September 24, 2021

U.S.-Mexico Climate Change Agenda Working Group

Briefing Paper – The Role of Renewable Energy in Mexico's Climate Change Strategy and Potential U.S.-Mexico Cooperation in Support of that Strategy
Follow-Up to Discussion on Wednesday, September 8, 3:00 pm EDT

Introduction

The International Energy Agency (IEA) earlier this year released its report "Net Zero by 2050: A Roadmap for the Global Energy Sector" (Net Zero 2050).[1] According to the report, renewable energy will play a central role in reaching the target of net zero emissions of greenhouse gases (NZE) by 2050, consistent with efforts to limit the long-term increase in average global temperatures to 1.5 °C above pre-industrial times.[2]

The NZE contemplates a significant increase in electricity needs in the world economy due, in substantial part, to increased economic activity and rapid electrification of end-uses (e.g., electric vehicles).[3] It is noteworthy that emerging market and developing economies account for 75% of the projected global increase in electricity demand to 2050.[4] To meet this need, Net Zero 2050 foresees that solar PV and wind will become the leading sources of electricity, supplemented by nuclear power; dispatchable renewable sources such as hydropower, bioenergy and geothermal generation; and batteries.[5] Under the NZE, the share of renewables in total output will increase from 29% in 2020 to over 60% in 2030 and nearly 90% in 2050."[6]

To date, Mexico has not made the pledge to reach net zero emissions by 2050, as 44 other countries have done.[7] Nevertheless, Mexico does incorporate renewables in its generation portfolio. As of April 30, 2021, 30.8% of Mexico's electricity generating capacity was renewable, including 14.1% hydroelectricity, 8.6% wind, and 7.9% solar.[8] By comparison, on the same date 23.9% of U.S. utility scale generating capacity was renewable, according to the U.S. Energy Information Administration (EIA).[9] This included 7.1% hydroelectricity, 10.9% wind, and 4.6% solar.[10]

Mexico has plans to build additional renewable generation capacity, but those plans are presented only in broad strokes. Mexico's state-owned power company, *Comision Federal de Electricidad* (CFE) states

---

[1] https://iea.blob.core.windows.net/assets/beceb956-0dcf-4d73-89fe-1310e3046d68/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf. Released on May 18, 2021..
[2] Ibid pp.3, 13.
[3] Ibid p. 113.
[4] Ibid.
[5] Ibid pp. 114-116.
[6] Ibid p. 114.
[7] The IEA reports that as of 23 April 2021, 44 countries and the European Union had "pledged to meet a net-zero emissions target: in total they account for around 70% of global CO2 emissions and GDP. Of these, ten countries have made meeting their net zero target a legal obligation, eight are proposing to make it a legal obligation, and the remainder have made their pledges in official policy documents." Net Zero 2050 at p. 32.
[8] *Programa para el Desarrollo del Sistema Eléctrico Nacional* (PRODESEN) 2021-2035, Capítulo 3, Cuadro 3.4. https://www.gob.mx/cms/uploads/attachment/file/649445/PRODESEN_CAP_TULO_1_-_2_-_3.pdf.
[9] U.S. Energy Information Administration, Electric Power Monthly, June 2021, https://www.eia.gov/electricity/monthly/archive/june2021.pdf, Table 6.1.
[10] Ibid.

that it plans to add new renewable generation to its portfolio in 2027, without any details.[11] The Ministry of Energy (*Secretaría de Energia* or SENER), in its power plant development program for 2021-2035,[12] presents aggressive figures on the projected growth of solar photovoltaic (PV) distributed generation (DG). But beyond this, the SENER program provides only generalized information, with nothing about what projects will be built, the capacity of those projects, what they will cost or how they will be financed. On the other hand, CFE does present some interesting ideas on private sector financing of CFE generation assets, where CFE's focus is on fossil-fuel generation. These financing structures could also be used for CFE renewable energy projects.

Mexico has significant renewable capacity, but will clearly need more to meet its own goals and join the NZE club. What role should the U.S. play to support the growth of renewable energy in Mexico? This paper makes the following suggestions:

- The U.S. should build upon Mexico's indicative power plant development program for 2021-2035, and seek clarification on key missing elements, as described above, so that the U.S. can help Mexico to implement that plan with respect to renewable energy.

- For Mexico's solar PV distributed generation plans, which are highly focused on rural areas and the poor, the U.S. can collaborate with Mexico on financing and implementation plans, which will include a Mexican contribution and a whole-of-government approach from the U.S. side.

- For Mexico's broader clean energy strategy contained in the power plant program, once Mexico identifies the projects to be built, at least on a tentative basis, the U.S. can collaborate with Mexico on renewable energy project planning, including feasibility, grid integration and reliability studies, as well as cost studies.

- The U.S. and Mexican governments should engage in discussions on the financing of renewable energy projects, and how the U.S. might support Mexico with financing strategies.

    - Mexico has placed substantial emphasis on the placement of green bonds, and the U.S. could discuss with Mexico how it might assist Mexico in leveraging the proceeds of these bonds for development of renewable energy.

    - The U.S. should consider how it might increase its ambition with respect to financial support of Mexican renewable energy projects, e.g., with respect to grants, direct lending, credit support for third party borrowing to develop renewable energy projects, and collaboration with the multilateral financial institutions on project finance.

---

[11] CFE Plan de Negocios 2021-2025. Table 5.2, https://www.cfe.mx/finanzas/Documents/Plan%20de%20Negocios%20CFE%202021.pdf.

[12] *Programa Indicativo para la Instalación y Retiro de Centrales Eléctricas* (PIIRCE) [Indicative Program for the Installation and Retirement of Power Plants], https://www.gob.mx/cms/uploads/attachment/file/649447/PRODESEN_CAP_TULO_5.pdf, included in Mexico's *Programa de Desarrollo del Sistema Eléctrico Nacional* (PRODESEN) 2021-2035 [Development Plan for the National Electric System 2021-2035], https://www.gob.mx/sener/articulos/programa-para-el-desarrollo-del-sistema-electrico-nacional.

    - Mexico has evinced strong opposition to private sector participation in the Mexican energy sector. Yet Mexico will not be able to carry out development of renewable energy on the scale it has proposed – much less what would be necessary under an NZE scenario – without private sector financing. The U.S. and Mexico should carry out a discussion on how private sector financing of renewable energy in Mexico might be structured consistent with Mexican energy sovereignty.

- Transmission is a bottleneck for development of renewable energy on both sides of the border. In this regard, the U.S. and Mexican governments should facilitate meetings of experts on both sides of the border to compare planning strategies and tools, decision processes, how to manage public input, strategies for financing new transmission, and cost allocation strategies.

- The North American Renewable Integration Study (NARIS) – a multi-year international effort with support from the governments of the U.S., Canada and Mexico – is the first detailed power system integration study for the entire North American continent. The U.S. and Mexico should discuss how U.S. support for Mexico's renewable energy planning could be structured to foster increased North American renewable energy integration consistent with NARIS.

- As the foregoing talks develop, the U.S. and Mexico might discuss whether Mexico could increase its ambition in renewable energy to move toward a net zero emissions strategy by 2050.

This paper is in five parts. The first part will discuss why electricity from renewable energy is a competitive opportunity for Mexico. The second part will review Mexico's development of renewable energy to date pursuant to the Energy Reform initiated under the administration of President Enrique Peña Nieto. Third, the paper will review recent moves by President Andrés Manuel López Obrador to modify the Energy Reform and prioritize the state-owned enterprises Petróleos Mexicanos (PEMEX) and CFE over private enterprise; and how such moves may impact further development of renewable energy in Mexico. The fourth part will review President López Obrador's plan for future development of renewable energy under his state-centered energy policy. Finally, the paper will develop in more detail the suggestions presented above regarding the role the U.S. might play in supporting Mexico's clean energy strategy, particularly with respect to renewable energy.

I. Solar and Wind Power provide a competitive opportunity for Mexico

The IEA highlights the importance of renewable energy generally in reaching Net Zero Emissions by 2050. However, the greatest opportunity is with solar and wind because of their cost advantages. Other renewable and clean technologies will play an important role, i.e. nuclear for meeting base load requirements, and geothermal for the same reason. Hydro can also meet base load and is dispatchable, which means it can help with the intermittency of other renewable resources. But nuclear and geothermal, with the technologies currently in use, are much more expensive than solar and wind. Hydroelectricity can be very inexpensive but it is dependent on water flows, which are becoming more uncertain due to climate change.

According to the International Renewable Energy Agency (IRENA), of which Mexico is a member, the cost of electricity from solar and wind power has declined precipitously over the last decade. Between 2010 and 2020, the cost of electricity from utility-scale solar photovoltaics (PV) fell 85%, concentrating solar power (CSP) costs fell 68%, onshore wind costs fell 56%, and offshore wind costs fell 48%.[13]

The trend "is not only one of renewables competing with fossil fuels, but significantly undercutting them."[14] Since 2010, 644 gigawatts (GW) of solar and wind capacity has been added globally, with estimated costs lower than the cheapest fossil fuel-fired option in each respective year. In emerging economies, the 534 GW added will reduce electricity generation costs by up to US$ 32 billion this year.[15]

New solar and wind projects are increasingly undercutting even the cheapest existing coal-fired power plants. IRENA analysis suggests 800 GW of existing coal-fired capacity globally has operating costs higher than new utility-scale solar PV and onshore wind, including US$ 0.005/kilowatt-hour (kWh) for integration costs. Replacing these coal-fired plants would cut annual system costs by US$ 32 billion per year[16] while also providing 20% of the emissions reduction needed by 2030 to achieve the 1.5°C climate pathway outlined in IRENA's World Energy Transitions Outlook.[17]

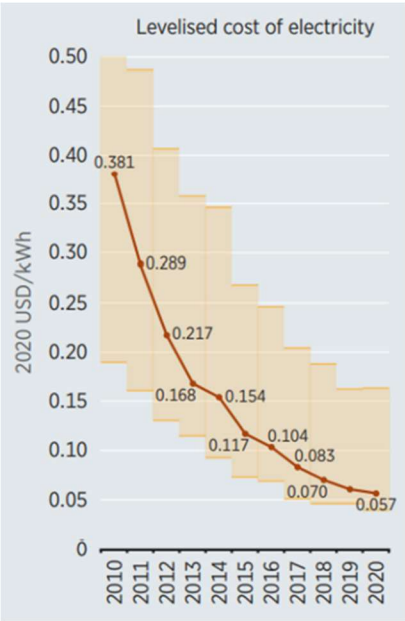
The falling cost of electricity from solar and wind presents an opportunity for Mexico on multiple fronts: decreasing electricity costs for citizens and businesses, decreasing the pollution load from aging fossil fuel power plants, which has a direct negative impact on its population's health, decreasing Mexico's greenhouse gas emissions, and increasing the country's overall economic competitiveness.

