WEBINAR SERIES

CLEAN ENERGY IN MEXICO

Co-Hosted by: Institute of the Americas and Mexico Institute at the Wilson Center

The Economic and Strategic Arguments for Renewable Energy in Mexico

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Summary of Arguments

- Renewable energy from solar and wind projects, supplemented by energy storage, is low-cost and reliable.
- Low-cost renewable energy plus storage can be a foundation for economic development, including job creation.
- Renewable energy plus storage can partially replace natural gas for generation of electricity, reducing Mexico's dependence on imported natural gas.
- Reduced imports of natural gas will help reduce Mexico's hydrocarbon balance of trade.

Costs, Reliability, and Grid Integration

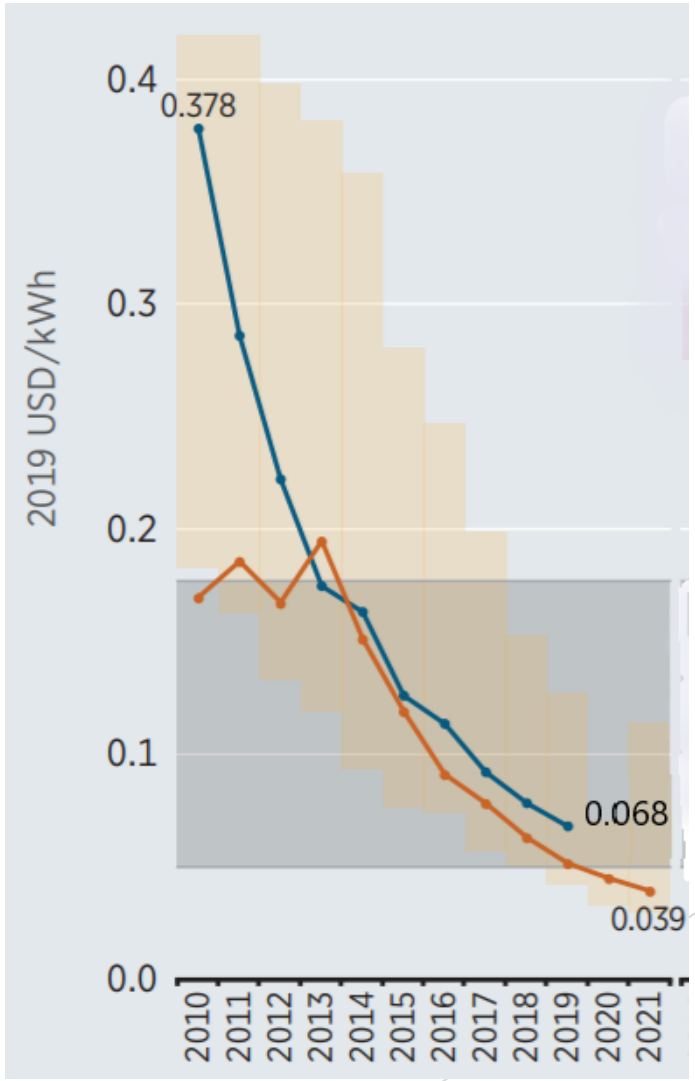
- Winning bids in the final clean energy auction in 2017 averaged $20.57 per Megawatt hour (MWh), or $0.02057 per Kilowatt hour (kWh), for electricity and CELs from solar and wind – among the lowest prices ever bid internationally.
- Key Reasons Underlying Low Bids
  - Long-term decline in the costs of renewable energy technologies. Reference: International Renewable Energy Agency (IRENA), of which Mexico is a member.
  - Mexico has extraordinary wind and solar resources

Technology Costs – LCOE and Auction/ PPA Prices - PV Solar

Global weighted average LCOE (blue line) and Auction/PPA prices (brown line) for Solar PV, 2010 to 2021.

