricity Services (CANREL) agreed to articulate and complement community discussion processes with the efforts of the SINEA (Andean Electricity Interconnection System) Initiative to structure a new general framework to integrate the electricity markets of the Andean Community and Chile. The result of these actions was materialized by Decision 816, approved in 2017, which established the regulatory framework of the Andean Regional Short-Term Electricity Market (MAERCP). Lastly, the Colombia-Panama line, promoted by the main suppliers of both countries ISA and ETESA, has not yet made progress in its construction despite advanced studies.

In the future, the entire region may benefit from reduced costs and greater efficiency with increases in the levels of energy trading between countries. Greater market integration will increase the share of VRE and contribute to environmental sustainability, reducing **curtailment** in the process. For example, the lack of mechanisms to export generation surpluses lead to forced curtailment in El Salvador, as dispatch priority is given to geothermal energy, which involves higher operating costs (more details can be found for this case study in the Definitions Document).

In terms of infrastructure, regional integration will make it possible to utilize it more efficiently by taking advantage of different demand patterns between countries, as well as different generation technologies and supply sources by reducing **reserve** requirements (primary, secondary, tertiary)[27] and allowing countries to postpone or even avoid large investments in generation.

Larger markets will also bring about greater liquidity in different products, creating more competitive markets not only in energy and capacity, but also in **ancillary-services**, increasing competition between stakeholders and minimizing the risk of oligopolistic activities. On the other hand, short-term operating reserves, frequency regulation services, initial system start-up, and long-term generation contracts are all services needed to reduce supply uncertainty and increase system reliability.

Despite all these advantages, in LAC there are still certain barriers to achieving regulatory integration and harmonization. Beyond the participation of the State in the electricity market and its subdivisions at the domestic level, each country promotes different markets and mechanisms for commercializing energy and power at the domestic or national level. The most widespread **energy market** in the region is long-term, but there are other operational and implementation modalities worth noting. For example, in Mexico, energy was recently commercialized in medium- and long-term **bids**, both carried out by CENACE. However, these were later cancelled or suspended. In Brazil, long-term energy contracting is developed through periodic bids of new energies and reserve bids. In Chile,

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[23] Data from (Levy Ferre, Alberto, & Di Chiara).
[24] Belize presented the second highest coverage index with 26.6% but is not part of SIEPAC.
[25] As described by XM, the interconnected system operator and wholesale energy market administrator in Colombia. See https://www.xm.com.co/portal-de-indicadores.
[26] Data from (Levy Ferre, Alberto, & Di Chiara).
[27] The definitions of each kind of reserve are outlined in the Definitions Document for each country along with the manner of application in each case.

long-term, short-term, and exceptional short-term tenders are considered. In the **capacity market** of Argentina, Uruguay, Panama, and Mexico, generators receive capacity payments, while in Peru and Brazil experts are studying the possibility of introducing them. The **short-term market** is the least developed market in the region, since, in most countries, it is limited to balancing contractual differences with the respective levels of generation or consumption, or to the participation of certain agents in the electricity sector. Such is the case in Peru, where distributors cannot access the short-term market to buy energy for the public electricity service. However, in Chile, the short-term market supplements the energy contracted in long-term tenders in cases of unanticipated growth in demand, deserted tenders, or others (Diario oficial de la república de Chile, 2015). Equally important, Chile's spot market aims to trade energy between surplus or deficit generators.[28]

However, the diversity of politics and degree of private investment participation poses a problem for regional integration. Some countries have chosen to maintain a state-monopoly model where the existence of a single buyer, the lack of rules to promote competition, and vertical and horizontal integration stand out. However, most of the electricity markets in the region do incorporate a coexistence between state participation and free competition, with multiple nuances and differences. Usually the State regulates, controls, and plans generation, transmission, and distribution to the public. It also manages any applicable subsidies, while private entities operate in the market as stakeholders in the generation and/or distribution under established state limits. The complexity, space and regional disparities (long distances, large, depopulated areas, and unequal economic growth) are remarkable, which is why national, regional, and local markets emerged (Ferney Moreno, 2012).