Solar

The global weighted-average levelized cost of electricity (LCOE) for newly commissioned utility-scale solar PV projects fell by 85% between 2010 and 2020, from US$ 0.381/kWh to US$ 0.057/kWh, as shown in Figure 1. Note that a "weighted average" LCOE means that there will be projects with costs above and below the weighted average. The shaded area in the chart below represents the 5th to 95th percentile of projects and the solid line is the weighted average.

[13] International Renewable Energy Agency (IRENA) (2021), *Renewable Power Generation Costs in 2020*, International Renewable Energy Agency, Abu Dhabi, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Jun/IRENA_Power_Generation_Costs_2020.pdf, p 3.
[14] Ibid.
[15] Ibid p. 11.
[16] Ibid p. 11.
[17] Ibid p. 3.

Figure 1: Levelized Cost of Electricity for Utility-Scale Solar PV



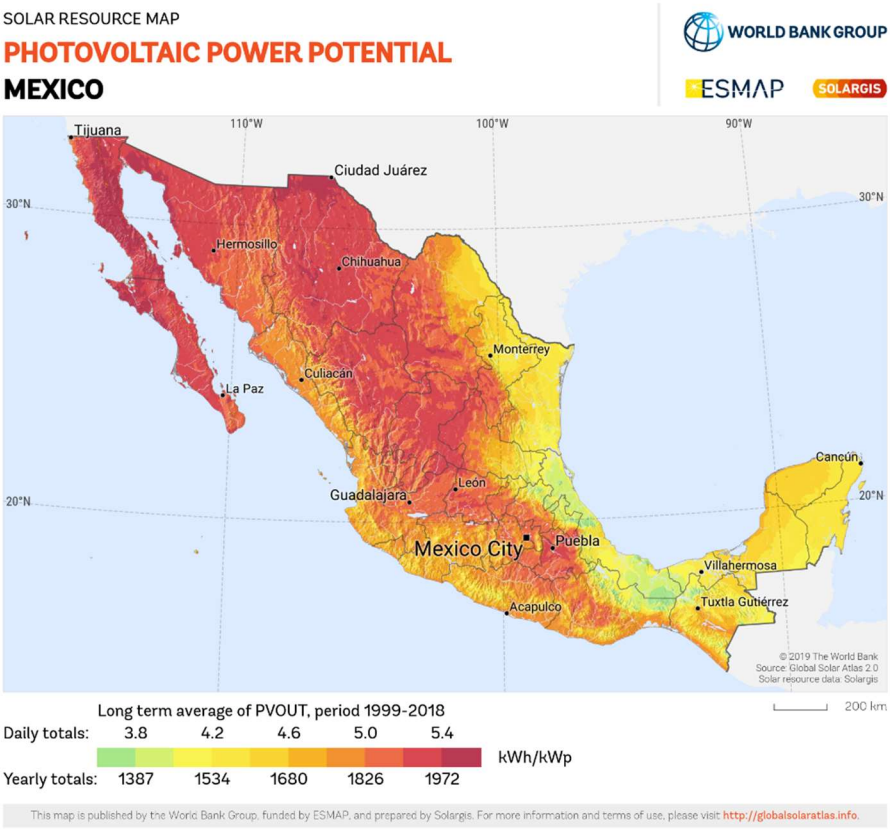
Source: IRENA[18]

For the period 2010 to 2020, total installed costs dropped dramatically, from US$ 4,731/kilowatt (kW) to US$ 883/kW over the same period.[19]

Mexico has high intensity solar energy over much of the country, which makes solar an attractive proposition for generation of electricity. The cost of electricity from solar, i.e. the LCOE, is affected not only by the installed costs of the solar project, but also by the intensity of the solar energy reaching the generation site. One way to measure the potential for solar energy generation is the electricity yield, meaning how much electricity (in kWh) is produced for every kW of module capacity (kWp) over time. Daily yield values greater than 4.5 kWh/kWp are considered excellent conditions for solar PV power.[20] Figure 2 shows that this criterion is true for much of Mexico, with particularly good conditions in Northern and Central Mexico and in the Baja California Peninsula.

[18] IRENA (2021), *Renewable Power Generation Costs in 2020*, International Renewable Energy Agency, Abu Dhabi, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Jun/IRENA_Power_Generation_Costs_2020.pdf , p 67.
[19] Ibid p. 14.
[20] https://globalsolaratlas.info/global-pv-potential-study.

Figure 2: Mexico's Photovoltaic Power Potential



Source: World Bank Energy Sector Management Assistance Program (ESMAP)[21]

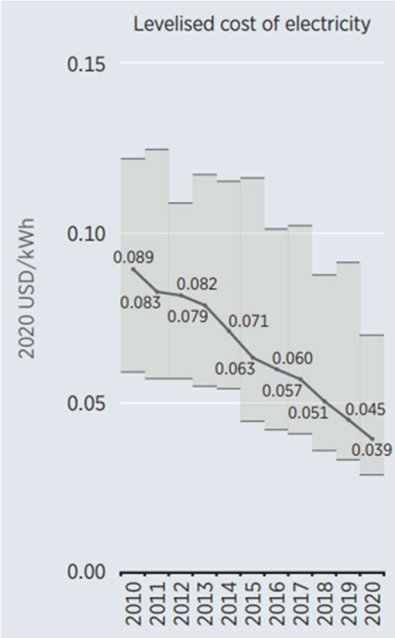
Wind

For onshore wind projects, the global weighted-average LCOE fell by 56% between 2010 and 2020, from US$ 0.089/kWh to US$ 0.039/kWh, as shown in Figure 3. Cumulative installed capacity grew from 178 GW to 699 GW over the same time period. Falling turbine prices and balance of plant costs, as well as higher capacity factors from today's state-of-the-art turbines were the drivers of the cost decline.[22]

[21] ESMAP. 2020. Global Photovoltaic Power Potential by Country. Washington, DC: World Bank. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/466331592817725242/global-photovoltaic-power-potential-by-country.

[22] IRENA (2021), *Renewable Power Generation Costs in 2020*, International Renewable Energy Agency, Abu Dhabi, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Jun/IRENA_Power_Generation_Costs_2020.pdf, p 26.

Figure 3: Levelized Cost of Electricity for Onshore Wind

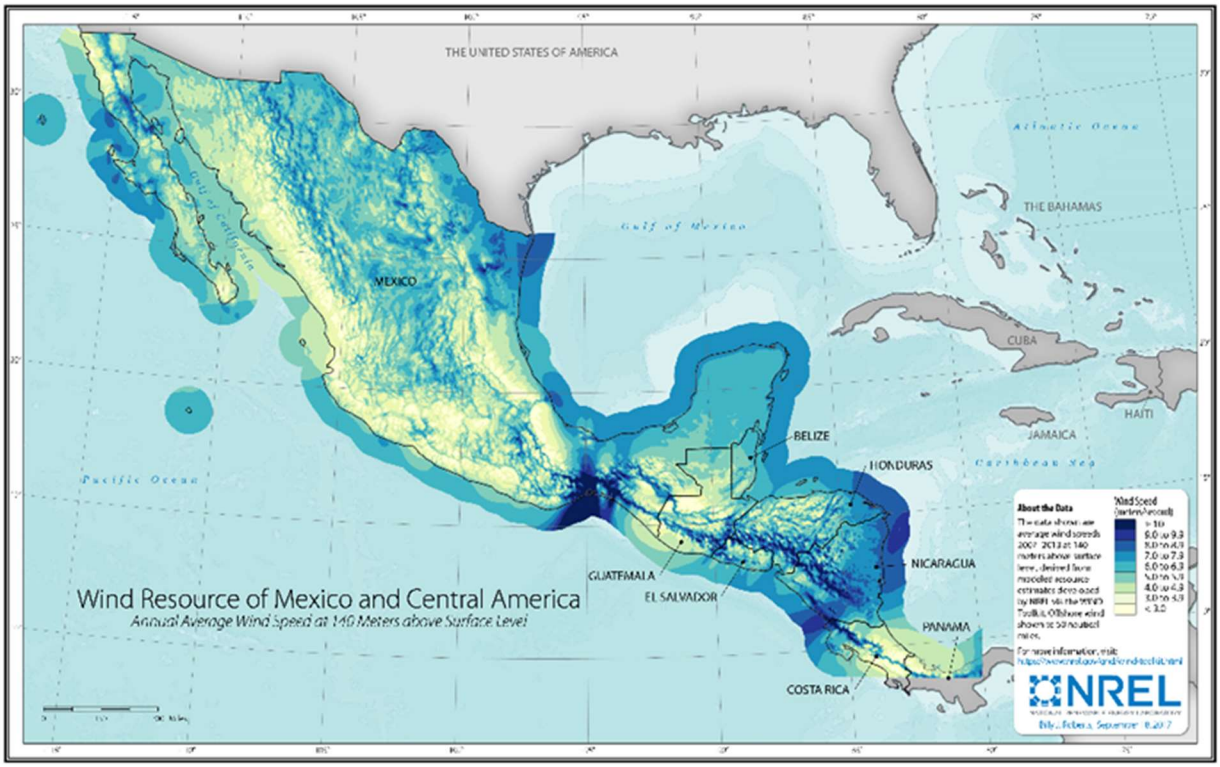


Source: IRENA[23]
Note: Shaded area represents the 5th to 95th percentile of projects and the solid line is the weighted average.

Some regions of Mexico have excellent potential for wind power. Wind speeds above 6 meters per second (m/s) are considered good for commercial wind generation.[24] Figure 4 shows suitable conditions in areas of Central Mexico and the Baja California peninsula and particularly good resources in the southern state of Oaxaca. The selection of wind speeds at 140 meters corresponds to the usual 500-foot limit for wind turbines in the United States,[25] and thus a likely common size of wind turbine in the region.

[23] IRENA (2021), *Renewable Power Generation Costs in 2020*, International Renewable Energy Agency, Abu Dhabi, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Jun/IRENA_Power_Generation_Costs_2020.pdf, p 51.
[24] https://www.eia.gov/energyexplained/wind/where-wind-power-is-harnessed.php.
[25] https://oeaaa.faa.gov/oeaaa/external/searchAction.jsp?action=showWindTurbineFAQs.

