Report on U.S.-Mexico Cross Border Electrical Interconnections in the Context of Connect 2022: Current Status and Future Outlook
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Introduction

In April 2012, at the Sixth Summit of the Americas, Colombian policymakers in partnership with the U.S. Department of State launched the Connecting the Americas 2022 (“Connect 2022”) initiative, which aims to increase access to reliable, clean, and affordable electricity in the region. Mexico and Guatemala are particularly important to achieving the goals of Connect 2022. Guatemala lies at the northernmost end of the SIEPAC electric interconnection, a transmission corridor which links the power grids of Central America. Mexico geographically links the United States and the SIEPAC region, and thus enhanced interconnectivity between the U.S. and Mexico and between Mexico and Guatemala would be a meaningful step toward connecting in the Americas from Canada to Panama.

The Stanford team examined progress on electrical interconnections and the potential for electricity trade between the United States and Mexico and between Mexico and Guatemala. Over the course of the project, we identified key drivers and barriers from the Mexican perspective that are critical to moving forward in cross-border electricity trade, including regulatory structures, the political climate, and private sector involvement.

The market transformative interconnections envisioned by Connect 2022 may be possible in the long-term. There are, however, a number of key steps that could be taken to enhance the U.S. commercial presence in the Mexican energy sector and address the regulatory and technical challenges that stand in the way of greater interconnectivity and private investment in this area.

In the short-term, the key recommendations are to establish a US commercial presence in the Mexico generation sector—an area where international private sector investment is welcomed. Simultaneously, U.S. utilities and electricity sector planning agencies should work with CFE, the Mexican state-run utility, to increase support for smaller cross-regional interconnections. In the long-term, the U.S. Department of State should facilitate engineering and policy communication on both sides of the border in order to establish technical feasibility for Connect 2022’s vision. Finally, in both the short-and long-term, the State Department should recognize the importance of renewables to justifying interconnections, and advocate as necessary for their integration into Mexican energy strategy.

Our 5 key findings are as follows:

1. There has been a history of reluctance toward private participation in Mexico’s energy sector
2. Private sector opportunities are abound in generation but restricted in transmission
3. There is a need for economic and technical studies to draw a clear case for interconnections
4. Renewable energy could be a driver for interconnection development
5. In the short to mid-term, interconnections will likely continue on a small scale
FINDING 1: There has been a history of reluctance toward private participation in Mexico’s energy sector

The mission of Connect 2022 is to encourage private power investment and cross-regional electricity interconnections. Mexico, however, has not had a strong history of private sector involvement in the power sector. The provision of electricity in Mexico has been considered a public good and thus has been reserved to the domain of the federal government. Attempts to allow greater private sector access to this area have been generally seen as a threat to national sovereignty and have faced strong resistance from powerful constituencies. Article 27 of the Mexican Constitution explicitly states that generation, transmission and distribution of electrical energy is solely the responsibility of the state. Additionally, Article 1 of the Law of Public Service of Electrical Energy (LSPEE) places these into the domain of the state-owned utility, the Federal Electricity Commission (CFE).

With the pressure of increasing demand and insufficient public funds for investment in the electricity sector, in 1992 exclusions to what was considered “electricity for public service,” were created to allow private sector participation in generation of electricity. To oversee this area falling outside CFE’s realm, a regulatory body, the Energy Regulatory Commission (CRE), was created in 1993. The regulatory structure of the Mexican energy sector is summarized in Appendix A. The market structure on the other hand, is vertically integrated where CFE acts as a monopoly in generation, transmission and distribution. An important ramification of this is that CFE, having a constitutionally guaranteed stake in the electricity market, has developed a considerable degree of political influence. Associated labor unions are also politically important and hold strong opposition to electricity sector privatization.

Political support for – or opposition to – electricity sector reform initiatives varies widely among political parties in Mexico. There are three key political parties: National Action Party (PAN), Institutional Revolutionary Party (PRI), and Party of Democratic Revolution (PRD). The PAN is the most market-oriented party of the three and generally supports initiatives to allow greater private actor involvement in the electricity sector. The PRI, while perhaps less market-oriented than the PAN, has also begun to show support for modest reform in recent years and this support may increase under the leadership of the new president, Enrique Peña Nieto. The PRD remains strongly opposed to any such initiatives.

