

ARTICLE

Evaluation of public policies for energy transition and sustainable regional development: a comparative analysis of Chile, Brazil, and Mexico

Evaluación de políticas públicas de transición energética y desarrollo regional sostenible: un análisis comparado de Chile, Brasil y México

Avaliação de políticas públicas de transição energética e desenvolvimento regional sustentável: uma análise comparada de Chile, Brasil e México

Robson Barbosa

¹ Instituto Federal de Educação, Ciência e Tecnologia de São Paulo (IFSP), São Paulo, SP, Brasil. ORCID: <https://orcid.org/0009-0009-5896-0323>

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ABSTRACT

The transition to low-emission energy systems is necessary but insufficient for sustainable regional development. This article comparatively evaluates public policies in Chile, Brazil and Mexico to identify the institutional, financial and territorial arrangements that transform national energy targets into lasting regional capabilities. A structured, focused comparison was conducted using laws, plans, official reports and specialized literature, with the documentary corpus updated through June 2024. The analysis combines relevance, coherence, effectiveness, efficiency, impact and sustainability with spatial equity, subnational capacity and participatory quality. Chile presents the most explicit territorial approach through instruments linked to the gradual coal phase-out, although financing and infrastructure gaps remain. Brazil combines a highly renewable electricity mix, industrial scale and public development banks, but faces fragmented multilevel governance and tensions between climate leadership and hydrocarbon expansion. Mexico has substantial renewable potential and relevant state capabilities, although regulatory instability and limited territorial coordination reduce

the predictability of its transition. The article recommends territorial transition contracts, regional diversification funds, benefit-sharing standards, independent observatories and fossil-investment coherence tests.

Keywords: public policy, energy transition, sustainable development, regional development, program evaluation

RESUMO

A transição para sistemas energéticos de baixas emissões é condição necessária, porém insuficiente, para o desenvolvimento regional sustentável. O artigo avalia comparativamente as políticas públicas do Chile, Brasil e México, buscando identificar arranjos institucionais, financeiros e territoriais capazes de transformar metas nacionais em capacidades regionais duradouras. Foi realizada comparação estruturada e focalizada com base em leis, planos, relatórios oficiais e literatura especializada, atualizada até junho de 2024. A análise combina relevância, coerência, efetividade, eficiência, impacto e sustentabilidade com equidade espacial, capacidade subnacional e qualidade participativa. O Chile apresenta territorialização mais explícita, associada à retirada progressiva do carvão, embora persistam lacunas de financiamento e infraestrutura. O Brasil reúne elevada renovabilidade elétrica, escala industrial e bancos públicos, mas enfrenta fragmentação federativa e tensões entre liderança climática e expansão de hidrocarbonetos. O México apresenta elevado potencial renovável e capacidades estatais relevantes, embora a instabilidade regulatória e as limitações de coordenação territorial reduzam a previsibilidade da transição. Propõem-se contratos territoriais, fundos de diversificação, padrões de compartilhamento de benefícios, observatórios regionais e testes de coerência para investimentos fósseis.

Palavras-chave: políticas públicas, transição energética, desenvolvimento sustentável, desenvolvimento regional, avaliação de programas

INTRODUCTION

For several years now, the energy transition has no longer been a topic confined to technological substitution in the electricity sector. In Latin America, the expansion of solar, wind, hydro, geothermal and bioenergy is taking place within economies marked by persistent territorial inequalities, concentrated fiscal capacity, insufficient grid infrastructure, and a high exposure to decisions made outside the regions where projects are located. For this reason, a policy can raise the share of renewable sources while producing modest results in stable employment, productive diversification,

energy poverty reduction, or the strengthening of subnational governments. Evaluating the transition therefore requires separating three dimensions that are often presented as though they were one and the same: the decarbonization of the electricity system, the productive transformation of territories, and sustainable regional development in its own right.

Chile, Brazil and Mexico offer an especially useful comparison for this purpose. All three countries have considerable economic scale, abundant energy resources and international climate commitments made under the United Nations Framework Convention, yet they differ markedly in their territorial organization, in the role they assign to the state, in the structure of their electricity markets, and in the recent trajectory of their policies. Chile has moved rapidly to incorporate solar and wind power, established an explicit coal phase-out policy, and linked decarbonization to territorial just-transition plans. Brazil starts from an electricity mix that is already predominantly renewable and from a continental-scale interconnected system, although it maintains strongly centralized energy governance and faces socio-environmental conflicts linked to hydroelectric dams, wind farms, transmission lines, mining, and the expansion of deep-water hydrocarbons. Mexico, in turn, combines substantial renewable potential with a structural dependence on natural gas, a strong predominance of state-owned enterprises, and successive institutional reforms that have, within a few years, altered the conditions for investment, regulation and federal coordination.