The solution to address the problems and barriers mentioned previously requires regulatory harmonization, market design, and competitive regional integration to create a market design that increases the share of VRE in the power grid, thus reducing wholesale electricity prices. Diagram 7 details elements that would contribute to the proposed solution, based on country case studies where such practices have been applied (the definition for each of the elements is detailed in the Synthesis Document).

The elements in Diagram 7 are essential to regulatory harmonization for regional integration, as explained below.

Grid codes are the documents that set the standards for the interface between the different stakeholders of electrical systems. In most systems, there is at least one transmission and one distribution grid code (which include different subcodes such as connection, planning, market code, etc.). At the same time, there are cases where specific grid codes were developed for wind and photovoltaic technologies, such as in Panama. However, at the regional level, it is difficult to find a specific and unified grid code separate and independent from national electricity legislation, which makes it difficult to review and update grid codes continuously to adapt to changes in the technical-economic environment of each country.

There are also differences in the technical, normative, legal, regulatory, and political realms of each country, as well as divergences between the denominations of concepts or technical elements. For example, grid codes are known as, *inter alia*, procedures, technical standards, provisions, or manuals. There's also distributed generation. In Brazil, distributed micro-generation refers to generation by RE or cogeneration of power less than 75kW, while in Peru the concept covers capacities less than 200kW of biomass, wind, solar, hydraulic and cogeneration technologies.

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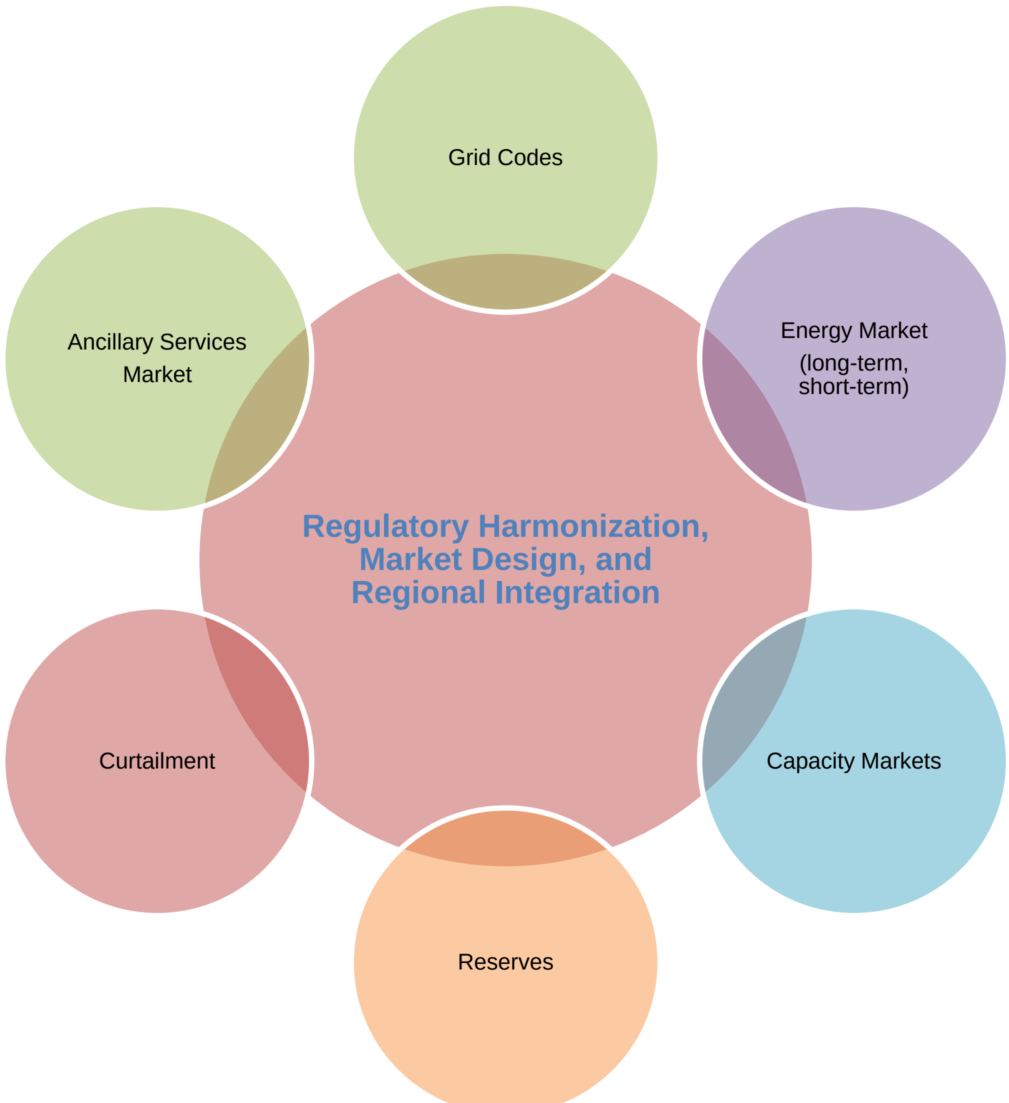
[28] Surplus generators provide more energy than the amount withdrawn by their customers. These generators cover their contracts and sell their surplus on the spot market to generators that incur energy shortfalls with respect to their contract obligations, or "Deficit Generators".