The Zedillo (PRI) reforms in 1999 reflected an ambitious plan for the privatization of the energy sector. The proposed reforms were essentially a full privatization of the sector and proved to be politically unpalatable. The next attempt at reform, by PAN under the Fox administration, was less drastic, but also met with significant opposition and was also unsuccessful. Thus far, some degree of success at reform was achieved under former president, Felipe Calderón (PAN), including a law strengthening the CRE, the renewable energy law, and the liquidation of Luz y Fuerza del Centro. Key opposition to the latter stemmed from public opinion and labor unions, which were strongly opposed to fundamentally reorganizing the electricity market structure. This history indicates that electricity sector reform may be more successful by proceeding with a step-by-step incremental approach in order to receive requisite political support.
President Peña Nieto (PRI) has stressed the need to modernize Mexico’s energy sector and implement a series of other structural reforms to promote investment and development in Mexico. Since the memory of drastic reforms by Zedillo is still fresh in the public mind, Peña Nieto does not seek to institute large-scale privatization of electric power service in the medium-term. However, Peña Nieto does seem to move in the direction of creating greater incentives for renewable energy, and importantly for private sector involvement in this area (See Section 4). In 2012, Peña Nieto recently signed the General Climate Change Law of 2012, which creates gradual subsidies for renewable energy development. This may increase the share of renewables in the power mix.

The link between electricity reforms and interconnections is indirect – but political support for increased interconnectivity between the U.S. and Mexico is highly unlikely to occur outside of a political landscape that is supportive of private sector involvement in the electricity sector. Appendix B depicts a timeline of events that have impacted private sector involvement in the electricity sector and their relative positive or negative impacts on private sector involvement and the development of interconnections between the U.S. and Mexico. The 1992 Article 27 constitutional amendment and the 1993 creation of CRE are notable events that increased the involvement of private sector actors in the electricity sector. However, the rejection of the 1999 Zedillo and 2001 Fox proposed reforms highlighted the resistance to widespread structural reform in the electricity sector. The failure of these reforms is still fresh in the memory of the political parties.

Within the context of Connect 2022, renewable energy is considered to be a window of opportunity. President Peña Nieto is moving slowly on encouraging more incentives for renewable energy, but there are significant problems on the ground when local populations and their concerns must be addressed – concerns that arise out of the political vacuum that exists in these areas.

FINDING 2: **Private sector opportunities abound in generation**

The expansion of cross-border electricity interconnections between the United States and Mexico offers world-class opportunities for private sector investment. While Mexico’s regulatory context forbids private sector ownership and operation of electricity transmission infrastructure, greater integration among the region’s electricity grids could catalyze a rich ecosystem of commercial activities. The most attractive commercial opportunities for private sector actors related to cross-border electricity interconnections are in the field of electricity generation. By providing companies with transmission infrastructure and more diverse market access, greater grid integration may spur development of power projects whose economics would otherwise not be viable. While most near-term growth in power generation is expected to occur through combined cycle natural gas power plants, electricity interconnections also promise to unlock vast renewable wind and solar resources close to the U.S.-Mexico border. In addition to growth in generation, transmission interconnections could lead to a proliferation of engineering, procurement, construction (EPC) contracts as well as opportunities for electricity trading, private consulting, and financial services.

Due to Constitutional and regulatory restrictions on non-state ownership of transmission infrastructure, the largest opportunities for private sector involvement in Mexico’s electricity sector is
in the field of generation. The most important private participants in Mexico’s electricity sector are the Independent Power Producers (IPPs) who provide electricity flows from their investments in exclusivity to CFE through long-term contracts. A second category of private involvement is self-supply, in which private investors or grouped interests pursue non-utility based generation for internal consumption (auto-generation). Another category that is closely related to self-supply is cogeneration, where industrial firms seek to generate electricity for self-supply from combustion processes derived from gases that originate as industrial byproducts. Finally, the law contains provisions for export and import related activities. Separate licenses are required for each activity which means, for example, that a company that maintains a permit, for say, cogeneration, may not engage in the importation or exportation of electricity unless it secures the appropriate permits.