Figure 4: Mexico's Wind Power Potential



Source: National Renewable Energy Laboratory[26]

Managing the Variability of Solar and Wind Energy

To take full advantage of its intense solar and wind resources for the generation of low-cost electricity, Mexico will need to effectively manage the variability of these resources (when the sun does not shine and the wind does not blow), over the course of each day and over longer periods, including seasonally. The fundamental objective is to maintain the balance of electricity supply and demand when the supply of electricity from solar and wind is variable. This balance becomes more of a challenge as the share of solar and wind power as a percentage of total power generation rises. Nevertheless, there are cost-effective solutions to maintain an affordable and reliable balance of supply and demand through system flexibility. The state of California is a case in point, as its grid hit a record of 95% of renewable energy in April of this year.[27]

IRENA in its study "Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables" [28] reviews the solutions available to balance supply and demand to ensure system reliability. The key solutions are shown in the following Figure 5:

[26] https://www.nrel.gov/gis/assets/images/wtk-140m-mex-2017-01.jpg.
[27] S. Roth, "California just hit 95% renewable energy. Will other states come along for the ride?" Los Angeles Times,, April 29, 2021, https://www.latimes.com/environment/newsletter/2021-04-29/solar-power-water-canals-california-climate-change-boiling-point.
[28] IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate

Figure 5. Summary of solutions available for Variable Renewable Energy (VRE) grid integration, created by combining innovations in technologies, business models, market design and system operation

Supply-Side Flexibility Solutions	Grid Flexibility Solutions
Solution I: Decreasing VRE generation uncertainty with advanced weather forecasting	Solution III: Interconnections and regional markets as flexibility providers
Solution II: Flexible generation to accommodate variability	Solution IV: Matching Renewable Energy generation and demand over large distances with Supergrids
	Solution V: Large-scale storage and new grid operation to defer grid reinforcements investments

Demand-Side Flexibility Solutions	System-Wide Storage Flexibility Solutions
Solution VI: Aggregating distributed energy resources for grid services	Solution X: Utility-scale battery solutions
Solution VII: Demand-side management	Solution XI: Power-to-X solutions [e.g. to hydrogen, to heat]
Solution VIII: Renewable Energy mini-grids providing services to the main grid	
Solution IX: Optimizing distribution system operation with distributed energy resources	

Source: IRENA[29]

Each of these solutions offer benefits and challenges, with varying degrees of:

- Increase in system flexibility,
- Technology and infrastructure costs,
- Required regulatory changes,
- Required changes in the role of actors, and
- Other challenges, including political challenges.[30]

Some solutions with high benefits and low costs include the following: (1) reliance on the existing power system to provide flexibility through VRE backup; (2) decreasing VRE generation uncertainty with advanced weather forecasting; (3) demand-side management; and (4) if prices continue to decline rapidly, linking VRE generation with batteries to manage short-term variability. On the fourth point, a recent U.S. bid process for utility-scale solar plus batteries led to a winning bid of US$0.033/kWh, far below the global 2020 weighted average LCOE for utility-scale solar of US$ 0.057/kWh (without batteries) described above.[31] The developer of the winning solar plus battery project, when asked about the cost if the same project were in Mexico, estimated that with a credit-worthy buyer and taking

variable renewables. International Renewable Energy Agency, Abu Dhabi, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Innovation_Landscape_2019_report.pdf

[29] Ibid at p. 64-65, Figure 16.

[30] Ibid at p. 140, Table 5.

[31] S. Roth, "Los Angeles OKs a deal for record-cheap solar power and battery storage," Los Angeles Times, September 10, 2019, https://www.latimes.com/environment/story/2019-09-10/ladwp-votes-on-eland-solar-contract.

account of the differences between the U.S. and Mexico tax and customs regimes, the cost in Mexico could be as low as US$0.04/kWh, still below the global 2020 weighted average.[32]

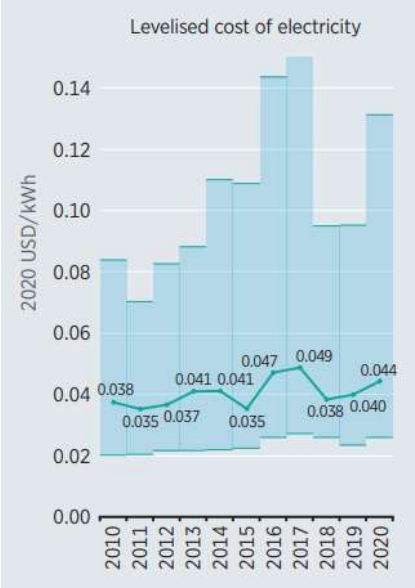
Determining the right solution or set of solutions for integrating VRE into a country's power grid is a complex undertaking, requiring careful analysis. There is no one-size-fits-all solution. Mexico could take a two-step process in its own analysis. The first would be to review the existing power system to determine the degree of flexibility that could be provided by the power system in its current state, since Mexico's existing gas-fired generation can ramp up and down quickly to provide support for VRE (subject to appropriate compensation). Then, if Mexico seeks to increase VRE for the generation of low-cost electricity beyond what the current power system can manage, it should undertake a planning process to evaluate different VRE scenarios and the use of alternative solutions to manage VRE under those scenarios. Mexico can then arrive at a tailored solution for its power system that balances the desired level of VRE penetration with management of costs, regulatory issues, system operations and other challenges.

Other Renewable and Clean Energy technologies

Solar and wind in Mexico will be supplemented by hydropower, nuclear and geothermal as alternatives to fossil fuels. We review here the costs of these technologies and related issues.

Electricity from new hydropower is potentially quite inexpensive. The following Figure 6, from IRENA, shows the LCOE for newly commissioned hydropower over the period 2010 to 2020:

Figure 6: Levelized Cost of Electricity for Hydropower



Source: IRENA[33]

[32] J. McNeece, The Economic and Strategic Arguments for Renewable Energy in Mexico, Institute of the Americas/Wilson Center Mexico Institute, pp. 3-4, The Economic and Strategic Arguments for Renewable Energy in Mexico.pdf (wilsoncenter.org).

[33] IRENA (2021), *Renewable Power Generation Costs in 2020*, International Renewable Energy Agency, Abu Dhabi, Renewable Power Generation Costs in 2020 (irena.org), p 51.

Once again, the shaded area represents the 5th to 95th percentile of projects and the solid line is the weighted average LCOE. In this case, we see the weighted average LCOE for hydropower in 2020 was US$0.044 per KWh, which is lower than the weighted average LCOE for utility-scale solar (US$ 0.057/kWh) and slightly higher than the weighted average LCOE for onshore wind (US$ 0.039/kWh) for the same year.

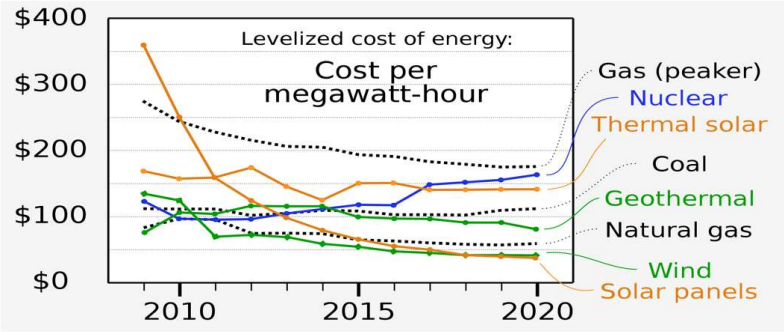
Unlike for solar and wind, where there is a decline in weighted average LCOE for the period 2010 - 2020, the weighted average LCOE for hydropower increases over the same period. IRENA explains this increase as follows: "The increase in LCOE since 2010 has been driven by rising installed costs, notably in Asia, which have been driven by the increased number of projects with more expensive development conditions compared to earlier projects. This is likely due to an increase in projects in locations with more challenging site conditions."[34] IRENA further advises "The data appears to suggest that many countries in [Asia, Europe and South America] are now developing hydropower projects at less ideal sites. Such projects are located further from existing infrastructure, or from the transmission network, resulting in higher logistical costs, as well as boosting grid connection costs. This results, overall, in higher installation costs."[35]

With the right site, in terms of conditions for construction and distance from existing infrastructure or the transmission grid, hydropower can be a low-cost source of electricity. One limiting condition is the availability of flowing water to run the hydropower generators. Reduced water flow as a result of drought can be devastating to the productivity of hydropower plants. In this regard, climate change is already affecting water flows and hydropower production and could have an even greater impact in the future.[36] Accordingly, developers of hydropower projects must analyze carefully forecasted rainfall and watercourse flows related to a proposed project.

For both nuclear and geothermal projects, costs are higher than for solar, wind and hydropower. IRENA does not analyze costs for nuclear, which is not renewable and hence not within IRENA's scope of analysis. However, there are alternative sources of cost data, The following Figure 7 is derived from data provided by Lazard, which prepares an annual cost analysis for different energy technologies:

[34] Ibid p.119.
[35] Ibid p.123.
[36] *Climate Impacts on Latin American Hydropower*, International Energy Agency (IEA), January 2021, page 26. https://iea.blob.core.windows.net/assets/8fa86b9d-470c-41a6-982e-70acd3fbdda4/ClimateImpactsonLatinAmericanHydropower_WEB.pdf .

Figure 7 Levelized Cost of Renewable Energy v Fossil Fuels (2009 – 2020)[37]



Source: Chodosh, Sara (infographic) (28 January 2021) derived from data in Lazard's Levelized Cost of Energy Report.

As noted in the chart, as of 2020, both nuclear and geothermal have LCOEs high above those for solar PV and wind.

There is still a place for nuclear and geothermal in a country's renewable energy strategy, since these technologies provide steady, non-intermittent power and are suitable to meet base load demand. But they will not be foundational due to cost concerns.