The comparison presented here does not seek to establish a simplified ranking among the three cases. A higher share of renewables in the electricity mix does not by itself imply a more coherent public policy, just as having a strong state does not guarantee implementation capacity on the ground. The analytical problem of interest to this article is to identify which combinations of rules, institutions, financial instruments and participation mechanisms manage to convert national energy targets into lasting capabilities for regions. This approach shifts the usual question — how much have renewables grown — toward a more demanding one: who decides, who finances, which territories bear the costs, and what capabilities remain once the investment has been completed.

The article's general objective is to comparatively evaluate the energy-transition public policies of Chile, Brazil and Mexico, with emphasis on their effects and on the conditions that allow them to contribute to sustainable regional development, and to formulate recommendations aimed at improving their coherence, implementation and evaluability. The research

question guiding the work is as follows: which governance arrangements, policy instruments and territorial mechanisms favor an energy transition that produces regional outcomes that are environmentally consistent, socially just and economically lasting? Three specific objectives follow from this question: to examine the normative and institutional architecture of each country; to compare their coordination, financing, participation and monitoring capacities; and to propose a transferable policy agenda, with the adaptations each context requires, for other countries in the region.

The thesis sustained throughout the text is that the regional performance of the transition depends less on the mere existence of national targets than on the quality of the connections between energy policy, climate policy, productive development, territorial planning and social protection. Chile shows the most explicit territorial linkage of the three cases, but still faces difficulties with infrastructure, permitting, spatial concentration of investment, and economic continuity in areas where thermal power plants are being closed. Brazil has scale, technological diversity and well-established financing instruments, but the relationship between national planning and subnational strategies remains fragmented. Mexico has abundant renewable resources and a significant state presence in the energy sector, but regulatory discontinuity, dependence on natural gas, and limited federal coordination make it difficult for this transition to translate into stable territorial outcomes.

The article is organized into eleven sections. After this introduction, the conceptual framework guiding the analysis is presented, followed by the methodological design. The fourth section summarizes the Latin American energy context and the common problems faced by countries in the region. The following three sections examine, respectively, the cases of Chile, Brazil and Mexico. The comparative results, policy recommendations, a discussion of the findings and, finally, the conclusions follow. The documentary corpus was closed on 30 June 2024; consequently, references to programs and plans correspond to the normative and institutional situation available up to that date, notwithstanding that some of these instruments may have since been modified.

ENERGY TRANSITION, POLICY EVALUATION AND TERRITORY

Sociotechnical transitions and path dependency

Energy transitions are long-duration processes that simultaneously alter technologies, infrastructures, business models, consumption practices,

institutions and power relations. Markard, Raven and Truffer (2012) warn that these transformations do not follow a linear sequence, nor do they result from simple gains in technical efficiency; rather, they involve the rearrangement of entire systems, with multiple actors and timescales that rarely coincide with one another. Geels (2002) had earlier proposed a multi-level perspective for understanding these processes, distinguishing between a dominant sociotechnical regime, innovation niches where alternatives emerge, and an exogenous landscape of economic, demographic and cultural pressures that can open or close windows of change. Geels and Schot (2007) further showed that different transition pathways are possible depending on the intensity of external pressure and the degree of niche preparedness: abrupt substitution, gradual transformation of the existing regime, reconfiguration through the accumulation of minor changes, or the misalignment and realignment of the entire system.

This perspective is useful for understanding why transition policies operate on structures that generate strong path dependency. Established energy systems have long-lived physical assets, specialized organizations, regulatory frameworks accumulated over decades, and interest groups with real capacity to protect their investments. Building a new solar plant may take only a few months; modifying the transmission grid, tariff regulation, the available professional skills and the territorial pattern of investment usually requires much longer periods, which frequently exceed the electoral and budgetary cycles of the governments driving the transition.

Policy mixes and coherence

The literature on policy mixes helps explain why the success of a transition cannot be evaluated by looking at one instrument at a time. Rogge and Reichardt (2016) propose analyzing the consistency among objectives, instruments, processes, and the overall characteristics of the set of policies in force at a given moment. In the energy field, incoherence appears when a decarbonization target coexists with subsidies for fossil fuels, when an industrial policy for electromobility fails to engage with the vocational training available in the regions, or when the fast-track authorization of renewable projects ignores the real capacity of transmission grids and existing land-use conflicts. A policy can be ambitious in its stated aims while remaining fragile in its actual implementation. For this reason, cross-country comparison must examine both the formal design of policies and the administrative, budgetary and territorial conditions that sustain — or fail to sustain — their execution.

The spatial dimension of the transition

The spatial dimension is equally decisive and, for a long time, was relatively neglected by sociotechnical transition studies, which tended to focus more on sectors than on territories. Coenen, Benneworth and Truffer (2012) showed that transitions always occur in concrete places, where resources, knowledge, institutions and economic networks are unevenly distributed. Bridge et al. (2013) developed this idea further, pointing out that the geography of the energy transition includes at least four elements: the location of usable natural resources, the configuration of infrastructure networks, the scales of government involved in each decision, and the new relationships that form between energy-consuming centers and producing peripheries. In Latin America, the best solar and wind resources tend to be far from the main centers of electricity demand. The infrastructure needed to transport electricity, critical minerals, or low-carbon fuels redefines entire logistics corridors, and can end up reproducing enclave economies if there is no deliberate policy aimed at generating local production linkages.

