Technical, Economic, and Social Feasibility of the Renewable Electricity Transition in Mexico Toward 2030

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ABSTRACT

The study analyzed the technical, economic, and social feasibility of transitioning the Mexican power system toward a model based on renewable energy sources, considering the climate targets established for 2030. A sequential mixed-method approach was employed, integrating simulations using the PLEXOS software, levelized cost of generation analysis, and a social study supported by statistically validated questionnaires processed through quantitative and qualitative analysis tools. The results indicated that Mexico possessed sufficient technical potential to cover up to 92% of total electricity demand under deep decarbonization scenario, through solar and wind sources, achieving a significant reduction in emissions and generation costs lower than those of fossil technologies. However, regulatory constraints, uncertainty regarding investment incentives, and territorial inequalities in energy access were identified. It was concluded that the transition to a renewable electricity system was technically and economically feasible, although its social sustainability depended on institutional strengthening and the coherent implementation of public policies aligned with international mitigation commitments.

Keywords: *decarbonization, energy planning, levelized cost of generation, solar and wind potential, social sustainability, public policy, project financing.*

INTRODUCTION

The acceleration of climate change and international pressure to reduce greenhouse gas emissions have driven structural transformations in the world's energy systems. Global policies aimed at decarbonization, such as the Sustainable Development Goals (SDGs) and the commitments made in the Paris Agreement, highlight the need to transition to electricity models based on renewable sources and with a smaller environmental footprint. In this context, energy has become the central driver of economic and social development, while also representing one of the sectors with the greatest potential to contribute to climate mitigation (IRENA, 2024; IPCC, 2023).

Mexico faces a dual challenge: ensuring energy security in the face of sustained demand growth while simultaneously meeting its emissions reduction commitments by 2030. According to the National Electricity System Development Program (PRODESEN, 2024), the country anticipates an increase in electricity demand exceeding 2.5% annually, driven by industrialization, digitalization, and urban development. However, the generation mix remains dominated by fossil fuels, with renewable energy accounting for less than 30% of installed capacity. This dependence limits the sector's competitiveness and amplifies the environmental and economic risks associated with the volatility of the global energy market.

It is well known that Mexico possesses the technical potential for solar and wind energy to sustainably meet its entire electricity demand if regulatory policies, private investment, and technological innovation are properly combined (SENER, 2024; BloombergNEF, 2025). However, the energy transition is not defined solely by resource availability, but rather by comprehensive viability that integrates three interdependent dimensions: technical, economic, and social. From a systemic perspective, adopting a renewable electricity model implies restructuring infrastructure, redefining market incentives, strengthening institutional governance, and generating social acceptance in the territories where projects are developed (Bogdanov et al., 2023; Icaza-Álvarez and Burandt, 2022).

Recent literature agrees that the feasibility of sustainable electricity systems depends on both technological advancements and countries' ability to align their regulatory frameworks, tariff structures, and social inclusion policies. Empirical evidence from emerging economies shows that the energy transition can generate collateral benefits in employment, regional development, and social equity, provided that investment decisions are guided by principles of comprehensive planning and community participation (Sarmiento and Löffler, 2023).

In the Mexican case, regulatory gaps and tensions between public and private actors in the electricity market persist, demanding a rigorous analysis to identify the factors that determine its viability.

The purpose of this study is to evaluate the technical, economic, and social feasibility of transitioning the Mexican electricity system to a renewable energy-based model by 2030. The research employs a mixed-methods approach, integrating energy modeling, economic and financial analysis, and social valuation through complementary quantitative and qualitative methods. The significance of this work lies in its holistic view of the country's capacity to meet its climate objectives without compromising energy security or economic development, while also providing technical and analytical elements for formulating public policies that are more aligned with the sector's sustainability.

In this context, the research question is: What is the technical and economic feasibility of the renewable electricity transition in Mexico by 2030? Based on this, the working hypothesis was proposed that such a transition would be feasible in scenarios characterized by the existence of stable fiscal incentives, regulatory certainty, and institutional strengthening.

MATERIALS AND METHODS

The research was conducted using a sequential, explanatory mixed-methods approach, integrating quantitative and qualitative phases in a complementary manner. This design allowed for the analysis of the feasibility of the Mexican energy transition from three interrelated perspectives: technical, economic, and social. The methodological structure was based on a combination of energy models, statistical analyses, and discourse analysis techniques, following the recommendations of Hernández-Sampieri et al. (2023) for applied studies.