II. Mexico was off to a good start in its transition to clean energy

Mexico first set national targets for non-fossil generation in 2008. Then in December 2015, Mexico adopted the *Law of the Energy Transition*, which established goals for clean energy generation of 25% by 2018, 30% by 2021 and 35% by 2024.[38] In 2016, the Mexican Senate reaffirmed the 35% target for clean generation by 2024 as part of its Clean Energy Certificate program, submitted as part of its documentation for the Paris Agreement.[39] Mexico's Nationally Determined Contributions are now recognized in domestic legislation through Mexico's General Law on Climate Change. This Law states that Mexico will achieve a 22% reduction of greenhouse gas emissions by 2030 from a business-as-usual scenario. The electricity generation sector is expected to produce 31% of these reductions, with the remainder from transport 18%; residential and commercial 18%; oil and gas 14%; industry 5%; agriculture and livestock 8%; and waste 28%.[40]

Electricity reforms allowed private sector participation in the market

Reforms to Mexico's constitution at the end of 2013 restructured the Mexican energy sector, including changing the structure of CFE, the state-owned vertically integrated electricity utility. The reforms allowed and encouraged greater private investment in generation and transmission, while leaving the responsibility for distribution and most retail supply with CFE. It functionally unbundled CFE into

[37] Thanks to Bruce Tsuchida of Brattle Group, who included this slide in a presentation to the US-Mexico Climate Change Agenda Working Group at the Working Group meeting of September 8, 2021.
[38] *Ley de Transición Energética*, Articulo Transitorio Tercero, http://www.diputados.gob.mx/LeyesBiblio/pdf/LTE.pdf.
[39] Secretaria de Medio Ambiente y Recursos Naturales - Instituto Nacional de Ecología y Cambio Climático (SEMARNAT-INECC), Mexico's Climate Change Mid-century Strategy, 2016, Mexico City, Mexico. https://unfccc.int/files/focus/long-term_strategies/application/pdf/mexico_mcs_final_cop22nov16_red.pdf
[40] Ley General de Cambio Climático, http://www.diputados.gob.mx/LeyesBiblio/pdf/LGCC_061120.pdf.

generation, transmission, and distribution, and introduced market-based auctions of medium and long-term power purchase agreements to encourage capacity additions.

Three clean energy auctions have taken place to date, in 2016 and 2017. The third auction brought a very low average price of US$ 20.60 per megawatt-hour (MWh) (or US$ 0.0206/kWh). A wind power project bid by Enel included one of the lowest electricity project prices in the world at the time.[41]

The prices achieved through the Mexican auctions were very low and recent developments suggest that even lower prices might be possible today. The Middle East has seen several record-low solar bids in recent months, culminating in April 2021 when Saudi Arabia awarded a 600 MW PV project at US$ 0.0104/kWh.[42]

Mexico has significant clean energy capacity, but modest amounts of wind and solar

The following Table 1 provides an overview of Mexico's generation capacity as of April 30, 2021, showing both clean energy generation and fossil fuel generation.

Table 1
Installed Generation Capacity in Mexico's National Electric System (SEN)
by Technologies, on April 30, 2021 and
Electricity Production in the SEN by Technologies, January - April 2021

Technology	Capacity (MW) April 30, 2021	% of Total Capacity	Production (GWh) Jan – Apr 2021	% of Total Production
Hydroelectric	12,614	14.1	8,827	8.9
Geothermal	976	1.1	1,434	1.4
Wind	7,691	8.6	7,600	7.7
Solar PV	7,026	7.9	5,610	5.7
Bioenergy	408	0.5	353	0.4
Total Renewables	**28,714**	**32.1**	**23,824**	**24.0**
Nuclear	1,608	1.8	3,250	3.3
Efficient Cogeneration	2,309	2.6	956	1.0
Total Non-Renewable Clean Energy	**3,917**	**4.4**	**4,206**	**4.2**
Total Clean Energy	**32,632**	**36.5**	**28,029**	**28.3**
Total Fossil Fuels	**56,847**	**63.5**	**71,067**	**71.7**
Total Generation	**89,479**	**100.0**	**99,097**	**100.0**

Source: Mexico's Ministry of Energy (SENER)[43]

[41] https://www.thedialogue.org/wp-content/uploads/2018/05/mexico_renewable_energy_future_0.pdf
[42] IRENA (2021), *Renewable Power Generation Costs in 2020*, International Renewable Energy Agency, Abu Dhabi, Renewable Power Generation Costs in 2020 (irena.org), p 36.
[43] Programa para el Desarrollo del Sistema Eléctrico Nacional (PRODESEN) 2021-2035, Capacity: Capítulo 3, Cuadro 3.4. https://www.gob.mx/cms/uploads/attachment/file/649445/PRODESEN_CAP_TULO_1_-_2_-_3.pdf, Production: Anexos, Anexo 3.7, https://www.gob.mx/cms/uploads/attachment/file/649444/PRODESEN_CAP_TULO_8.pdf.

As shown in table 1 above, on April 30, 2021, 36.5% of Mexico's electricity generating capacity was clean, whereas for the period January – April 2021, 28.3% of Mexico's electricity production was clean. In each case "clean" includes the non-renewable sources nuclear and efficient cogeneration.

Hydroelectricity constitutes 14.1% of Mexico's total generating capacity. The overwhelming majority of Mexico's hydroelectric capacity is owned by CFE[44] with most facilities over 50 years old.[45] In an effort to upgrade its aging hydroelectric infrastructure, in late 2018 Mexico announced plans to modernize and upgrade 60 existing hydropower plants across the country. [46] In spite of these planned investments, Mexico's hydroelectric capacity remains vulnerable to drought and climate change impacts. According to a recent International Enegy Agency (IEA) study, Mexico's hydropower capacity could fall by up to 28% under a 4°C scenario.[47] Due to recent droughts, Mexico's electricity generation from hydropower declined from 32,486 GWh in 2018 to 23,608 GWh in 2019 (a 27% decline) according to IRENA figures, even though hydropower capacity was substantially the same in both years.[48]

Wind and solar make up another 8.6% and 7.9% of Mexico's generating capacity, respectively. Notably, these resources are overwhelmingly owned by the private sector.[49] A key issue with wind and solar is that they require large upfront investment. To date, only the private sector has been willing and able to make that investment—because the right incentives and regulatory certainty were in place.

The various technologies will produce different amounts of electricity for a given MW of generation capacity, depending on a number of circumstances. Hence for the first four months of 2021, hydroelectric generation produced only 8.9% of total electricity production compared to 14.1% of capacity, perhaps due to the drought conditions in Mexico.[50] For the same period, wind and solar produced 7.7% and 5.7% of total production, respectively, compared to 8.6% and 7.9% of Mexico's generating capacity.[51] The intermittency of these technologies likely caused their production to be less than the corresponding generation capacity.

[44] PRODESEN 2021-2035, Annexes, Annex 3.2, https://www.gob.mx/cms/uploads/attachment/file/649444/PRODESEN_CAP_TULO_8.pdf.
[45] *Climate Impacts on Latin American Hydropower*, International Energy Agency (IEA), January 2021, page 17. https://iea.blob.core.windows.net/assets/8fa86b9d-470c-41a6-982e-70acd3fbdda4/ClimateImpactsonLatinAmericanHydropower_WEB.pdf.
[46] Ibid p. 26.
[47] *Climate Impacts on Latin American Hydropower*, International Energy Agency (IEA), January 2021, page 26. https://iea.blob.core.windows.net/assets/8fa86b9d-470c-41a6-982e-70acd3fbdda4/ClimateImpactsonLatinAmericanHydropower_WEB.pdf.
[48] IRENA (2021), Renewable Energy Statistics 2021 The International Renewable Energy Agency, Abu Dhabi, p. 13 (Mexican hydropower electricity production statistics), p. 12 (Mexican hydropower capacity statistics), https://irena.org/-/media/Files/IRENA/Agency/Publication/2021/Aug/IRENA_Renewable_Energy_Statistics_2021.pdf.
[49] PRODESEN 2021-2035, Annexes, Annex 3.2, https://www.gob.mx/cms/uploads/attachment/file/649444/PRODESEN_CAP_TULO_8.pdf
[50] PRODESEN 2021-2035, Capítulo 3, FIGURA 3.14. https://www.gob.mx/cms/uploads/attachment/file/649445/PRODESEN_CAP_TULO_1_-_2_-_3.pdf.
[51] Ibid.

III. Mexico's current energy policy and the role of renewables

In a July 2020 memorandum to Mexico's energy regulators, President López Obrador presented his policy toward the energy sector, with the fundamental objective of strengthening Mexico's state-owned enterprises PEMEX and CFE.[52] According to the memo, the Energy Reform left PEMEX and CFE "almost in ruins: indebted, with their productive capacities diminished, with a reduction in their markets, and, to top it all, subject to regulations that privilege private parties."[53] In this context, President López Obrador found it "urgent" to rescue PEMEX and CFE, since these public enterprises are "strategic and indispensable to the independent and sovereign development of our nation."[54] This means "not continuing with the privatization of the energy sector and restraining the application of the measures imposed for the benefit of private parties."[55]

In the memorandum, President López Obrador set a path to carry out these objectives:

> "In this direction, we should advance to the limit of what is permitted under the existing legal framework. Nevertheless, if in order to apply the new policy of rescuing PEMEX and CFE, it were necessary to propose a new energy reform, we do not dismiss that possibility, that is to say, the option, among others, of presenting a constitutional reform initiative to the Congress of the Union to assert, without room for doubt, the dominion of the nation over its natural resources, should remain open."[56]

To learn whether the government could strengthen PEMEX and CFE within the existing legal framework, President López Obrador set forth a series of commitments, actions and changes to be undertaken by the two public companies and by the regulators themselves.[57] For purposes of this paper, the critical points made by President López Obrador with regard to the electricity industry include the following:

- Avoid increasing the price of electricity (in real terms).
- Enhance the production of hydroelectric power "since the basic infrastructure and water exist, there is no risk of damage to the environment, and it is only necessary to modernize or expand the system of turbines to produce more low cost, clean energy."
- CFE should recognize electricity purchase contracts made by prior governments, provided they do not involve fraud against CFE or the nation.
- Remove all subsidies to private parties in the energy sector.

[52] Memorándum de Andrés Manuel López Obrador, Presidente de México a Servidores Públicos e Integrantes de los Órganos Reguladores del Sector Energético, 22 de julio de 2020, https://www.energiahoy.com/wp-content/uploads/2020/08/MEMORA%CC%81NDUM-2020.pdf
[53] Ibid.
[54] Ibid.
[55] Ibid.
[56] Ibid.
[57] Ibid.

- Supply electricity to the national system in the following order: first, hydroelectricity; second, electricity from other CFE power plants; third, wind or solar energy from private parties; and finally, energy from privately owned combined cycle plants.

- Stop granting permits or concessions to private parties in the energy sector for the oversupply of electricity for the medium and long term.

- CFE should develop a plan for the use and sale of natural gas, imported via the gas pipeline infrastructure developed by the prior administration, in order to help with transportation charges.[58]

- Support CFE with policies that avoid it continuing to lose participation in the national market, weakening financially, and failing to fulfill the commitment that electricity prices will not increase, in real terms, for national consumers.

