**The Tangled Path to Decarbonizing the Mexican Grid**

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According to recent studies, Mexico could achieve net-zero carbon dioxide emissions by mid-century using wind and solar energy at significantly lower costs than the current generation based on fossil fuels. There is already growing evidence that Mexico has insufficient transmission capacity today, and integrating a massive amount of renewables would require additional expansion in the transmission lines to deliver that power. In addition, more sectors of the economy are expected to be electrified in the future, making this even more relevant. The political context is not favorable to private initiatives investing in renewable energies, and the low price of natural gas imported from Texas favors the official speech toward giving the national utility CFE more market share in the generation segment, regardless of the economic dispatch order. Throughout the paper, we analyze the intricate situation of the Mexican electricity market and identify the challenges that make it difficult to build the necessary transmission capacity, but also identify the existing opportunities for massively incorporating renewable energy sources. Finally, we suggest potential policy solutions that can solve these problems while helping to achieve the targeted reductions in GHG emissions.

The Energy Transition Law (ETL), approved by the Mexican government in December 2015, commits the country to two clean energy generation targets. These targets are part of the country’s commitment to reducing greenhouse gas emissions and transitioning to a more sustainable energy system. In the short run, the ETL sets a target for the country’s electricity generation to be 35% clean energy by 2024. The term 'clean energy' in this context refers to both renewable energy sources, such as solar, wind, hydro, and geothermal, as well as other low-carbon energy technologies like nuclear power and efficient cogeneration. Most cogeneration plants in Mexico burn natural gas. Considering cogeneration as ‘clean’ is controversial at best and clearly brings the country closer to its 2024 goal. The long-term goal is to achieve 50% clean electricity generation by 2050. This goal may seem more or less ambitious depending on one's perspective, but, in fact, more than 75% of the electricity generated during the last five years was derived from fossil fuels, with natural gas accounting for 60-64%, oil for 8-10%, and coal for 2-3%.

There are several factors that combined are critical to achieve the proposed goals. First, due to its abundance of natural resources, notably wind and solar, Mexico has considerable potential for developing renewable energies ([Hancevic et al.](#_bookmark7), [2022](#_bookmark7); [Alem´an-Nava](#_bookmark3) [et al.](#_bookmark3), [2014](#_bookmark3)). Second, the levelized cost of electricity (LCOE) for renewable generation technologies is becoming increasingly competitive. This is true even considering adjustments to the traditional LCOE for non-dispatchable variable renewable energy due to its intermittent nature ([Shen et al.](#_bookmark13), [2020](#_bookmark13)). Third, in the current electricity sector configuration, more than 60% of the electrical energy is produced by burning natural gas, and this fuel is mostly imported from the United States at very affordable prices. That makes it tempting to continue using natural gas for years to come during the energy transition process. This raises the question of how fast renewable sources should be accommodated while natural gas plants remain operational ([Vera et al.](#_bookmark17), [2023](#_bookmark17); [Bugaje et al.](#_bookmark4), [2022](#_bookmark4); [Gu¨rsan and de Gooyert](#_bookmark6), [2021](#_bookmark6); [Kemfert et al.](#_bookmark9), [2022](#_bookmark9)). According to the results in [Sarmiento, Molar-Cruz, Avraam, Brown,](#_bookmark11) [Rosell´on, Siddiqui, and Rodríguez](#_bookmark11) ([2021](#_bookmark11)), low natural gas prices could decrease the use of carbon-intensive technologies in the short term, but also decrease renewable investments over time, leading to lower emissions in the short term and higher emissions in the long run.

Fourth, the current administration has aimed to strengthen the national electricity company (*Comisi´on Federal de Electricidad*, CFE) which mostly operates thermal power plants. Since December 2018, several attempts have been made to end the economic dispatch, giving priority to CFE generation plants regardless of their marginal costs and pollution emission levels (Gutiérrez-Meave, Rosellón, and Sarmiento, 2024; [Moreno](#_bookmark10), [2022](#_bookmark10); [Hancevic, Núñez, and Rosell](#_bookmark7)ón, [2022](#_bookmark7)). Also, the current administration has made it difficult for private generators of electricity from renewable sources to connect their newly constructed plants to the network. The general feeling in the industry is that the government consider renewable sources to be unreliable and intermittent to a degree that they cannot contribute significantly to electricity supply or provide baseload power ([Torres and Niew¨ohner](#_bookmark16), [2023](#_bookmark16)). Finally, the government has altered the game rules and flooded the market with renewable energy certificates. As a result of all these factors, renewable energy projects have been discouraged and therefore disrupted. If the hostile climate towards renewable energy continues, the 50-percent long-term goal will be difficult to achieve.

Fifth, if as expected, renewable generation will be incorporated into Mexico’s grid to a large extent, expanding the transmission network and developing sufficient storage capacity will be the biggest challenges. In the first case, there are already some bottlenecks due to insufficient transmission lines ([Tarín-Santiso et al.](#_bookmark15), [2019](#_bookmark15)). And this applies regardless of whether the electricity is generated from conventional or renewable sources. [Zen´on and](#_bookmark18) [Rosell´on](#_bookmark18) ([2017](#_bookmark18)) compared a centrally-planned grid expansion in Mexico by an ISO within a power-flow model vis-a-vis a proposed incentive price-cap mechanism to promote the expansion of Mexican networks. They concluded that the transmission planning process proposed by Mexican authorities during the previous administration converged to a welfare-optimal planning process. However, the question remains open now since the new administration is in power. In terms of storage capacity, its emergence depends strongly on technological advances that make energy storage affordable ([Schmalensee](#_bookmark12), [2022](#_bookmark12); [Junge, Mallapragada, and](#_bookmark8) [Schmalensee](#_bookmark8), [2022](#_bookmark8); [Shi, Wang, Huang, Li, and Dong](#_bookmark14), [2020](#_bookmark14)). Additional measures like real-time pricing of electricity and cross-border interconnection with US electricity and imbalance markets can help reduce the need for transmission and storage investments.

There is then a contradiction between the favorable conditions the country has to undergo an energy transition in its electricity sector, and the current configuration of the electricity market and the political objectives of the current administration. In sum, environmental, social, political, and economic objectives are in tension. This problem, of course, is not unique to Mexico. For instance, a similar analysis for the US electricity market is performed by [Davis, Hausman, and Rose](#_bookmark5) ([2023](#_bookmark5)). There are, however, certain avenues through which diverse perspectives and objectives can be brought together in the Mexican case. The aim of this paper is precisely to analyze each of the points raised above and to propose different paths towards decarbonizing the Mexican system.

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