Despite significant regulatory barriers and mixed policy incentives, Mexico offers world-class opportunities for private actors seeking to invest in the electricity space. Strong economic growth combined with tremendous renewable resource potentials have spurred a steady influx of foreign investment in the country’s semi-liberalized, but expanding, power market. Policy factors such as Mexico’s renewable portfolio standard, CFE’s movement to upgrade old, inefficient power plants via IPP and OPF contracts, and municipality-level partnerships with private companies will also provide fresh channels for private participation. Above all else, the ubiquitous presence of top global power companies in Mexico has proven that, despite heavy state involvement, Mexico’s energy sector holds plentiful possibilities for private ventures. As Mexico’s energy system evolves, opportunities will continue to emerge in a wide variety of areas, and the government will continue to rely on increased private investment to meet the country’s future energy needs.

FINDING 3: There is a need for economic and technical studies to draw a clear case for interconnections

There are significant benefits that could be realized by actors on both sides of the border through greater interconnectivity in the region. Such benefits include grid stability, the ability to take advantage of load profile differences, opportunities for renewable development, increased reserve margins, trading opportunities, and decreased marginal cost of generation.

There is considerable support for electrical interconnectivity among public sector actors in the U.S. and in Mexico. Officials at CFE and CRE have expressed a positive attitude toward this idea. CFE’s upcoming Development Plan will for the first time have an appendix dedicated explicitly to interconnections.

There are differing conditions, and therefore differing incentives for electricity trade, in different areas of the border region. Inexpensive electricity prices in the Texas (ERCOT) region, driven largely by the low price of natural gas, provide incentive for CFE in import electricity during off-peak hours. The price paid per Megawatt Hour (MWh) to import from ERCOT is much below CFE’s marginal cost of generation in most hours. In addition, industrial consumers on the Mexican side of the border
could greatly benefit by arranging PPAs with generators in ERCOT as they pay high electricity prices under Mexico’s tiered pricing system.

ERCOT may also benefit through the development of more interconnections in the region. In addition to the fact that generators in the region would have a larger market for power sales in off-peak hours, grid stability would be improved through interconnectivity. ERCOT is currently experiencing problems with falling reserve margins meaning that on extremely hot summer days (and in some cases cold winter days) the amount of spare capacity available to accommodate jumps in demand becomes dangerously low, increasing the likelihood of forced load shedding or even outages. Under emergency conditions ERCOT may be able to depend on CFE for the import of electricity to maintain an acceptable level of stability. This generally characterizes the power flow that occurs over existing generation. During off-peak hours CFE imports power from ERCOT. During emergency conditions in ERCOT, ERCOT imports power from CFE.

The situation in the Baja California region is much different. This area of the Mexican grid is not connected to the mainland grid. There is a plan to connect this grid to the mainland grid which has appeared in literature as to be completed in 2014, however our sources indicated that this will be delayed at least until 2017, and others indicate that this is always three years away.

The large geothermal resource in Baja California provides a significant amount of baseload generation in the area. During off-peak hours Baja California exports surplus generation to California while during peak hours Baja California imports electricity to maintain grid reliability. This pattern is markedly different from that described above in the ERCOT region. As the Baja California grid is part of WECC these connections are synchronous which facilitates trade across the border. This area of the border region holds vast potential for greater solar and wind power development.

Despite these potential benefits, the periodic positive dialogue surrounding U.S.-Mexico interconnections has led to very little tangible action. In order for Connect 2022 to proceed, relevant actors must be unequivocally convinced of the positive economic benefits of cross-border electricity infrastructure development. Therefore, a robust feasibility study including an economic cost benefit analysis with detailed nodal price forecasting that addresses engineering challenges must be completed.

Enhancing interconnectivity across the U.S.-Mexico border will require a substantial amount of attention to engineering difficulties. It is not sufficient to merely increase capacity for cross-border flows. Increased transmission infrastructure is needed from point of import to where loads are being served. Planning for altered congestion patterns, contingencies, and ancillary services would be necessary and determining the precise engineering requirements will require a significant investment in engineering studies.