- Regarding the role of private parties in the energy sector:

    - Association with private investors in electricity generation will not be ruled out, so long as this involves complementary actions that do not affect the national interest.

    - The private sector can participate, as is presently occurring, in CFE bid processes for the procurement of goods and services.

    - Private power plants, whether owned by domestic or international parties, will not under any circumstances exceed 46% of national consumption, the percentage of electricity produced by the private sector in 2020. [59]

The Memorandum closes by asking the regulators to advise if the foregoing points can be attained under the existing legal framework, in compliance with the rule of law, and if not, what plan of action the regulators would propose to benefit the Mexican people and the national interest.

Measures to Implement Mexico's Current Energy Policy

Consistent with the energy policy set forth in the Memorandum, the López Obrador administration moved to favor CFE and to disfavor the private sector. Among those actions are the following:

First, in December 2018 the administration indefinitely delayed the fourth renewable electricity auction. CFE General Director Manuel Bartlett General argued that the auction prices for solar and wind energy were a "lie" because they did not cover all the costs of delivered electricity and were supported by

[58] The gas pipelines were built by the private sector or with private sector participation in response to CFE tenders. As part of the deal, CFE committed to pay transportation charges for its use of the pipeline. The CFE commitment, in turn, was used by the private developers to obtain financing for the pipeline projects. As a general matter, CFE has to pay the full transportation charges even if it uses less natural gas than anticipated. It is in CFE's interest to import (or have third parties import) as much gas as possible over the pipelines and obtain revenue derived from the imported gas to help pay the transportation charges.

[59] According to a June 28, 2020 article in El Universal, private companies, under the legal regime in place prior to the energy reform, provided 45.8% of all electricity consumed in Mexico. https://www.eluniversal.com.mx/cartera/empresas-privadas-controlan-45-de-la-energia-electrica.

improper subsidies to the private sector; the result would be higher electricity prices for the Mexican people.[60] This statement was presented without support, and the statement about delivered electricity costs is contrary to CFE's own data on the generation costs for different technologies[61] as well as the experiences of other grids with similar amounts of intermittent renewable power.[62]

Second, in January 2019 CFE and SENER cancelled tenders for two high-voltage, DC transmission lines that were crucial to further development of renewable energy. The CFE Yautepec-Ixtepec Line, spanning six states, would have transported wind energy generated in the wind-rich southern state of Oaxaca to the central part of the country, which has high industrial and residential electricity demand. The second project, under the auspices of SENER, would have connected the Baja California Electric System, isolated from the rest of the country, with the National Interconnected System (SIN). This in turn would have allowed solar projects in Baja California, taking advantage of the intense sunlight that in that state, to export electricity from those projects to the SIN. In this context, the termination of the two transmission projects was adverse to private sector renewable energy developers.

Third, in October 2019 SENER attempted to change the rules of Mexico's Clean Energy Certificates to allow existing hydroelectric capacity owned by CFE to earn the certificates, contrary to the original regulatory regime that did not permit this.[63] The resulting increase in the quantity of certificates available would have decreased the value of existing certificates and harmed the economics of existing renewable projects, in addition to disincentivizing new construction. Companies harmed by the change filed suit and in December 2019, a court in Mexico City suspended the change.[64]

Fourth, in April 2020 the *Centro Nacional de Control de Energía* (CENACE) issued an *Acuerdo* ostensibly to mitigate the reliability effects of the COVID-19 pandemic on the Mexican electricity grid. The resolution included the temporary suspension of pre-operative commissioning tests for wind and solar power plants and allowed curtailment of intermittent renewable power while the pandemic-related contingent measures remain in place.[65] The *Acuerdo* declared that renewable energy undermines the reliability of the national electric system because of its intermittency and other grid integration issues. However, at a news conference on May 6, 2020, President López Obrador explained that the actual objective of the measure was to ensure that CFE has priority in providing electricity and not private

[60] https://www.forbes.com.mx/la-gran-mentira-de-las-energias-renovables-segun-la-cfe/.
[61] See the analysis by former CRE commissioners Montserrat Ramiro and Jesús Serran, "Participación Privada en la Generación de Electricidad, July 14, 2020, http://www.pued.unam.mx/export/sites/default/archivos/actividades/Seminarios/060820/2_Documento.pdf. The authors analyzed CFE's own data on the cost of generation for basic service, and found that the private sector renewable energy costs pursuant to the long terms auctions were lower than CFE costs even for combined cycle generation. See section II.4.2 of their paper, pp. 30-36.
[62] Agora Energiewende, The Integration Cost of Wind and Solar Power: An Overview of the Debate on the Effects of Adding Wind and Solar Photovoltaic into Power Systems, December 2015, https://www.agora-energiewende.de/en/publications/the-integration-cost-of-wind-and-solar-power/.
[63] https://www.edisonenergy.com/blog/mexico-clean-energy-certificates-cels/.
[64] https://renewablesnow.com/news/mexican-court-suspends-govts-new-policy-on-cels-report-679953/.
[65] https://www.shearman.com/perspectives/2020/05/recent-regulatory-developments-in-the-mexican-power-sector?utm_source=Mondaq&utm_medium=syndication&utm_campaign=LinkedIn-integration.

companies.[66] The *Acuerdo* was challenged in the courts by various generators and in October 2020 a court issued an "*amparo*" order that suspended the *Acuerdo*.[67]

Fifth, in May 2020 the *Comisión Reguladora de Energía* (CRE) adopted a resolution permitting an increase in transmission tariffs for projects with legacy interconnection agreements for renewable energy or efficient cogeneration built before the energy reform.[68] The theory underlying the increase was that the prior transmission rates were too low and constituted an improper subsidy. CFE, through its legacy contract subsidiary, then issued tariff rate increases for such projects, with the increases ranging from 407% to 775% depending on the transmission voltage.[69] The decision is expected to lead to an increase in transmission tariffs for many industrial and commercial users, adversely affecting the economics that developers had counted on to build the generation capacity serving such users. The tariff increase may affect more than 251 grandfathered renewable and conventional projects with an overall value of more than $17 billion.[70] Many generators filed lawsuits against the measures, arguing that the resolution was contrary to the terms of the *Electricity Industry Law*, which allowed legacy projects to continue operating under the prior legal framework or to opt into the new regime. Under the prior legal regime, the legacy projects were permitted a modest "postage stamp" transmission charge as an incentive for these projects. In response to the lawsuits, a judge issued an *amparo* order that suspended the increase in the transmission tariffs.[71]

Finally, in early 2021 the administration succeeded in obtaining amendments to the electricity law that modified the rules for how existing power plants are dispatched, in a way that disproportionately harms privately owned renewable supply.[72] Instead of dispatching generation in the order of lowest marginal cost, as the *Electricity Industry Law* states, generation owned by CFE would be dispatched first. Since renewable power has zero marginal cost of generation, it would be displaced from its favored position in the dispatch merit order. Instead, older, more expensive, and more polluting CFE plants would be dispatched first. This change would greatly harm the economics of existing projects as well as discourage the construction of new private generation. Once again, renewable energy developers filed suit against the new measure, and once again a court issued an *amparo* order, this time suspending the effectiveness of the amendments to the electricity law.[73]

---

[66] https://www.milenio.com/politica/amlo-cfe-tendra-trato-justo-con-acuerdo-del-cenace.
[67] Juez otorga amparo contra acuerdo del CENACE - EIEM / Encuentro Internacional de Energía México (encuentroenergia.mx).
[68] Comisión Reguladora de Energia, RES/893/2020, https://drive.cre.gob.mx/Drive/ObtenerResolucion/?id=YjAwZWRiMmUtYTk1ZC00M2Q3LTIwNDIzLTFkOWYwNDI4MzVlYg==.
[69] http://www.dof.gob.mx/nota_detalle.php?codigo=5594800&fecha=10/06/2020. For a calculation of the percentage increases, see https://www.ey.com/es_mx/energy-reimagined/energy-alert/new-wheeling-tariffs-.
[70] https://www.thedialogue.org/wp-content/uploads/2020/08/Mexican-Power-Sector-Policies_Final.pdf.
[71] www.milenio.com/policia/cfe-juez-otorga-amparo-alza-tarifas-energia-renovable.
[72] http://dof.gob.mx/nota_detalle.php?codigo=5613245&fecha=09/03/2021,
[73] https://www.bing.com/newtabredir?url=https%3A%2F%2Felcodigolibre.com%2F2021%2F03%2F17%2Fsuman-ya-25-suspensiones-contra-la-reforma-electrica%2F.

In response to the successful legal challenges to his efforts to favor CFE and disfavor private investors, President López Obrador on September 1, 2021, stated that he would propose a constitutional amendment to strengthen CFE and counter privatization of the electrical sector in months to come.[74]

Renewable Energy in Mexico's Current Energy Policy

President López Obrador has made it clear that there is a place for renewable energy in his energy policy. He stated in May 2020, "we are not against the generation of clean energies, we are not against that; on the contrary, we are increasingly going to promote alternative energies."[75] It is also clear, however, that renewable energy must fit within the policy framework that President López Obrador has established, in particular the primary role of CFE.

For example, the President highlights the benefits of hydropower and it comes first in the dispatch order called for in his policy statement. Hydropower is renewable energy but CFE owns nearly all of the hydroelectric generation capacity in Mexico.

The dispatch order recognizes private sector renewable energy, but it is dispatched after all CFE power plants, including fossil fuel plants with higher marginal costs of electricity than private sector renewables. On its face, this contradicts the administration's policies to avoid increasing electricity prices.

Additionally, this means that private sector renewable energy would be on weak economic footing. A private developer could not be sure that it would be able to sell electricity to the grid because CFE power plants come first. This leaves open bilateral power purchase agreements with electricity users, whether public or private, but those contracts are then subject to the ability of the developer to obtain federal generation permits. Mexico's Energy Regulatory Commission (CRE) granted only four renewable generation permits in 2020.[76] Whether or not this is consistent with the law, it is consistent with President López policy of disfavoring the private sector.

It appears, then, that the López Obrador administration is fine with renewable energy so long as it is developed by CFE. This leaves open the possibility of "association with private investors" as approved in the Memorandum, "so long as this involves complementary actions that do not affect the national interest." And the private sector could participate in bid processes to supply goods and services to CFE for renewable energy projects, i.e. sale of solar panels or wind turbines and provision of construction services.