Levelized cost of electricity **(LCOE) -** the average revenue per unit of electricity generated needed to recover the costs of building and operating a generating plant during an assumed financial life and duty cycle. Range in gold band

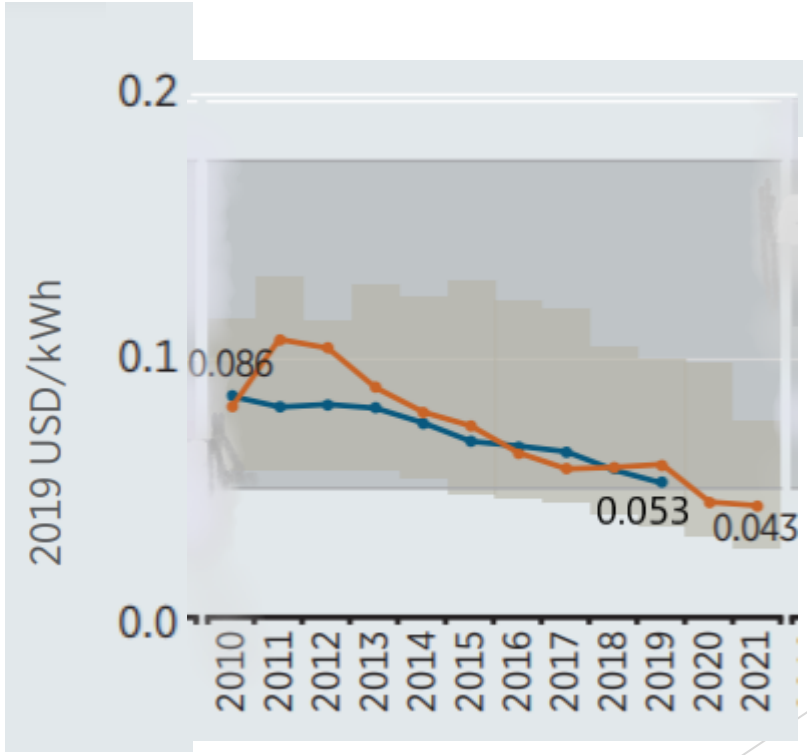
- Weighted Av. LCOE from $0.378/kWh in 2010 to $0.068 in 2019, down 82%.
- Auction/PPA price for 2021 start-up ($0.039) is 42% below 2019 W.A.LCOE ($.068), <fossil fuel cost (gray band).



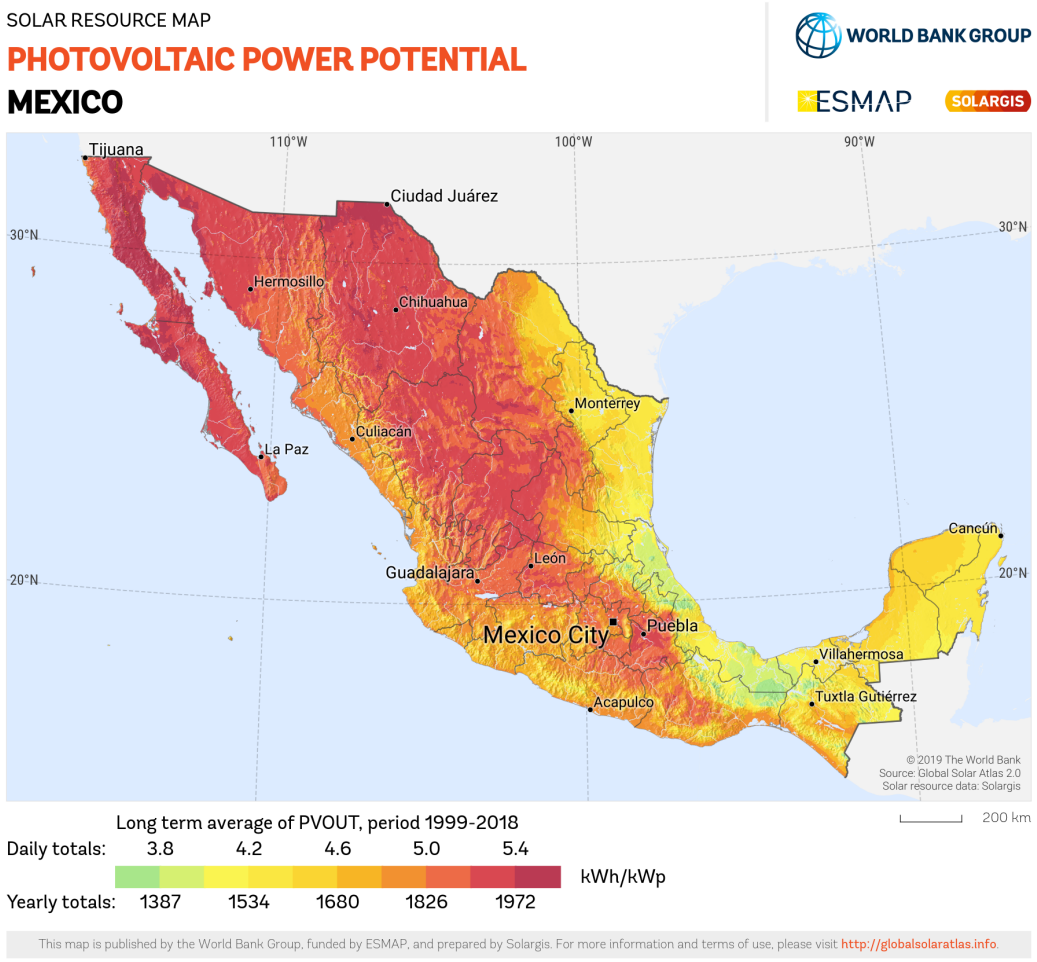
Technology Costs – LCOE and Auction/ PPA Prices - Onshore Wind