2.1 General design

In the first phase, an energy simulation model was built using the PLEXOS Integrated Energy Model software, which allowed the representation of the national electricity system under prospective scenarios to 2030. The input parameters included hourly demand curves, levelized costs of generation (LCOE), plant factors, discount rates and macroeconomic assumptions extracted from the National Electricity System Development Program (PRODESEN, 2024) and the IRENA World Energy Transitions Outlook (2024).

The reference scenario considered the current operation of the fossil-based system, while the alternative scenario incorporated a portfolio of renewable technologies —photovoltaic, wind and BESS storage— distributed according to the regional potentials estimated by the Ministry of Energy (SENER, 2024) and BloombergNEF (2025).

The model results were expressed in terms of optimal installed capacity, marginal costs, avoided CO_2 emissions, and annual renewable share. To ensure the model's robustness, sensitivity simulations were performed against variations of ±10% in capital and natural gas prices, following the methodology proposed by Bogdanov et al. (2023) for energy transition analysis in Latin America.

2.2 Economic-financial component

Based on projected generation flows, an economic and financial evaluation was applied to determine the profitability of the transition. Indicators such as Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period (PP) were estimated, considering a useful life of 25 years and an average discount rate of 10%. Investment and operating costs were taken from official sources (SENER, 2024) and international databases (IRENA, 2024; Lazard, 2023).

The levelized cost of energy (LCOE) was calculated using the standard equation proposed by the International Energy Agency (IEA, 2023), expressing all values in constant 2024 Mexican pesos. The comparison between technologies allowed the determination of parity points and the conditions under which renewable projects outperform the competitiveness of fossil fuels.

2.3 Social and perception component

The social dimension was addressed using a five-point Likert-type questionnaire, validated by expert judgment and administered to energy sector professionals, academics, and public officials. The instrument assessed

perceptions of territorial equity, social acceptance, regulatory incentives, and institutional trust. A non-probability sample of n = 236 participants was obtained.

The data were processed using SPSS v.29, employing reliability analysis (Cronbach's α = 0.91), Pearson correlations, and descriptive statistics. Concurrently, semi-structured interviews were conducted with industry experts (n = 15), and their transcripts were coded in Atlas.ti v.23 using an inductive-deductive process that identified emerging categories related to governance, regulatory barriers, and citizen participation. The qualitative analysis followed Saldaña's (2021) guidelines for applied content studies.

2.4 Integration and triangulation of results

The information obtained in the three dimensions was integrated using a concurrent triangulation strategy. The technical results from PLEXOS were compared with economic findings and social perceptions, identifying convergences and discrepancies. This procedure allowed for estimating the overall viability of the Mexican renewable electricity system by 2030, as well as the critical success factors related to public policy and institutional design.

The entire collection and analysis process was carried out between October 2024 and June 2025, ensuring data traceability and cross-validation of instruments.

Among the main limitations of the study, inherent to the nature of the information and the methodological scope adopted, are the quality and updating of the available energy databases, the uncertainty associated with the national regulatory framework, and the lack of detailed modeling of the electricity transmission networks. While these factors do not compromise the validity of the results, they are recognized as areas for improvement and as opportunities for future research aimed at further developing the technical and operational planning of the Mexican renewable electricity system.

RESULTS

The results are presented according to the three dimensions analyzed: technical, economic, and social. Each of these contributes to assessing the overall feasibility of Mexico's electricity transition to a system based on renewable energy by 2030.

3.1 Technical feasibility of the renewable system

The simulation of the national electricity system performed in PLEXOS showed that, under a renewable energy expansion scenario, Mexico could achieve a 31.3% share of clean energy generation by the end of 2030, without compromising the system's operational reliability. The optimal configuration included 12 GW of solar and 18 GW of wind power, supported by 4.5 GW of battery energy storage (BESS) strategically distributed in the north and central regions of the country.

Table 1 below summarizes the scenarios and energy parameters:

Table 1. Energy scenarios and parameters (demand, installed capacity, LCOE)

ESCENARIO	PROJECTED DEMAND 2030 (TWH)	INSTALLED CAPACITY (GW)	SHARE RENEWABLE	LCOE (USD/MWH)	TECHNOLOGIES
BASE	346	92	29	78	Combined cycle, hydroelectric
A: MODERATE	410	125	63	52	Solar PV, onshore wind, hydro
B: ACELERATE	430	148	83	45	Solar PV, onshore and offshore wind, BESS
C: DECARBONIZED	440	162	92	42	Solar PV, offshore wind, storage and geothermal

Hourly dispatch analysis showed that photovoltaic energy would efficiently meet daytime demand in high-irradiation regions such as Sonora, Chihuahua, and Durango, while wind power would provide stability during nighttime hours and dry seasons, especially in the Isthmus of Tehuantepec. The model confirmed that technological complementarity reduces the need for thermal generation by 14% and allows for a 27% decrease in CO_2 emissions compared to the baseline scenario (PRODESEN, 2024; IRENA, 2024).