Beyond this, CFE would need to approve private sector participation in generation, e.g. if CFE for some reason did not have the capacity to provide new power plants needed to meet growing demand. But even in that scenario, the private generation would be subject to the policy constraint "that private power plants, whether owned by domestic or international parties, will not under any circumstances exceed 46% of national consumption." CFE might also press for gas fired generation from the private sector rather than renewable energy in light of President López Obrador's mandate to use or sell gas

---

[74] "Presidente de México anuncia reforma para fortalecer industria eléctrica nacional," Infobae, September 1, 2021, https://www.infobae.com/america/agencias/2021/09/01/presidente-de-mexico-anuncia-reforma-para-fortalecer-industria-electrica-nacional/

[75] "No estamos en contra de la generación de energías limpias, al contrario, cada vez vamos a impulsar más las energías alternativas" – pv magazine Mexico (pv-magazine-mexico.com)

[76] https://www.edisonenergy.com/blog/will-mexico-reach-their-clean-energy-goals/

imported over the gas pipeline network built by the prior administration. The point would be to find new users for natural gas to help cover the costs of the gas pipelines.

IV. Mexico's Plans for future development of clean energy

As noted above, the private sector currently owns substantially all the solar and wind projects in Mexico, while CFE owns most of the hydroelectric assets.[77] In light of President López Obrador's state-centered energy policy, what are Mexico's plans for future development of clean energy, particularly renewable energy?

CFE, Mexico's state-owned power company, includes plans for new generation in its Business Plan for 2021 -2025, as shown in Figure 8.

Figure 8 Principal characteristics of CFE's proposed power plants[78]

Central generadora	Ubicación	Año entrada en operación
CC Tuxpan fase I (CC PALM I)	Veracruz	2024
CC Riviera Maya -Valladolid	Yucatán	2023
CC Mérida	Yucatán	2024
CC Baja California Sur	Baja California Sur	2024
CC González Ortega	Baja California	2023
CC San Luis Río Colorado	Sonora	2024
CTG Aero González Ortega	Baja California	2021
Unidades Turbo Gas Aeroderivadas	Baja California Sur	2020

Central generadora	Ubicación	Año entrada en operación
Norte IV	Durango	2027
Arreglo 2x2x1 en la C.T. Salamanca	Guanajuato	2027
Arreglo 1x1x1 en la C.T. Francisco Pérez Ríos	Hidalgo	2026
CC Presidente Juárez	Baja California	2026
CC Baja California IV (Cerro Prieto)	Baja California	2027
Proyectos de energías renovables	--	2027

Fuente: DCPE

As shown in this figure, CFE states only that it plans to add new renewable generation to its portfolio in 2027, without any details.

Another source of information on Mexico's plans for new generation is the *Programa Indicativo para la Instalación y Retiro de Centrales Eléctricas* [Indicative Program for the Installation and Retirement of Power Plants] for the period 2021-2035,[79] referred to in this paper as the Power Plant Program. In the Power Plant Program, SENER presents its projections of future construction (and decommissioning) of generation capacity.

Distributed Generation

The 2021-2035 Power Plant Program highlights development of distributed generation (DG) as a high priority for Mexico, with a focus on rural communities and the poor:

[77] On ownership of all generating assets in Mexico as of April 30, 2021, see PRODESEN 2021-2035, Annexes, Annex 3.2 (Installed Capacity (MW) of CFE and the rest of the permitholders at April 30, 2021-2035), https://www.gob.mx/cms/uploads/attachment/file/649444/PRODESEN_CAP_TULO_8.pdf.

[78] CFE Plan de Negocios 2021-2025. Table 5.2, https://www.cfe.mx/finanzas/Documents/Plan%20de%20Negocios%20CFE%202021.pdf.

[79] https://www.gob.mx/cms/uploads/attachment/file/649447/PRODESEN_CAP_TULO_5.pdf, included in Mexico's *Programa de Desarrollo del Sistema Eléctrico Nacional* (PRODESEN) 2021-2035 [Development Plan for the National Electric System 2021-2035], https://www.gob.mx/sener/articulos/programa-para-el-desarrollo-del-sistema-electrico-nacional.

> The National Development Plan 2019-2024 establishes that the new energy policy of the Mexican State will promote sustainable development by providing populations and communities with production of energy from renewable sources, which will be essential to provide electricity to small, isolated communities that still lack it . . ..
>
> The proposal for the installation of Distributed Generation in Mexico considers federal entities with municipalities that have less than 2,500 inhabitants (rural communities), with a higher percentage in poverty, with homes that do not have Electricity Supply and have 1.0% or less of the percentage of solar panel installed.[80]

This focus on DG is consistent with President López Obrador's commitment to fulfilling the UN Sustainable Development Goals (SDGs), including SDG 7 on universal access to affordable and clean energy. According to Mexico's 2020 Population and Housing Census, about 826,039 people (0.7% of the national total) or 268,863 dwellings lack energy access to their rural, off-grid homes that are not serviced by CFE.[81] Providing renewable energy to these households could address the needs of marginalized Mexican communities and not directly compete with CFE. According to the National Strategy for the Implementation of the 2030 Agenda in Mexico (of the current administration), "Mexico's energy sector will consolidate itself as a lever for development and national well-being. We will have a modern and efficient energy model, based on the principles of transparency, sustainability and responsible long-term use. National energy production will be able to supply all social and productive sectors at competitive prices, with quality and efficiency, prioritizing energy security and diversification, energy saving, reduction of Greenhouse Gas (GHG) emissions and protection of the environment through the generation of renewable energies."[82]

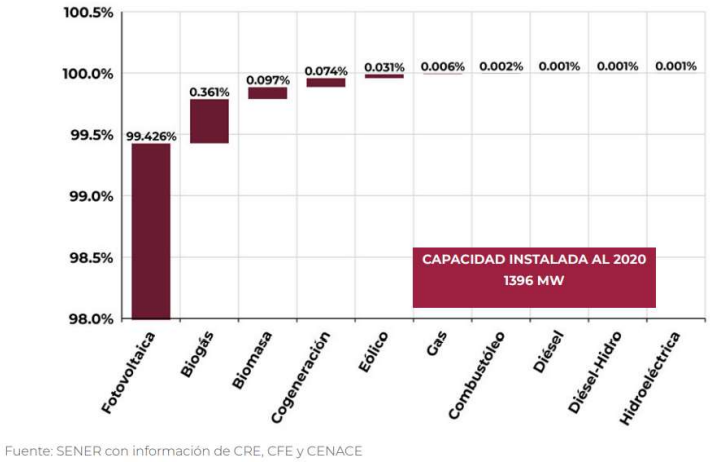
Additionally, despite nearly universal access to electricity, one study found that nearly 37% of Mexican households are "energy poor," a much larger number than the *Consejo Nacional de Evaluación de la Política de Desarrollo Social* counts in its work.[83] The issue is one of affordability rather than access. The top areas of deprivation were maintaining homes at a comfortable temperature, efficient refrigeration, and gas or electric cooking.[84] Perhaps new DG can be of assistance to the energy poor if they are able to obtain and install the DG equipment without charge or at a nominal cost.

Figure 9 shows the existing distributed generation in Mexico, which is mostly solar with an important contribution from biogas.

---

[80] PRODESEN 2021-2035, Chapter 5 https://www.gob.mx/cms/uploads/attachment/file/649447/PRODESEN_CAP_TULO_5.pdf, p. 86.
[81] http://en.www.inegi.org.mx/programas/ccpv/2020/.
[82] Estrategia Nacional para la Implementación de la Agenda 2030 en México https://www.gob.mx/agenda2030/documentos/estrategia-nacional-de-la-implementacion-de-la-agenda-2030-para-el-desarrollo-sostenible-en-mexico.
[83] Rigoberto García-Ochoa, Boris Graizbord, "Caracterización espacial de la pobreza energética en México. Un análisis a escala subnacional," *Economía*, *Sociedad y Territorio*, vol. xvi, núm. 51, 2016, 289-337 xvi, núm. 51, 2016, 289-337. http://www.scielo.org.mx/pdf/est/v16n51/2448-6183-est-16-51-00289.pdf.
[84] Ibid.

Figure 9: Existing distributed generation capacity in Mexico by Type of Technology in 2020

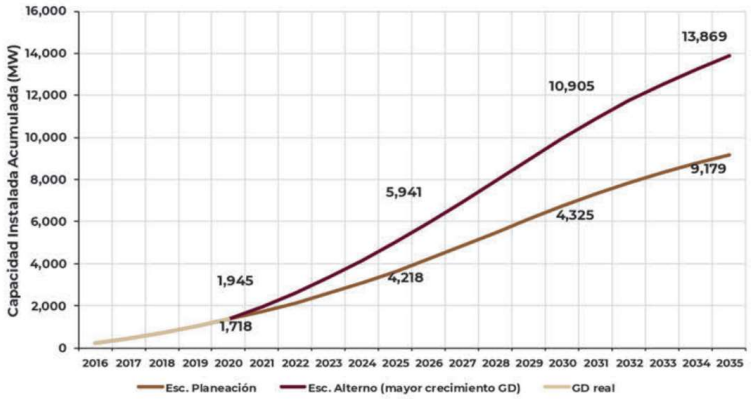


Fuente: SENER con información de CRE, CFE y CENACE

Source: PRODESEN2021-2035, Figure 5.1[85]

The Power Plant Program then goes on to project how much new DG will be built, based on a planning forecast and an alternative scenario involving faster growth, as shown in Figure 10. Unfortunately, there is no discussion of what circumstances would underlie the alternative scenario of faster growth, or otherwise how such faster growth would be attained.