Sustainable regional development: beyond gross investment

Sustainable regional development is understood in this article as the persistent expansion of economic, social and institutional capabilities in a given territory, compatible with the environmental limits of the system and with a reasonably equitable distribution of benefits and risks among its inhabitants. It is not enough to measure the gross investment received or the temporary tax revenue generated by an energy project. Attention must also be paid to the quality and duration of the jobs created, the ability of local suppliers to take part in the value chain, the generation of transferable technical knowledge, the diversification of tax revenue sources, access to affordable energy for households, the resilience of infrastructure to extreme weather events, the protection of surrounding ecosystems, and the effective participation of communities in decisions that affect them. A region can receive a considerable volume of investment and still remain almost entirely dependent on external business decisions, volatile fiscal transfers, or jobs concentrated almost exclusively in the construction phase of projects, which tends to be far more labor-intensive than the operating phase.

Energy justice and just transition

The concept of energy justice makes it possible to organize these considerations within a more precise analytical framework. Jenkins et al. (2016) distinguish three dimensions: distributive justice, which examines how the costs and benefits of an energy system are shared; procedural

justice, which concerns the quality and accessibility of the processes by which decisions are made; and justice of recognition, which requires identifying and respecting the groups, identities and ways of life that are often left outside the dominant administrative categories of energy planning. Sovacool and Dworkin (2015) broaden this framework by incorporating concerns about universal access to energy, the responsibility of those who cause environmental harm, and equity between present and future generations. Applied to the energy transition, this perspective requires evaluating aspects such as electricity tariffs, ownership of generation assets, the cumulative impacts of multiple projects in the same territory, resettlement processes when they occur, working conditions during construction and operation, prior consultation with indigenous peoples, and the real — not merely formal — possibilities for a community to influence a project's final design.

Closely related to the previous point, the notion of just transition broadens the focus to include workers and territories exposed to facility closures or productive reconversion processes. Newell and Mulvaney (2013) argue that this debate cannot be reduced to economic compensation delivered after job losses have already occurred; it must instead shape the very orientation of public and private investment, social protection during the transition period, workers' vocational retraining, and the advance creation of viable productive alternatives. In coal-mining, port, oil-producing regions, or regions heavily dependent on thermal power plants, the decarbonization timeline needs to be accompanied, from the outset, by rigorous labor and fiscal diagnostics. The absence of this forward planning turns what is, in principle, a necessary climate policy into a predictable source of social opposition — something that has already occurred in different parts of the world when facility closures were decided without simultaneous territorial planning.

Multilevel governance and subnational capacities

Multilevel governance refers to the distribution and coordination of authority among the different levels of government and among the public, private and social actors involved in formulating and implementing a policy. Meadowcroft (2009) stresses that transitions toward sustainability require experimentation, continuous learning and periodic institutional review, processes that can hardly be concentrated in a single organization or level of government. However, transferring responsibilities to subnational governments without simultaneously transferring resources, information or technical competencies produces, in practice, merely nominal decentralization. Regional and municipal governments need timely access to

energy data, technical capacity to formulate and evaluate projects, their own fiscal instruments, and binding — not merely consultative — spaces for coordination with national ministries and regulators. Avelino and Rotmans (2009) add that these processes also involve power relations that rarely become explicit in policy documents: who has the capacity to veto, delay or accelerate a decision often depends on resources that go beyond what is formally established by law.

Program evaluation and territorial evidence

Public policy evaluation, as a disciplinary field, contributes methodological tools that complement the analysis of sociotechnical transitions characteristic of innovation studies. While the latter tend to describe long-term processes of change with relative distance from precise causal attribution, the program-evaluation tradition demands asking, as rigorously as possible, whether a specific instrument produced the effect attributed to it, and at what cost compared with available alternatives. Applying both traditions together makes it possible, on the one hand, to place each policy within a broader historical and institutional trajectory and, on the other, to maintain a standard of evidence that avoids conclusions based merely on the ambition declared in official documents. This combination is particularly necessary in the Latin American energy field, where an abundance of targets and strategies frequently contrasts with a scarcity of independent evaluations verifying their actual results at the territorial level.

The role of international organizations

International organizations have considerably influenced the design of national transition policies in Latin America. The International Energy Agency (IEA, 2023), in its World Energy Outlook report, argues that global investment in clean energy already substantially exceeds investment in fossil fuels, although it warns that this trend is heavily concentrated in a small number of advanced economies and in China, while developing countries face a substantially higher cost of capital for equivalent projects. The International Renewable Energy Agency (IRENA, 2023), for its part, documented in its annual reports on renewable employment that job creation in the sector is not distributed evenly among countries or among regions within the same country, and that much of this employment remains concentrated in the manufacturing and installation phases rather than in long-term operation. This international evidence reinforces the relevance of examining, case by case, how the global push toward renewables translates into capabilities actually installed within territories.