Completing such a robust study that will require a significant amount of communication among engineers on both sides of the border suffers from a “chicken and egg” problem. Without assurance of substantial economic benefits this does not reach a high enough level to actively pursue a study that incorporates these engineering difficulties. However, without such a study economic benefits remain highly uncertain and relevant actors will likely remain uncommitted to the initiative.
Another reason that interconnections tend to not reach a high level of priority is that they are often overshadowed by other issues in the energy sector. Currently, resources in the energy sector are largely concentrated on shale gas and deep-water oil while interconnections (and the electricity sector more generally) tend to take a backseat.

Although many individuals in policy making roles on both sides of the border may be aware of the benefits that could be achieved through greater interconnectivity, this issue tends to not reach a high enough level of priority for follow up action to occur. It may be effective to identify individual “champions” within government that could promote the issue of interconnections to a higher level of priority. In Mexico, one such individual could be Luis Videgaray Caso, current Secretary of Finance and Public Credit, who holds a favorable position toward the development of interconnections.

**FINDING 4: Renewable energy demand could be a driver for interconnection development**

According to forecasts, between 2011 and 2026, electricity demand in Mexico is expected to increase by approximately 32 GW and require 17,000 km of new transmission lines along with transformation substations, a significant number of distribution lines, and distribution substations. The massive investments required (of more than US$100 billion) may lead to a lack of sufficient public resources to meet rising demand. This has become a leading factor in supporting the need for private involvement in the electricity sector.

CFE currently faces major financial challenges in the expansion of its electrical grid. Historically, CFE has been awarded the amount of funding that it indicates is necessary through its annual development plan. In recent years, however, there has been increasing push back from the executive branch in order tighten up the budget and reign in national debt. CFE will have difficulty in the coming years to meet the country’s power infrastructure investment needs without funding from private investors. There are, however, major barriers to private participation in power transmission in Mexico. Meanwhile, there is strong political and popular opposition to unbundling or privatization of the electricity sector to give more opportunities for private actors and progress is likely to be very slow in this area.

The U.S.-Mexico border region holds enormous potential for the development of wind and solar power generation. In many areas, optimal locations for generation lie on the Mexican side of the border while the closest large demand centers lie on the U.S. side. Greater interconnectivity, particularly in the Baja California region, may lead to increased opportunities for renewable development and for private sector involvement in the development of such projects.

Two Mexican agencies that are particularly important in renewable resource project development are the energy regulator, CRE, and the Ministry of Energy, SENER. The role of CRE in the Mexican electricity sector has become increasingly important in recent years, and notably increased through the legislation of 2008. The role of CRE is most apparent in the permitting of renewable projects and
import and export projects. However, thus far CFE maintains a monopoly on infrastructure and contract negotiations with IPPs.

The LAEFRTE (renewables law) states that SENER is mandated to enforce the renewable generation target (35% non-fossil fuel powered energy by 2024) and thus SENER is very committed to meeting this goal. For CFE however, incentives are not aligned such that this goal should be in their interest. CFE has the explicit mandate to provide electricity to the Mexican population at the lowest technically possible cost of generation. The lowest cost under current conditions is achieved by increasing the share of fossil fuel powered generation, particularly natural gas due to its low price. Due to their relatively higher cost of generation, it is not in CFE’s interest to emphasize the development of renewables into their annual development plan.

Every year the planning division of CFE develops a 15 year plan to specify the new generation and transmission that will be needed to meet future demand. SENER has the responsibility to approve this plan. Load forecasts are coordinated with SENER and are based on expected economic development. This planning includes the planning of interconnections and notably for the first time this year’s 15 year plan will include an appendix dedicated to interconnections. This year’s plan is also likely to reflect CFE’s lack of commitment to the renewable generation goal in which case SENER may not approve of the plan creating a political divide between the two agencies.

CFE receives project financing the Secretaría de Hacienda (The Ministry of Finance). In order to receive approval CFE must show that a generation project will achieve 12 percent minimum return on investment. Projects that meet this are generally approved while others so not. For less profitable renewable projects CFE may submit proposals that do not meet this benchmark knowing that they will likely be declined but passes on the responsibility of meeting the renewable standard of the LAEFRTE.