Figure 10: Projected growth in Mexico's distributed generation capacity



Fuente: SENER con información de CRE, CFE y CENACE

Source: PRODESEN 2021-2035, Figure 5.3[86]

The projected growth in DG in this figure is impressive, particularly in the alternative scenario, where the 2035 projected capacity of 13,869 MW is almost 10 times the 2020 capacity shown in Figure 9 above. However, there is no analysis or set of assumptions presented that would support a conclusion that these projections can realistically be attained. Among other things, there is no estimation of the

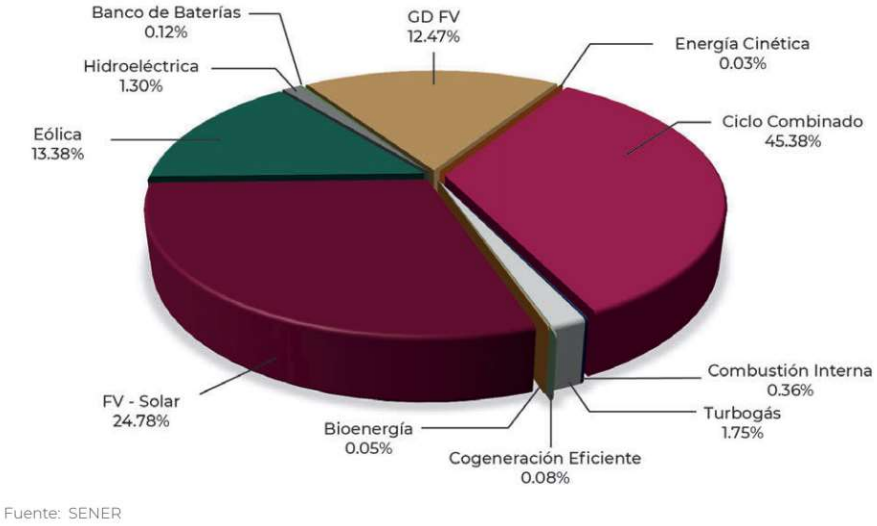
[85] PRODESEN 2021-2035, Capítulo 5, https://www.gob.mx/cms/uploads/attachment/file/649447/PRODESEN_CAP_TULO_5.pdf.
[86] Ibid.

cost of the DG in either scenario, and no discussion of how the procurement and installation of the DG would be paid for.

Short/Medium Term Planning

Beyond the commentary on the priority issue of distributed generation, the 2021-2035 Power Plant Program includes generalized projections for the short/medium term, i.e. 2021-2024, and for the entire planning period, i.e. 2021-2035. For the 2021-2024 period, Figure 11 shows the anticipated growth in generation capacity by technology:

Figure 11. Percentage of Addition to Capacity by Technology 2021 to December 31, 2024



Source: PRODESEN 2021-2035, Figure 5.7[87]

This figure shows that more than 50% of the new generation capacity for the 2021-2024 period will be in renewable energy, i.e. 24.78% for solar PV, 13.38% for wind, 12.47% for solar PV DG (consistent with the high priority placed on distributed generation as discussed above), 1.30% for hydropower and 0.05% for bioenergy. The figure also identifies as 0.12% of new generation from battery storage, which would likely be used as a complement to the variable renewable energy generation. But there is no identification of specific projects, or the contemplated capacity measured in MW of such projects, what those projects would cost or how the new capacity would be paid for.

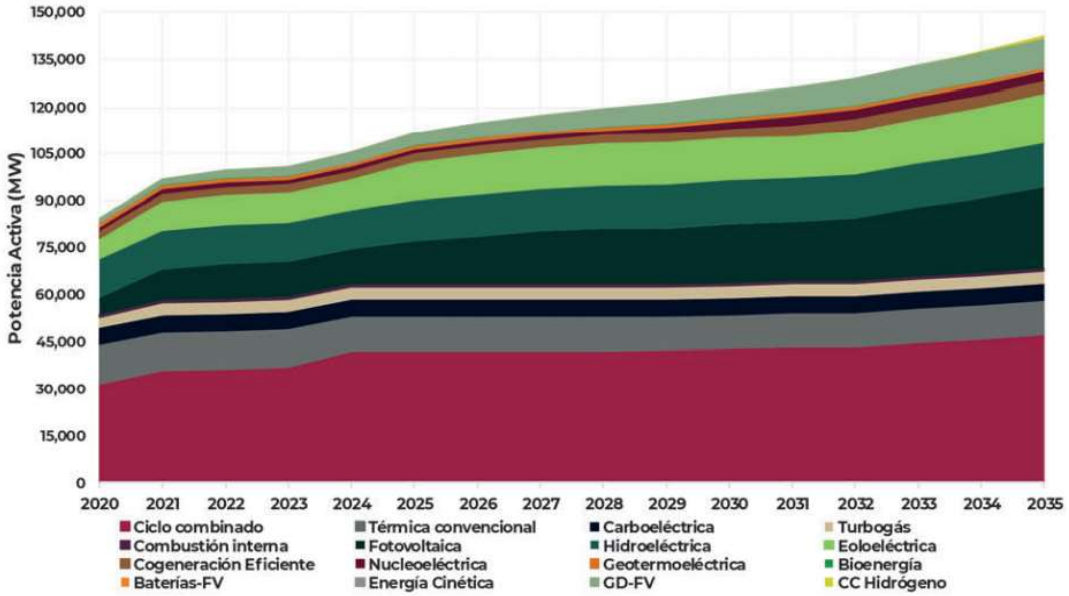
Long Term Planning 2021-2035

The projections for the entire planning period of 2021-2035 are also at a high level of generality, covering both increases in capacity and increases in electricity generation. But the projections have the same shortcomings as to lack of detail as described above.

The following Figure 12 shows the evolution of generation capacity by technology over the period 2020-2035. However, there are no numbers attached to the graphic so the only way to review the projects is by visual impression.

[87] Ibid.

Figure 12. Evolution of Capacity (MW) by Technology 2020-2035



Fuente: SENER

Source: PRODESEN 2021-2035, Figure 5.6[88]

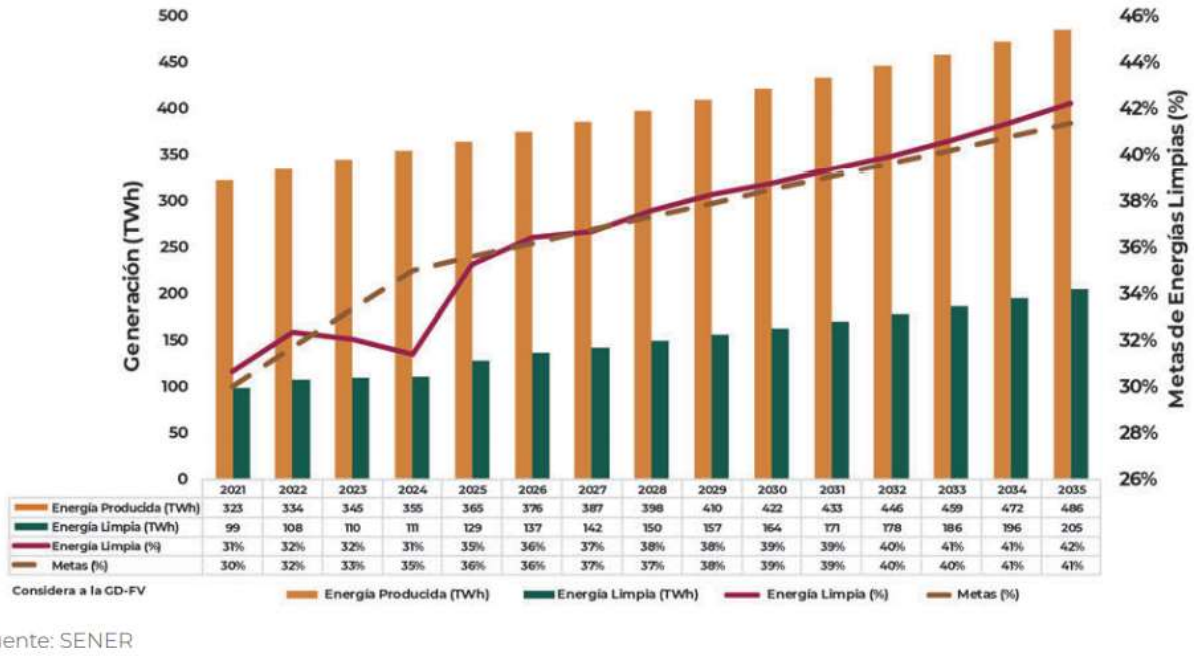
The five lowest color bands on this chart are fossil fuel generation according to the legend for the graphic – combined cycle, conventional thermal, coal-fired generation, turbogas and internal combustion. The graphic shows growth in fossil fuel generation over the 2020-2035 period, so Mexico is not intending to turn away from this type of generation or even keep it at current levels.

As for renewables, there is substantial growth (by visual impression) over the 2021-2035 period in solar, wind and distributed generation PV, with some growth in hydropower.

Figure 13 shows the projected evolution of generation in Mexico over the 2021-2035 period, including both total generation and clean energy generation, as well as the measurement of clean energy generation against Mexico's corresponding clean energy goals.

[88] Ibid.

Figure 13. The evolution of generation in Mexico and the Clean Energy Goals 2021-2035



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Energía Producida (TWh)	323	334	345	355	365	376	387	398	410	422	433	446	459	472	486
Energía Limpia (TWh)	99	108	110	111	129	137	142	150	157	164	171	178	186	196	205
Energía Limpia (%)	31%	32%	32%	31%	35%	36%	37%	38%	38%	39%	39%	40%	41%	41%	42%
Metas (%)	30%	32%	33%	35%	36%	36%	37%	37%	38%	39%	39%	40%	40%	41%	41%

Fuente: SENER

Source: PRODESEN 2021-2035, Figure 5.15[89]

This chart shows electricity production from clean energy rising from 99 TWh in 2021 to 205 TWh in 2035, more than doubling over this period. Total generation increases from 323 TWh in 2021 to 486 TWh, an increase of roughly 50%. With electricity from clean energy growing faster than total electricity production, the percentage of clean energy electricity production versus total production increases, from 31% in 2021 to 42% in 2035. Even with this increase, generation from sources other than clean energy continues to provide the majority of Mexico's electricity through the year 2035.

The projected increases in clean energy generation capacity and electricity production for the 2021-2035 period share the same weaknesses as in the case of the short/medium term planning scenario: no identification of specific projects or the contemplated capacity (MW) of such projects, what those projects would cost or how the new capacity would be paid for. Also, such projections do not adequately take into account Mexico's potential future variability in hydroelectric capacity due to climate change impacts that need to be taken into account. Without this information, it is difficult to evaluate whether the long-term projections can realistically be attained.

The importance of wind and solar in the projections raises another issue. Since substantially all wind and solar projects in Mexico as of April 30, 2021 are privately owned, a key question will be whether President López will permit private investment in the proposed new wind and solar capacity or, if not, whether the Mexican state, acting through CFE or otherwise, will be able to make the necessary upfront investment or otherwise obtain financing to develop these projects.

[89] Ibid.

CFE Private Sector Financing Strategies

In its Plan de Negocios [Business Plan], 2021-2025, CFE identifies two strategies whereby the private sector might invest in new generation assets that would be owned or under the control of CFE. These strategies are interesting and could be used to build renewable energy projects as well as fossil-fuel generation plants (CFE's current primary interest).