Evaluation framework used in the article

To evaluate the selected policies, this article combines the criteria of relevance, coherence, effectiveness, efficiency, impact and sustainability defined by the Organisation for Economic Co-operation and Development (OECD, 2019) with three additional territorial criteria: spatial equity, subnational capacity, and participatory quality. Relevance asks whether the policy responds to clearly diagnosed energy and territorial problems, rather than to agendas imported without adaptation to the local context. Coherence looks at the compatibilities and contradictions existing among different instruments and levels of government. Effectiveness compares stated objectives with verifiable outcomes based on available evidence. Efficiency examines the relationship between the resources employed, execution timelines and the outputs obtained, without reducing the analysis to a simple comparison of financial costs. Impact considers the broadest changes produced by the policy, both positive and negative, including those not originally anticipated. Sustainability investigates whether the benefits generated can be maintained once the initial funding or the political cycle that drove the policy has ended. The three complementary territorial criteria check, respectively, whether the policy reduces existing asymmetries between regions, whether it strengthens the local institutions responsible for implementing it, and whether it allows affected communities to genuinely influence decisions that alter their immediate surroundings.

METHODOLOGICAL PROCEDURES***General design***

The research adopts a qualitative design of structured, focused comparison, following the methodological tradition that favors a small number of cases analyzed in depth rather than a large-scale statistical analysis. The three cases were selected for their regional relevance and for presenting institutional contrasts capable of illuminating distinct causal mechanisms. Chile is a unitary state with strong national regulation and specific territorial policies for areas affected by the closure of coal plants. Brazil is a federation with an integrated national electricity system, a high share of renewable sources, and highly heterogeneous subnational capacities across its twenty-seven federal units. Mexico is a federation whose energy sector combines binding planning, a historical predominance of state-owned enterprises, and recent legal reforms that substantially altered the rules governing private participation. This combination of similarities and differences allows for a comparison that approximates a most-different-

systems design, aimed at identifying functionally equivalent conditions that produce comparable outcomes despite operating within distinct institutional contexts.

Unit of analysis and components examined

The unit of analysis is not a single program, but the set of policies that link the energy transition to regional development in each country. In each case, five components were examined: the legal framework and formally established targets; the governance architecture involved in implementation; the expansion, financing and regulatory instruments available; the territorial and social mechanisms envisaged to manage local impacts; and the existing monitoring and evaluation systems. The main period analyzed runs from 2015 to June 2024, although earlier antecedents are incorporated when necessary to understand longer-term institutional trajectories, such as the 2013 Mexican energy reform or the reform of the Brazilian electricity sector in the 1990s.

Documentary corpus and sources

The corpus comprises laws, decrees, administrative resolutions, long-term energy policies, electricity-system expansion plans, national climate strategies, annual institutional performance reports, official energy balances, and technical documents produced by multilateral organizations. Information was extracted using a common matrix, with identical questions applied to all three countries, which made it possible to preserve comparability across cases despite differences in format and availability among sources. Primary sources were systematically triangulated with academic literature on sociotechnical transitions, energy justice and multilevel governance, so as to avoid the analysis relying exclusively on official accounts produced by each government. When a document stated a target with no results available for its verification, that target was classified as a programmatic commitment rather than an actually achieved accomplishment — a distinction central to avoiding overestimating the performance of any of the three countries.

Evaluation scale and limitations

The evaluation uses a qualitative three-level scale for each criterion: consolidated, when there is sustained evidence of effective implementation over several years; partial, when there are documented advances but also significant gaps in coverage, financing or continuity; and incipient, when the policy is still in the design phase or early implementation, without sufficient

evidence of results. Four main limitations should be made explicit. First, the comparison relies on public documents and does not include direct interviews with institutional actors, which may leave out relevant nuances regarding the day-to-day implementation of policies. Second, regionally disaggregated information is uneven across the three countries, being more complete in the Chilean case than in the Brazilian or Mexican ones. Third, Mexico's energy framework underwent significant regulatory changes and institutional disputes for much of the period analyzed, which introduces a degree of instability into the temporal comparability of the data. Fourth, the official definitions of renewable energy are not identical across the three countries, which requires caution when comparing aggregate figures on the renewable share of the electricity mix. Despite these limitations, inherent to any comparative study based on documentary sources, the design is well suited to the article's purpose, which is to formulate policy recommendations grounded in available evidence rather than to produce highly precise quantitative estimates.

THE LATIN AMERICAN CONTEXT AND COMMON PROBLEMS

Latin America and the Caribbean have a relatively renewable electricity mix compared with the global average, largely thanks to the historical presence of hydroelectric power in countries such as Brazil, Colombia, Paraguay and Chile itself. In 2024, the regional share of renewable sources in electricity generation exceeded sixty percent, a considerably higher figure than in most regions of the world. The progressive electrification of transport, industry and buildings can build on this initial advantage, but it will also steadily raise total electricity demand and, with it, the need to expand grids, incorporate storage, develop flexible demand management, and maintain reserve capacity for periods without sufficient sun or wind. The transition thus ceases to be exclusively a matter of generation supply and comes to involve the entire architecture of the energy system.