In order to meet the non-fossil fired generation targets of the LAERFTE, there have been various policies put in place to incentivize the development of renewable resources. Such policies are generally contrary to the interests of CFE. For example, CFE is required to offer greatly reduced wheeling rates, $1-3/MW for renewable generators engaged in self-supply contracts compared to $10-13/MW for thermal fired generation.

Retail electricity prices are determined by the Secretaría de Hacienda (Ministry of Finance) and follow a tiered system. Within this system residential customers pay the lowest rates, which are below the marginal cost of generation for CFE. This means that CFE loses money providing electricity to households in Mexico. Industrial and commercial consumers pay significantly higher rates and account for a large portion of the revenue of CFE. In the short term there may be substantial economic incentive for border region industrial and commercial consumers to import power from the United States, particularly from the ERCOT region. However, this is contrary to the interests of CFE, which would lose the revenue generated from power purchases by these consumers.

It may be in the interest of the Mexican government to create independent bodies that take some of the responsibilities of CFE. For example an independent system operator (if CENACE were to be separated from CFE) and an independent body in charge of import and export of electricity could create incentives that are perhaps more aligned with supply and demand in the electricity market.
Finding 5: In the short-to-mid-term, interconnections will likely continue on a small scale

Due to differences in market structure and regulations, development of electricity interconnections between the U.S. and Mexico will most likely be limited to small scale projects in the short-to-mid term. The previous sections have presented a variety of reasons why small scale projects are more likely to succeed than major (1 gigawatt plus) grid interconnections. On one level, entrenched legal restrictions and historical reluctance within Mexico’s political system limits the channels for investment in regional electricity infrastructure. Secondly, conflicting incentives within the CFE and asymmetric market structures on both sides of the border have created a risky, costly, and confusing environment for cross border transmission development. Although electricity trade across most of the existing interconnections are low in volume, the large interconnections in Baja California serve as an example of how electricity trade can dramatically increase when an interconnection has been put into place.

A total of 11 electrical interconnections currently exist between the United States and Mexico. These interconnections appear in Appendix C. Four of these interconnections have synchronous trade of electricity between the U.S. and Mexico, meaning that electricity is continuously exchanged back and forth. These interconnections link the Baja California peninsula with California, and Chihuahua with New Mexico. It is no accident that these four are key thriving interconnections: a unique setup, both from a regulatory perspective, as well as an economic commitment in both U.S. and Mexico, have been pivotal to making this happen.

The largest interconnections are the two in Baja California, which serve 800 MW of electricity over the interconnection lines – more than the other nine combined. These large interconnections have had a significant impact on electricity trade between the U.S. and Mexico. Electricity trade has increased overall in recent years -- this suggests that Connect 2022 is set in an appropriate context, one where electricity trade is increasing overall (see Appendix D). Furthermore, Baja California accounts for a significant portion of this overall trade in imports and exports. However, the region has seen a progression from a net importer to a large net exporter, but the amount of net exports appears to be following a downward trend.

Geography and politics plays a significant role in successful interconnections. Baja California is a peninsula within Mexico, meaning that it is both a) horizontally separated from the rest of Mexico, existing almost in parallel with the rest of the country, and b) vertically aligned with California and Canada. The separation from the rest of Mexico is not only geographical, but also true with respect to electricity grids: Baja California is truly its own entity in terms of energy. This separation from the rest of Mexico makes CFE, the national energy utility, and its regulators, more open to experimenting in the region as projects launched there can serve as a testing ground for the rest of Mexico without having immediate implications for the rest of the country.
As a result of these developments, Baja California is a member of the Western Electricity Coordinating Council (WECC)—a regulatory body that coordinates electricity interchange between the western regions of Canada, the US, and Mexico. In terms of a forward-thinking outlook on interconnections, this framework is critical: the Baja interconnection is successful because the regulatory body necessary to coordinate electricity flow and manage the technical aspects of an internationally-shared transmission resource was already put in place.

The nine other interconnections highlight the diverging stances of the CFE and Connect 2022 on the strategic size and goal of interconnections. The State Department envisions a border that is replete with interconnections that mirror the size and scope of the Baja California interconnection, while CFE envisions any expansion in transmission capacity to mimic the smaller interconnections already in place.