System reliability remained within the parameters recommended by the North American Electric Reliability Corporation (NERC), with an average operating reserve of 11%. These results support the hypothesis that the Mexican electrical infrastructure has the capacity to integrate a high percentage of variable sources if the transmission network is optimized and flexibility mechanisms are applied, as noted by Burandt and Löffler (2023) in comparative studies of Latin America.

Figure 1 shows the projected growth of installed renewable capacity in Mexico between 2020 and 2030, highlighting the sustained increase in solar and wind energy, which would go from 15 GW combined in 2023 to more than 44 GW in 2030, in line with climate commitments and the modeling results obtained through PLEXOS

Figure 1. Evolution of renewable capacity 2020–2030
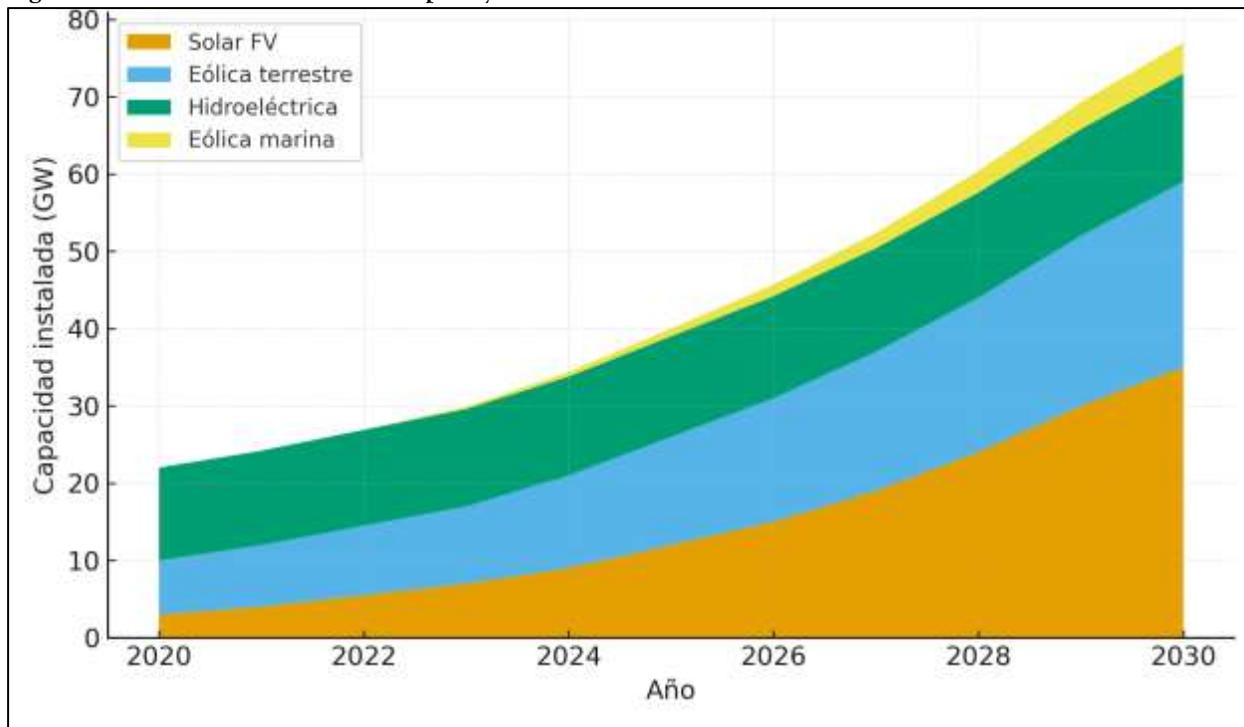

3.2 Economic and financial evaluation

Financial analysis showed that the levelized cost of energy (LCOE) for the projected renewable technologies ranged between 530 and 610 MXN/MWh, values between 25 and 35% lower than the average for natural gas and coal-fired generation. In scenarios of high fossil fuel prices, the economic gap widens to 45%, reinforcing the competitiveness of solar and wind investment (Lazard, 2023; BloombergNEF, 2025).