The first constraint common to countries in the region is transmission and distribution infrastructure. Renewable projects tend to cluster where the natural resource is best, while existing grids were built for an earlier energy geography, designed around traditional thermal and hydroelectric plants. Delays in building new transmission lines lead to the waste of renewable energy already generated, congestion at existing nodes, regional price differences that penalize producing territories, and the underuse of assets the system has already paid for. The Inter-American Development Bank consistently identifies transmission as one of the central bottlenecks for the

energy transition in the region, a diagnosis that matches what is observed in the three countries analyzed in this article.

The second common constraint is financial in nature. Mature renewable technologies, such as solar photovoltaic and onshore wind, are now cost-competitive against fossil alternatives in practically any part of the world, but projects located in Latin American countries face greater currency risk, a higher cost of capital, persistent regulatory uncertainty, and less availability of public or private guarantees to reduce that risk. Abramskiehn et al. (2017), in a study commissioned by the Inter-American Development Bank itself, document how the national development banks of Brazil, Mexico and Chile attempted to partially offset this gap through specific credit lines, albeit with uneven results depending on the country and the type of technology financed.

The third constraint is institutional and is characterized by the frequent separation between the centralization of energy decisions, which usually resides with national ministries and regulators, and the subnational impacts of these same decisions, which fall directly on regional and municipal governments with little prior capacity to weigh in. The fourth constraint is distributive and manifests itself in recurring conflicts over land use, access to water, and impacts on local communities, including indigenous peoples whose territories often coincide with the areas of best wind and solar resources. The fifth constraint is productive: preventing the region from once again being reduced to exporting raw materials or energy without generating sustainable local production linkages is one of the most persistent challenges of Latin American industrial policy, and the energy transition does not escape this risk. Finally, the fiscal tension faced by the region's oil- and gas-producing countries calls for clear, explicit rules to avoid the unnecessary prolongation of fossil assets whose long-term profitability grows increasingly uncertain as global decarbonization advances.

CHILE: ACCELERATED DECARBONIZATION AND INCOMPLETE TERRITORIALIZATION

Over the past decade, Chile has built one of the most visible renewable-expansion trajectories in all of Latin America. The National Energy Policy 2050, updated by the Ministry of Energy in 2022, set out a long-term vision built around four pillars: security of supply, energy efficiency, environmental sustainability, and citizen participation in sector decisions (Ministerio de Energía de Chile, 2022a). The Framework Climate Change Law, enacted in

2022, turned the carbon-neutrality and climate-resilience target for 2050 into a binding legal reference for the sectoral and territorial instruments to be issued thereafter, including regional climate action plans (Chile, 2022). As of June 2024, the rapid uptake of solar and wind power had steadily increased the share of non-conventional renewable sources in the electricity mix, while at the same time reinforcing the urgency of new investment in transmission, storage and operational flexibility of the system, without which much of this additional energy risks not being fully usable.

The policy for the progressive retirement of coal plants recognizes, in its own design, that decarbonization requires enabling conditions of security, flexibility, stability and resilience for the electricity system as a whole, not merely the disconnection of the most polluting plants. The territorial dimension of this policy is particularly clear in the Just Transition Strategy and in local plans aimed specifically at areas affected by the closure of thermal power facilities. The Just Socio-Ecological Transition Plan for Tocopilla, published by the Ministry of Energy in 2024, incorporates components of environmental recovery, job creation, alternative productive development, and improved urban well-being, all through a multi-actor participation process that included local authorities, social organizations and private-sector representatives (Ministerio de Energía de Chile, 2024a). However, the actual execution of this type of plan depends largely on cross-sectoral budgets committed by different ministries and on sustained coordination with regional and municipal governments, whose technical and financial capacity remains limited in several of the affected communes.

Distributed generation has been promoted through a new regulatory framework aimed at facilitating community self-consumption, which allows different users to join together to share the energy generated by a single photovoltaic system (Ministerio de Energía de Chile, 2019, 2024b). This policy opens up a meaningful path for lower-income households and small businesses to access the benefits of solar energy without needing to make a full individual investment, although its actual reach as of 2024 remained modest compared with the country's available technical potential.

From the perspective of the evaluation framework used in this article, Chile shows clear strengths in setting long-term targets and in the explicit territorialization of at least part of its decarbonization policy, particularly with regard to coal-plant closures. However, the country faces significant gaps in the continuity of regional socioeconomic indicators that would make it possible to verify, with systematic evidence, whether the just-transition plans are actually generating lasting productive alternatives. Difficulties also

persist in managing the impacts generated by new green industries — such as green hydrogen production or lithium extraction — in regions that until recently were not considered energy hubs of this magnitude, and that today face pressures on water, land and local infrastructure for which a fully developed institutional response is still lacking.