The Baja interconnection, though a success, is not representative for how interconnection development is likely to occur between the U.S. and Mexico. Barring a game-changing reform in Mexico’s electricity sector, the various complexities and barriers discussed above will likely limit cross border interconnections to smaller, largely asynchronous projects.

**Conclusion**

The vision of Connect 2022 is that increased electrical interconnectivity along the U.S.-Mexico border has the potential to yield large social and economic benefits for both sides. A main finding of this paper is that various interconnections exist in the region, but there is substantial potential to increase the number of interconnections and volume of electricity trade.

Despite these benefits, development of interconnections remains a relatively low priority on both sides of the border. In order to increase the visibility of Connect 2022, the Stanford research team offers a number of key conclusions and policy recommendations that will help increase connectivity between the US and Mexico.

While there are gains that could be made through electricity interconnections, political initiatives such as the Cross-Border Electricity Task Force are not followed up upon and will not be sufficient to incentivize action on the ground. In order for interconnections to reach a high level of priority, building an economic case as well as an engineering feasibility study will be necessary. This leads to a “chicken-and-egg” problem: a large-scale engineering study with cross-border cooperation is not a priority if the economic benefits are unclear, however the economic benefits will remain unclear without such a study.

A multilateral engagement should thus be encouraged in order to sponsor a comprehensive study of the US-Mexico border region and demonstrate the economic and technical feasibility of large scale grid interconnections. The U.S Department of State can facilitate the coordination of state-level actors with the CFE in order that both sides understand each other’s plans and can move forward effectively.
Although it may not be possible in the near term to begin work on large-scale interconnections, small-scale interconnections will be a way to move forward. Large-scale interconnections will require massive investment in transmission infrastructure to support them on both sides of the border while smaller interconnections can more effectively rely on existing infrastructure with more modest upgrades. These will be less disruptive to congestion patterns but may still offer significant opportunity for trade between the two countries. In addition, interconnections may need a “champion” within the electricity sector on both sides of the border. Mexico Energy Ministry, SENER, must develop a long term and medium term strategy that eventually leads towards interconnection building. The United States government can help develop a strategy to bundle and lock in these plans.


Lopez Hoyo, Jose. Former economic advisor to the President of Mexico. Personal Interview. 18 Feb 2013.


Peraza, Alejandro (PhD). Director General de Electricidad y Energías Renovables, Comisión Reguladora de Energía, México. Personal Interview. 18 Feb 2013.


Appendix A - Regulatory structure of the Mexican energy sector

Source: General Electric
Appendix B - **Timeline of significant events in the electricity sector**

Source: Authors’ creation
Appendix C - **Mexico's existing electrical interconnections**

Source: Author’s creation from SENER, Prospectiva del Sector Eléctrico 2012-2026
Appendix D – Mexico’s Electricity Imports and Exports (2000-2011)

Source: SENER Prospectiva
Appendix E – List of Experts Interviewed

Bob Lane, Regulatory Manager, San Diego Gas and Electric, United States

Carlos Alvarez, Vice President, Intergen, Mexico

Belcar Cuentas Zavallo, Development Manager, Iberdrola, Mexico

Chris Davy, Economic Officer, Embassy of the United States Mexico City, Mexico

Dr. Alejandro Peraza García, Director General de Electricidad y Energías Renovables, Comisión Reguladora de Energía CRE, México

Ramon Olivas Gastelum, Chief of Staff of the Undersecretary of Electricity, Secretaria de Energia, Mexico

Helio Gonzalez, Economic Value Manager, GE Power and Water, Mexico

Jose Gerardo Lopez Hoyo, former economic advisor to the President of Mexico, Mexico

Joseph Rowley, Vice President, Power, Sempra US Gas and Power

Jeremy Martin, Director, Energy Program, Institute of the Americas, USA

Jeff Thomas Pavlovic, Director of Electricity Operations, Secretaria de Energia

Pedro Resendez, Senior Counsel, Greenburg Traurig, Mexico City

David Campbell Shields, Director General, Energía a Debate Magazine, Mexico

Michael Simpson, Research Assistant, University of Texas-Austin LBJ School of Public Affairs, USA

Hernan Trevino, Analyst, Hunt Power, L.P, USA