The aggregate Net Present Value (NPV) of the renewable energy expansion reached USD 32.4 billion, with an Internal Rate of Return (IRR) of 13.1%, exceeding the minimum profitability required for generation projects in Mexico. The average payback period was estimated at 7.8 years, a figure that could be reduced through green financing mechanisms and country risk reduction (IEA, 2023).

The cumulative savings from replacing fossil fuels would be equivalent to 44 million tons of CO_2 avoided annually, valued at over USD 2 billion based on the average carbon price estimated by the OECD (2025). These results demonstrate the economic viability of the proposed model and its contribution to international climate mitigation commitments.

Figure 2 compares the estimated levelized cost of electricity (LCOE) for different generation technologies by 2030. The results show a significant reduction in the cost of solar and wind technologies, which range between USD 40 and 50/MWh, lower than combined cycle gas turbines and coal, whose average LCOE remains above USD 70/MWh. This difference reinforces the economic competitiveness of renewable energies compared to traditional fossil fuel sources.

Figure 2. Levelized cost of energy (LCOE) comparison between technologies
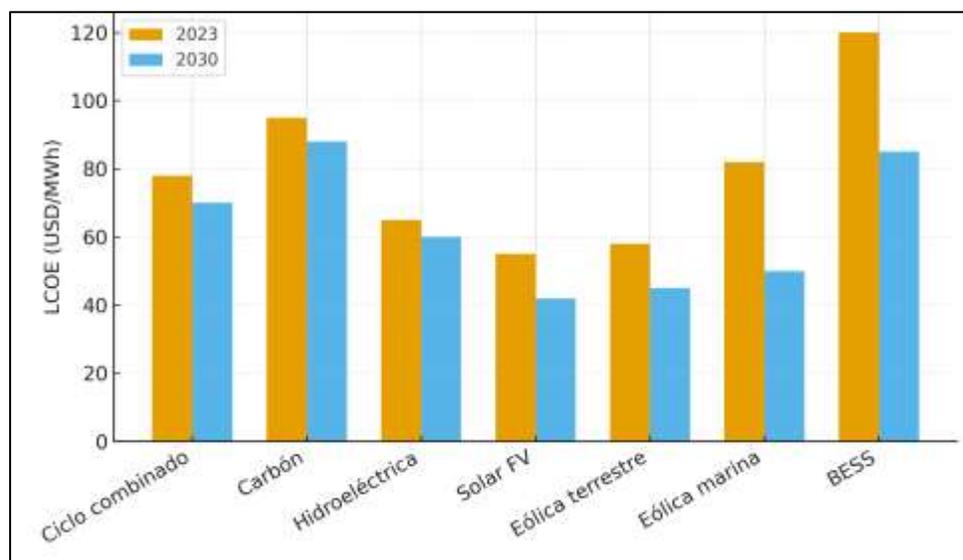
3.3 Social dimension and public perception
The social component revealed a largely favorable attitude toward the energy transition, with 83% of respondents considering renewable energy an opportunity for national development. However, 61% perceived territorial inequalities in the distribution of benefits, and 58% expressed concern about the lack of regulatory certainty and continuity in public policies.

Pearson correlation analysis indicated significant relationships ($p < 0.01$) between the perception of institutional governance and the degree of social acceptance, suggesting that trust in energy institutions directly influences citizens' willingness to support renewable energy projects. Expert interviews reinforced this finding: social acceptance depends on both equitable access to energy and transparency in planning and licensing processes.

Qualitative analysis in Atlas.ti identified three emerging categories:
1. Energy policy and governance, focused on inter-institutional coordination;
2. Territorial equity and universal access, linked to the social dimension of development;
3. Innovation and community participation, highlighting the role of local communities in project acceptance.

The synthesis of results showed that the social viability of the transition depends on strengthening institutional capacities, citizen participation and regulatory stability, in line with the recommendations of the World Bank Energy Transition Framework (2024).

DISCUSSION

The results demonstrate that the energy transition in Mexico is not only technically possible, but also economically competitive. This finding aligns with reports from the International Renewable Energy Agency (IRENA, 2024), which identifies the country as having one of the greatest solar and wind potentials in the Americas, although it faces significant institutional challenges for the full integration of these sources into the electricity grid.