Diagram 7
Elements to achieve regulatory harmonization and appropriate market design in planning



Source: ECLAC.

In light of the above, and given the lack of common terminology, norms, legal, and regulatory frameworks, the region would need the individual States to steer their electricity sectors towards the development of a regional market. This in turn would require political consensus with a joint long-term vision, along with determination from the economic and political diversity that dominates the region. Given that there are countries where over 50% of the population lives in poverty, geographical dispersion and overpopulation in the capitals, and economic interest groups with great influence over political decisions on energy, the debate is generally limited to restricting free competition or limiting the role of the state through privatization and liberalization (Ferney Moreno, 2012).

In all of the interconnection schemes mentioned, there is technical and economic feasibility in some cases, but rules need to be adjusted to allow greater trading (Levy Ferre, Alberto, & Di Chiara). Regulatory harmonization (grid codes), and developed markets (energy, capacity, and ancillary services), will result in mitigation of VRE curtailment and reduce the need for reserves.

As for regulatory harmonization, one recommendation would be to review international grid codes, especially those that focus on harmonization at the regional or national level (where there are different jurisdictions within the country, e.g., Argentina). Some other examples include the European RFG (Requirements for Generators) or IEEE 1547[29] for distributed generation (mainly for the US).

Integration schemes with the greatest probability of success are those built based on respect for the economic interests and development models of each country and present a flexible design that allows adaptation to changing environments (CEPAL, 2013). At the same time, trading rules must be stable and broad in scope to provide predictability and adapt to changing national strategies. The design of these rules must recognize pre-existing agreements, offer legal certainty to the involved parties, and establish arbitration mechanisms in case of disputes. Additionally, countries need basic, coherent institutional frameworks and regulatory harmonization to make different types of agreements possible. Countries in the region should aspire to create national energy plans with an integrated regional focus, at least to coordinate the expansion of transmission and capacity requirements for emergency situations (Levy Ferre, Alberto, & Di Chiara).

Table 5 lists the strengths and weaknesses identified in regulatory harmonization and regional market design.

Table 5
Strengths and weaknesses identified at the regional level

Strengths (individual examples from the countries)	**Weaknesses and assessment (at the regional level)**
SIEPAC	Limited short-term market
Long-term markets	Differences in electrical concepts between countries
Technically and economically viable interconnection schemes	Lack of agreeable rules to enable greater trading
Specific grid codes for wind and photovoltaic technologies in Panama	Difficult to find specific, unified national grid codes

Source: ECLAC.

[29] Standard for Interconnecting Distributed Resources with Electric Power Systems.

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