The Ministry of Energy's 2022-2026 Energy Agenda complements the long-term policy with medium-range targets on electromobility, energy efficiency in public buildings, and the strengthening of the regulatory institutional framework (Ministerio de Energía de Chile, 2022b). This instrument matters because it links the decarbonization trajectory to more everyday decisions, such as the renewal of public transport fleets in different regions or the installation of charging points in extra-urban areas, where the lack of basic infrastructure had until then been a concrete barrier to extending the benefits of the transition beyond the Metropolitan Region and the areas where most generation investment is concentrated.

One aspect deserving particular attention is the geographic concentration of large-scale projects in the Antofagasta, Atacama and Tarapacá regions, where the solar resource is exceptional by global standards. This concentration has allowed Chile to position itself as a relevant player in the production of green hydrogen for export, but it has also generated local tensions over water use in desert areas, pressure on Atacameño indigenous communities, and a disparity between the value of projected exports and the benefits that actually remain in the regional economy. The experience of copper mining, with decades of history in these same regions, offers lessons that green-hydrogen policy has not always managed to incorporate systematically by the close of the period analyzed.

BRAZIL: RENEWABLE SCALE, CENTRALIZATION AND FEDERATIVE HETEROGENEITY

Brazil has a highly renewable electricity mix, historically underpinned by hydroelectric generation, along with large-scale public planning and financing instruments that few countries in the region can match. In August 2024, the National Energy Policy Council approved CNPE Resolution No. 5, which formally established the National Energy Transition Policy, together with planning and participation mechanisms designed to guide the sector's transformation toward lower emissions, greater energy equity, and associated economic development (Brasil, Conselho Nacional de Política Energética, 2024). This normative architecture is further supported by the National Policy on Climate Change, in force since 2009, which for the first

time established a comprehensive legal framework for the country's climate policies (Brasil, 2009). The effectiveness of this set of instruments depends, however, on their concrete articulation with existing industrial, climate and territorial policies, and on the — very uneven — capacities of the twenty-six states and the Federal District to implement them at the local level.

Brazilian federalism produces markedly diverse territorial dynamics. States in the Northeast region have strongly driven wind power and, more recently, solar power, drawing on both the quality of their natural resources and the transmission infrastructure developed specifically to support this expansion. Teixeira et al. (2024) document how different states in Brazil's Northeast developed their own renewable-energy promotion policies, with uneven results depending on each state administration's prior institutional capacity. São Paulo, for its part, directed much of its energy policy toward biofuels and industrial energy efficiency, drawing on its decades-long tradition of sugarcane ethanol production. Nonetheless, energy planning centralized at the federal level maintains a significant multilevel coordination gap, in which states and municipalities tend to react to projects already decided at the national scale rather than actively participating in their initial design. Lazaro et al. (2022) analyze precisely this problem and conclude that, despite renewable growth, Brazil's energy regime remains strongly centralized, with little real room for subnational governments to influence long-term planning decisions.

The country also has solid public financial tools to sustain this transition, among which the National Bank for Economic and Social Development (BNDES) and the Climate Fund stand out, both offering specific credit lines for renewable-energy, energy-efficiency and climate-adaptation projects. Werner and Benites-Lazaro (2023) examine the evolution of Brazilian renewable-promotion policy between 2000 and 2022, and find that, although the country has managed to consolidate a relatively stable framework of incentives, unresolved tensions persist between the international climate leadership Brazil often claims and the simultaneous expansion of hydrocarbon production, particularly in deep-water fields off its coast. This tension is also expressed at the territorial level: Santos et al. (2023) document socio-environmental conflicts associated with the installation of wind farms in Brazil's Northeast, where local communities have reported inadequate consultation processes and an inequitable distribution of the economic benefits generated by projects installed in their territories.

The Brazilian experience illustrates, perhaps better than any other in the region, the dilemma of a transition that is advancing strongly in electricity

generation while simultaneously maintaining a strong fiscal and export dependence on hydrocarbons. Revenue from pre-salt oil finances a significant share of the federal government's social and infrastructure programs, which makes any discussion of limits on the expansion of new exploration blocks politically difficult, even when that expansion is hard to reconcile with the climate commitments the country has made to the international community. This dilemma is not unique to Brazil, but there it takes on a particular scale because of the size of its economy and the political weight of the state oil company in national energy decisions.

At the territorial level, it is also worth noting that the wind and solar expansion in the Northeast coexisted with a relative lag in the region's basic social indicators, which led different state governments to demand more robust mechanisms for compensation and local productive linkage. Lazaro et al. (2022) suggest that, absent a deeper reform of federal energy governance, this state-level demand is unlikely to translate into substantive change in the short term, given that the main decisions on system expansion continue to be made through planning instruments centralized in Brasília.