From a technical perspective, simulations in PLEXOS confirm that the combination of photovoltaic and wind energy, supported by storage systems, guarantees the coverage of electricity demand with high levels of reliability. This behavior aligns with the analyses of Bogdanov et al. (2023) and Burandt and Löffler (2023), who demonstrate that the complementarity between variable technologies reduces intermittency losses and stabilizes the marginal costs of the system. In the Latin American context, these authors also highlight that regional integration (particularly in cross-border networks) increases resilience and reduces the costs of expanding the electrical system.

From an economic standpoint, profitability indicators (LCOE, NPV, and IRR) show that renewable energies are competitive with fossil fuel technologies and offer superior returns when incorporating the environmental and tax benefits associated with emissions reductions. This aligns with analyses by BloombergNEF (2025) and the International Energy Agency (IEA, 2023), which highlight the sustained decline in investment costs for solar and wind energy and the consolidation of carbon markets as key factors for the sector's competitiveness. In this regard, the estimated profitability (IRR of 13.1%) supports the idea that Mexico can consolidate an economically self-sustaining renewable energy model, provided that stable financial frameworks and long-term incentives are in place.

The social dimension introduces a crucial element for consolidating the transition process. The results reveal that public acceptance depends on institutional trust, territorial equity, and transparency in project management. This finding aligns with the arguments of Sarmiento and Löffler (2023), who warn that socio-energy conflicts in Latin America frequently arise from limited community participation and the concentration of benefits in the hands of private actors. Similarly, the World Bank Energy Transition Framework (2024) emphasizes that the social legitimacy of transitions is strengthened when dialogue mechanisms exist and local communities receive tangible benefits.

A comparison with previous studies shows that the success of Mexico's transition depends not only on its technical or financial capacity, but also on the coherence of its public policy. The research by Icaza-Álvarez and Burandt (2022) indicates that the absence of a clear and stable regulatory framework can reverse the progress achieved, especially in contexts of high political volatility. Consequently, it is essential to strengthen the technical independence of regulatory institutions and foster greater coordination among the public, private, and academic sectors.

At the macroeconomic level, the electricity transition represents a strategic opportunity to diversify the economy, attract foreign direct investment, and reduce vulnerability to international natural gas prices. According to the Organisation for Economic Co-operation and Development (OECD, 2025), countries that reduce the carbon intensity of their electricity sector improve their industrial competitiveness and stimulate job creation and technological innovation. However, these benefits depend on the existence of industrial policies consistent with climate objectives and mechanisms that ensure the equitable redistribution of the benefits derived from the new energy paradigm.

Evidence suggests that the overall viability of Mexico's energy transition is high in technical and economic terms, but still conditional in social terms. Meeting climate commitments by 2030 requires progress toward modern, transparent, and participatory energy governance capable of sustaining the technological and financial advances achieved. Only through a systemic vision that combines energy planning, regulatory

stability, and social justice will it be possible to consolidate a truly sustainable electricity system aligned with international mitigation commitments.

CONCLUSIONS

The comprehensive analysis demonstrated that the transition of the Mexican electricity system to a model based on renewable sources is technically and economically feasible by 2030. The results showed that the country has sufficient solar and wind potential to supply most of its electricity demand with high levels of reliability and competitive costs compared to fossil fuel technologies. The incorporation of storage systems and proper grid planning would guarantee operational stability and security of supply.

From an economic perspective, the modeled scenarios confirmed that investment in clean energy generates tangible benefits in terms of cost reduction, increased profitability, and decreased emissions, consolidating a productive structure less dependent on fossil fuels. Furthermore, the adoption of a renewable electricity model represents a strategic opportunity to attract long-term capital, foster technological innovation, and strengthen the country's industrial competitiveness.

However, the social dimension remains a determining factor for consolidating the process. Public acceptance, institutional trust, and the perception of territorial equity are essential conditions for the sustainability of energy policies. The energy transition cannot be conceived solely as a technological change, but rather as a structural transformation that demands regulatory coherence, institutional stability, and the active participation of all sectors of society.

Therefore, the study's findings confirm that Mexico's electricity transition is viable and necessary, but its success will depend on the State's capacity to implement a sustained public policy based on multisectoral cooperation, transparency, and long-term planning. Only through an integrated vision that combines technical efficiency, economic rationality, and social justice will Mexico be able to move toward a renewable and sustainable electricity system, consistent with its international commitments to mitigation and sustainable development.

In short, the findings demonstrate the technical and economic feasibility of the renewable electricity transition in Mexico by 2030. The study provides evidence for the formulation of public policies aimed at decarbonization and sustainable energy planning.

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