The PIDIREGAS. CFE proposes to use the PIGIREGAS - "*proyectos de inversión diferidos en el registro del gasto*" [investments projects that are deferred in the cost registry] – to obtain private financing for CFE generation projects.[90] Under the PIDIREGAS, the private sector finances and builds a generation project for CFE. CFE buys the project when it is operational, since the project can then provide cash flow to pay back CFE debt used to complete the buy-out. But if CFE does not buy, the federal government has a direct obligation to make the private sector developer whole. That federal government obligation is contingent or "deferred" and is NOT shown as debt on the government's books. The benefit to CFE is that it gets a generation plant financed and built by the private sector. The private sector gets a return on investment, and its only risk is government default as to the contingent obligation.[91]

The FIBRA-E. The FIBRA-E is an investment trust for energy and other infrastructure. [92] In concept, it is similar to a U.S. real estate investment trust (REIT). The basic idea is that a trust sells equity interests to the private sector and then builds a power plant with equity plus borrowed money. The power plant generates money by selling electricity instead of charging rent (the usual strategy for a US REIT). The money is used to repay debt and give a return to equity. The trust structure could be set up so that CFE is in control without putting up much equity. CFE also benefits in that the debt incurred is trust debt and not debt on CFE's books. In this case, CFE is not the direct owner of the power plant, but it does have control.

These financing mechanisms are potentially promising as a means of obtaining private sector financing for CFE renewable energy projects.

V. What role should the U.S. play in supporting Mexico's renewable energy plans?

With this generalized view of Mexico's clean energy future, what role should the U.S. play in supporting Mexico's renewable energy plans? This section of the paper develops in more detail the suggestions made in the Introduction.

---

[90] CFE, Plan de Negocios 2021-2025, pp. 66-67, https://www.cfe.mx/finanzas/Documents/Plan%20de%20Negocios%20CFE%202021.pdf. For a discussion of the PIDIREGAS and how CFE proposes to use it for transmission assets, see https://mexicobusiness.news/energy/news/cfe-transmission-hints-return-private-investment-scheme?tag=pidiregas.

[91] For a discussion of the advantages and disadvantages of the PIDIREGAS, see https://www.altonivel.com.mx/empresas/que-son-los-pidiriegas-de-cfe-y-cuales-son-sus-desventajas/

[92] CFE, Plan de Negocios 2021-2025, p. 67, https://www.cfe.mx/finanzas/Documents/Plan%20de%20Negocios%20CFE%202021.pdf.

Building on Mexico's 2021-2035 Power Plant Program

The U.S. should build upon Mexico's Power Plant Program for 2021-2035 as a basis for cooperation, even though the program lacks detail. If the U.S. proposes to work with Mexico based on that program, it can seek clarification on key missing elements. To the extent Mexico cannot answer questions as to the details, the U.S. can offer to provide energy planning expertise from the appropriate U.S. government agencies to work with Mexico in filling in the blanks for the Power Plant Program. This type of collaborative effort, with Mexico taking the lead, supported from U.S. experts as Mexico may request, would build confidence in the collaborative planning process.

Distributed Generation

For Mexico's distributed generation plans, which are highly focused on rural areas and the poor, the U.S. can collaborate with Mexico on financing and implementation plans, which will include a Mexican contribution and a whole-of-government approach from the U.S. side. The Biden Administration has committed a modest $2M in fiscal year 2022 for clean energy in Mexico, which could be applied to Mexico's high-priority DG projects. However, this money could be leveraged with private philanthropic support via US AID's Global Development Alliance (GDA) and focused on providing solar energy connections to rural communities that lack energy access. Such projects could open the door to future philanthropic collaboration.

Renewable Energy Project Planning

For Mexico's broader clean energy strategy contained in the 2021-2035 Power Plant Program, once Mexico identifies the projects to be built, at least on a tentative basis, the U.S. can collaborate with Mexico on renewable energy project planning, including feasibility, grid integration and reliability studies, as well as cost studies. Within the U.S. government, the partnership between the National Renewable Energy Laboratory (NREL) and the U.S. Agency for International Development (USAID) is highly focused on these matters as a means to support delivery of clean, reliable, and affordable power in the developing world.[93]

Power System Planning Using Different Technologies

President López Obrador's administration is clearly concerned about CFE's financial obligations with respect to the natural gas pipeline system that was built under the prior administration for the benefit of CFE and its planned gas-fired power plants. The pipeline system is at risk of becoming a "stranded asset" if renewable energy were to take the place of gas-fired generation. But Mexico has substantial additional power needs, and renewables could be supplemental to gas-fired generation for the short to medium term. The U.S. has substantial experience with these issues. The U.S. and Mexican governments could facilitate discussions between experts on both sides of the border with respect to long-term power system planning with different generation technologies and managing the potential for stranded assets.

Government Financing Programs

The U.S. and Mexican governments should engage in discussions on the financing of renewable energy projects, and how the U.S. might support Mexico with financing strategies by means of its whole-of-government approach.

[93] The USAID-NREL Partnership, https://www.nrel.gov/usaid-partnership/.

Mexico has placed substantial emphasis on the placement of green bonds, and the U.S. could discuss with Mexico how it might assist Mexico in leveraging the proceeds of these bonds for development of renewable energy. This could include direct U.S. funding and formation of funding consortia to include governments outside of the U.S., multilateral financing institutions such as the Global Environment Fund and the Green Climate Fund, and the multilateral development banks.

The U.S. should consider how it might increase its ambition with respect to financial support of Mexican renewable energy projects, e.g. with respect to grants, direct lending, credit support for third party borrowing to develop renewable energy projects, and collaboration with the multilateral financial institutions on project finance.

Discussion of Private Sector Financing[94]

Mexico has established certain limitations on the participation of the private sector in the Mexican energy sector. Yet there is strong evidence that Mexico will not be able to carry out development of renewable energy on the scale it has proposed – much less what would be necessary under an NZE scenario – without private sector financing. The U.S. and Mexico should carry out a discussion on how private sector financing of renewable energy in Mexico might be structured consistent with Mexican energy sovereignty.

The private sector has shown itself willing, through its response to the clean energy auctions, to invest in renewable energy projects based on long-term contracts. CFE canceled the auctions because they left intermittency and grid integration to be managed by CFE, without compensation. One way to foster renewable energy would be to redesign the auction model to address these issues. This would mean an auction process where the bid must include energy storage and other tools for managing intermittency and grid integration, to be provided or paid for by the bidder rather than CFE. The private sector could also be called up to provide advanced wind and solar technologies that include regulation capability (frequency and voltage regulation), advice on improved weather forecasting, fast-ramp conventional generation to meet shortfalls, and other ancillary services. The U.S. and Mexico could facilitate discussions between experts on both sides of the border to discuss these issues.

It may also be possible to foster development of renewable energy projects through financing options that maintain CFE ownership of power generation. Renewable energy requires large upfront capital expenses, and CFE may not have the capability to self-fund on the scale necessary. Yet as indicated above, CFE is contemplating the use of the PIDIREGAS and the FIBRA-E to obtain private financing for generation projects that CFE would own or control. To facilitate U.S. investor interest in these mechanisms with respect to renewable energy projects, the U.S. and Mexico could discuss the cross-border tax treatment for these financing mechanisms, and also possible investment support through U.S. agencies and U.S.-influenced entities like the North American Development Bank (within its area of jurisdiction).

[94] This commentary reflects recommendations regarding U.S.-Mexico cooperation on renewable energy contained in the study U*.S.-Mexico Forum, Energy and Sustainability*, by Carlos Pascual, Angelica Ruiz, David Crisostomo, Samantha Gross, Veronica Irastorza, Alejandra León, Jeremy Martin, John McNeece, Isabel Studer, and Lisa Viscidi (Center for U.S.-Mexican Studies, UCSD, 2021), usmex-forum-2025_report_energy.pdf (ucsd.edu).

Coordinated Transmission Planning[95]

Transmission is a bottleneck for development of renewable energy on both sides of the border. In this regard, the U.S. and Mexican governments should facilitate meetings of experts on both sides of the border to compare planning strategies and tools, decision processes, how to manage public input, strategies for financing new transmission, and cost allocation strategies.

On the US side, regional transmission operators and independent system operators such as the Electric Reliability Council of Texas (ERCOT), the Southwest Power Pool (SPP), the Midcontinent Independent System Operator (MISO), and the California Independent System Operator (CAISO) have experience with large-scale transmission projects, which have produced multiple benefits that together far exceed their costs. The US Federal Energy Regulatory Commission (FERC) has regulatory expertise in "Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities," as reflected in its Order 1000.[96] On the Mexican side, CFE and CENACE have built and managed Mexico's transmission grid. The U.S. and Mexican governments could facilitate a dialogue among these US and Mexican parties on transmission planning issues.

Coordination on Implementation of the North American Renewable Integration Study

The North American Renewable Integration Study (NARIS) – a multi-year international effort with support from the governments of the U.S., Canada and Mexico – is the first detailed power system integration study for the entire North American continent.

Under NARIS, "NREL developed and evaluated a set of four core scenarios to understand the impacts of renewable technology cost trajectories, emission constraints, and demand growth on the key outcomes. The scenarios were informed by the goals in the Mid-Century Strategies for the Paris Agreement in each country, with up to 80% carbon reductions continent-wide."[97] The results of the study were as follows:[98]

- Multiple pathways can lead to 80% power-sector carbon reduction continent-wide by 2050.
- The future low-carbon system can balance supply and demand in a wide range of future conditions, with all technologies contributing to resource adequacy.
- Regional and international cooperation can provide significant net system benefits through 2050.
- Operational flexibility comes from transmission, electricity storage, and flexible operation of all generator types, including hydropower, wind, solar, and thermal generation.

The U.S. and Mexico should discuss how U.S. support for Mexico's renewable energy planning could be structured to foster increased North American renewable energy integration consistent with NARIS. This continent-wide integration would increase energy security as well as bring cost, health and climate benefits for Mexico and the U.S.

---

[95] Ibid.

[96] https://www.ferc.gov/industries-data/electric/electric-transmission/order-no-1000-transmission-planning-and-cost.

[97] https://www.nrel.gov/analysis/naris.html.

[98] Ibid.

Discussion on Potential Increased Mexican Ambition

As the foregoing talks and other collaborative efforts develop, the U.S. and Mexico might discuss whether Mexico could increase its ambition in renewable energy to move toward a net zero emissions strategy by 2050.