MEXICO: INSTITUTIONAL REFORM, ENERGY JUSTICE AND THE IMPLEMENTATION CHALLENGE

Mexico has considerable renewable potential, especially solar power in the north of the country and wind power in the Isthmus of Tehuantepec, but its energy transition has been slower than Chile's or Brazil's, and was marked by significant institutional instability for much of the period analyzed. Over these years, Mexican energy policy combined a growing predominance of state-owned enterprises in the sector, a high dependence on natural gas — partly imported from the United States — and recurring controversies over the role that private participation should play following the 2013 energy reform and its subsequent modifications. Anglés-Hernández and Valenzuela (2023) describe this period as one of prolonged legal and institutional uncertainty, in which successive regulatory changes altered grid-access rules, dispatch conditions, and renewable-energy contracting mechanisms, raising doubts among investors about the long-term stability of operating conditions.

The National Electric System Development Program 2024-2038, published by the Mexican government, steered the projected expansion of the electricity system toward a combination of public and private generation, although significant challenges persisted regarding the expansion of transmission, the certainty needed to attract long-term investment, and

coordination with the federated states, whose specific powers in energy matters remain limited compared with those of other federal countries in the region (México, 2024).

The central role given to the Federal Electricity Commission within this program reflects a vision of energy sovereignty that prioritizes state control over generation and transmission, but it has also raised doubts among private investors about the actual conditions of dispatch and grid access for non-state renewable projects. This tension between energy sovereignty and openness to private investment runs through much of the Mexican public debate on the transition and had not, by the close of the period analyzed, found a stable institutional resolution capable of reducing the regulatory uncertainty noted by Anglés-Hernández and Valenzuela (2023).

Despite these regulatory advances, implementation of the program faces concrete challenges related to the actual expansion of transmission networks, the regulatory certainty needed to sustain private and public investment predictably, and coordination with state governments, several of which have developed their own technical capacities without yet having sufficiently robust institutional channels to connect them to federal planning. Elizondo, Smith and Ibarrarán (2023) map precisely this development of state-level renewable policies in Mexico and find considerable heterogeneity: some states have moved forward with their own promotion instruments, while others still lack any specific regulatory framework on the matter, deepening existing territorial asymmetries. The social dimension of Mexico's transition also calls for rigorous indigenous consultation procedures — particularly relevant in the Isthmus of Tehuantepec, where Zapotec and Ikoots communities have for years been questioning the installation of wind farms — and effective benefit-sharing mechanisms in wind and solar projects developed in territories with a significant indigenous presence.

COMPARATIVE RESULTS

The comparison among the three cases shows that Chile, Brazil and Mexico are advancing along clearly differentiated paths, each with particular strengths and gaps that are worth systematizing before proposing policy recommendations.

In terms of relevance, all three countries show consolidated performance: their policies respond to well-founded energy and climate diagnoses, albeit with different levels of detail in characterizing the specific territorial

problems each region faces. In terms of coherence, performance is more uneven. Chile shows a partial level, with significant advances in linking climate policy to energy policy, but with as-yet-unresolved tensions between the expansion of new extractive industries associated with the transition — such as lithium and green hydrogen — and territorial-protection objectives. Brazil likewise shows a partial level, marked by the persistent tension between its international climate leadership and the expansion of hydrocarbon production. Mexico shows the most incipient level of the three cases, due to the regulatory instability that has made it difficult to sustain long-term coherence among different policy instruments.

In terms of effectiveness, Chile shows consolidated results in the expansion of installed renewable capacity and in the progress of coal-plant retirement, although with only partial results in the associated regional-development indicators. Brazil shows consolidated effectiveness in maintaining a predominantly renewable electricity mix, although with more partial progress on multilevel territorial governance. Mexico shows incipient effectiveness, constrained by the successive regulatory changes that have hindered the continuous execution of planned expansion programs.

Regarding spatial equity, subnational capacity and participatory quality — the three territorial criteria this article adds to the traditional evaluation framework — Chile achieves the relatively most favorable performance thanks to its explicit just-transition plans, although financing and infrastructure gaps remain that limit its actual reach. Brazil achieves partial performance, with subnational capacities that vary greatly among states and a participatory quality that varies enormously depending on the type of project and the region of the country. Mexico achieves the most limited performance on these three criteria, owing to the combination of weak federal coordination, heterogeneous state capacities, and indigenous consultation processes that, while formally existing, do not always manage to alter the final design of projects challenged by communities.

These results allow for a central comparative conclusion: none of the three countries analyzed simultaneously combines consolidated energy effectiveness with equally consolidated territorial equity. Chile comes closest to this combination thanks to its explicit territorialization, but financing remains insufficient given the scale of pending regional challenges. Brazil has the scale and financial instruments needed, but has yet to translate that capacity into more balanced multilevel governance. Mexico, above all, needs to recover regulatory stability before it can advance

steadily on the territorial criteria this article considers essential for speaking of genuinely sustainable regional development.

PUBLIC POLICY RECOMMENDATIONS

Building on the preceding analysis, a common agenda of twelve lines of action is proposed, one that each country should adapt to its own institutional conditions rather than apply uniformly without regard to differences in context.

First, territorial transition contracts: multi-year agreements signed between the national government, subnational governments and relevant social actors, applicable to territories affected by the closure of existing facilities or by the arrival of large-scale energy investments, setting verifiable commitments for both parties rather than mere general statements of intent.

Second, regional diversification funds: resources specifically earmarked for technical training, productive infrastructure, environmental recovery and local innovation, disbursed before the most significant territorial impacts occur, rather than as a reactive response once economic or social harm has already taken place.

Third, synchronization of grids and storage: coordinated planning between the expansion of renewable generation and the simultaneous expansion of transmission networks and storage capacity, so as to avoid the congestion and energy waste that today affect different regions in all three countries analyzed.

Fourth, benefit-sharing standards: mandatory options for community participation in energy projects, which may include local development funds, technical-training programs, and infrastructure shared between the company and the host community, rather than leaving this decision entirely up to each private developer.

Fifth, distributed and community ownership: specific credit and regulatory support so that cooperatives, municipalities and community organizations can develop and operate their own small- and medium-scale renewable generation projects, thereby broadening the ownership models available beyond the dominant model of large private developers.

Sixth, an explicit link with industrial policy: training programs and technical certifications aligned with the real demand of projects planned for each territory, avoiding both an oversupply of trained labor for jobs that will

never materialize and a shortage of qualified personnel in the regions where new projects are actually installed.

Seventh, regional additionality in financing criteria: national development banks that incorporate, in their project-evaluation criteria, indicators of quality employment, local supplier participation and territorial resilience, rather than only the project's expected financial return.

Eighth, independent observatories: open systems for tracking data on employment, health, land use and socio-environmental conflicts associated with the energy transition, managed with sufficient independence from the very bodies being evaluated, so that civil society and academia can autonomously verify the progress governments claim.

Ninth, fossil-coherence tests: a rigorous, public assessment of the climate compatibility of every new hydrocarbon project with national decarbonization targets, applied consistently and not selectively depending on the project's origin or the fiscal circumstances of the moment.

Tenth, participation with real influence: deliberative processes triggered at early stages of a project's or policy's design, with genuine capacity to change decisions already made, rather than merely informative processes carried out once the core decisions have already been adopted.

Eleventh, energy poverty as a mandatory monitoring indicator: systematic territorial monitoring of electricity tariffs, grid access, thermal comfort in housing and continuity of supply, so that the energy transition can also be assessed from the standpoint of households' day-to-day experience, not only from the growth of installed capacity.

Twelfth, adaptive reviews: periodic updating of policy instruments based on evidence generated by their own implementation, within a context of institutional stability that allows continuous learning without undermining the predictability needed to sustain long-term investment.

DISCUSSION

The results presented confirm that the energy transition cannot be treated as a conventional sectoral policy confined to the remit of energy ministries. Its effects simultaneously cut across employment, industrial policy, territorial planning, environmental protection, electricity tariffs, transport infrastructure, and each country's public finances. When governance remains compartmentalized among different ministries without effective

coordination mechanisms, the transition's unwanted costs end up being shifted between departments and levels of government, with no single body assuming full responsibility for managing them. This finding aligns with what Rogge and Reichardt (2016) note regarding the coherence of policy mixes, and suggests that the main outstanding task in all three countries is not so much designing new isolated instruments as building institutional architectures capable of integrating those that already exist.

Likewise, the comparison shows that energy justice needs to translate into enforceable rights and effectively committed budgets, moving beyond the often merely rhetorical use it receives in the official documents of all three countries. It is relatively easy to declare that a transition will be just; it is far more demanding to establish the concrete mechanisms — funds, timelines, verifiable indicators — that make it possible to confirm, years later, whether that promise was actually fulfilled in the territories where projects were installed or where existing facilities were closed.

The limits of this comparison should also be noted. The analysis focuses on official documents and academic literature available up to June 2024, without incorporating direct interviews with local actors, which would likely enrich the understanding of how the energy transition is experienced from the territory itself. Future research could complement this documentary approach with fieldwork in specific regions, as well as extend the comparison to other Latin American countries with different energy trajectories, such as Colombia, Argentina or Uruguay, whose transition processes present particularities not addressed in this article for reasons of scope.

CONCLUSIONS

The comparative evaluation of Chile, Brazil and Mexico shows that energy-transition policies generate sustainable regional development when they manage to combine national targets that remain stable over time, adequately coordinated transmission and storage infrastructure, explicit territorial instruments, multi-year financing committed in advance, and evaluation systems capable of observing the actual distribution of benefits and costs among different social groups and territories. None of the three countries analyzed has so far managed to fully integrate these five elements, although each offers distinct and valuable lessons for the others and, more broadly, for the rest of the region.

The Latin American energy transition will not be just simply because of the clean nature of the technologies that underpin it. It will be just, to the extent that it truly is, if it manages to bring about a positive and verifiable change in the distribution of capabilities, risks and opportunities between the regions that today concentrate the energy resources of the future and those that, until now, have remained relatively on the margins of their most lasting benefits. This is, ultimately, the criterion that should guide both the design and the evaluation of the public policies examined in this article.

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