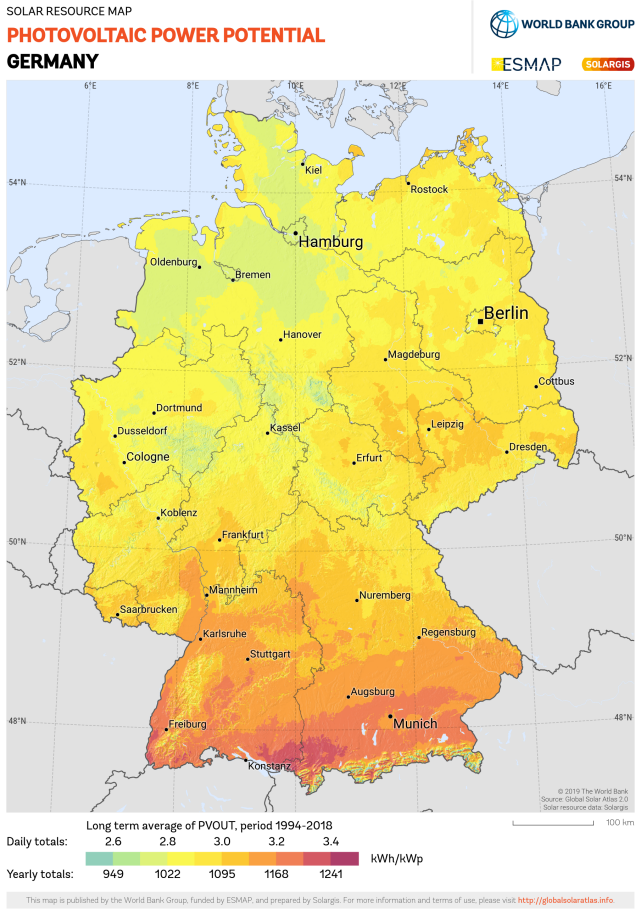
Global weighted average LCOE (blue line) and Auction/PPA prices (brown line) for Onshore Wind, 2010 to 2021. Range in tan band.

- Weighted Av. LCOE down from $0.086/kWh in 2010 to $0.053/kWh in 2019, down 38%.
- Auction/PPA price for 2021 start-up ($0.043/kWh) is 19% below 2019 Weighted Average LCOE ($0.053/kWh). Also less than electricity generated with fossil fuels (gray band).



Lower Costs from PV with High Solar Intensity





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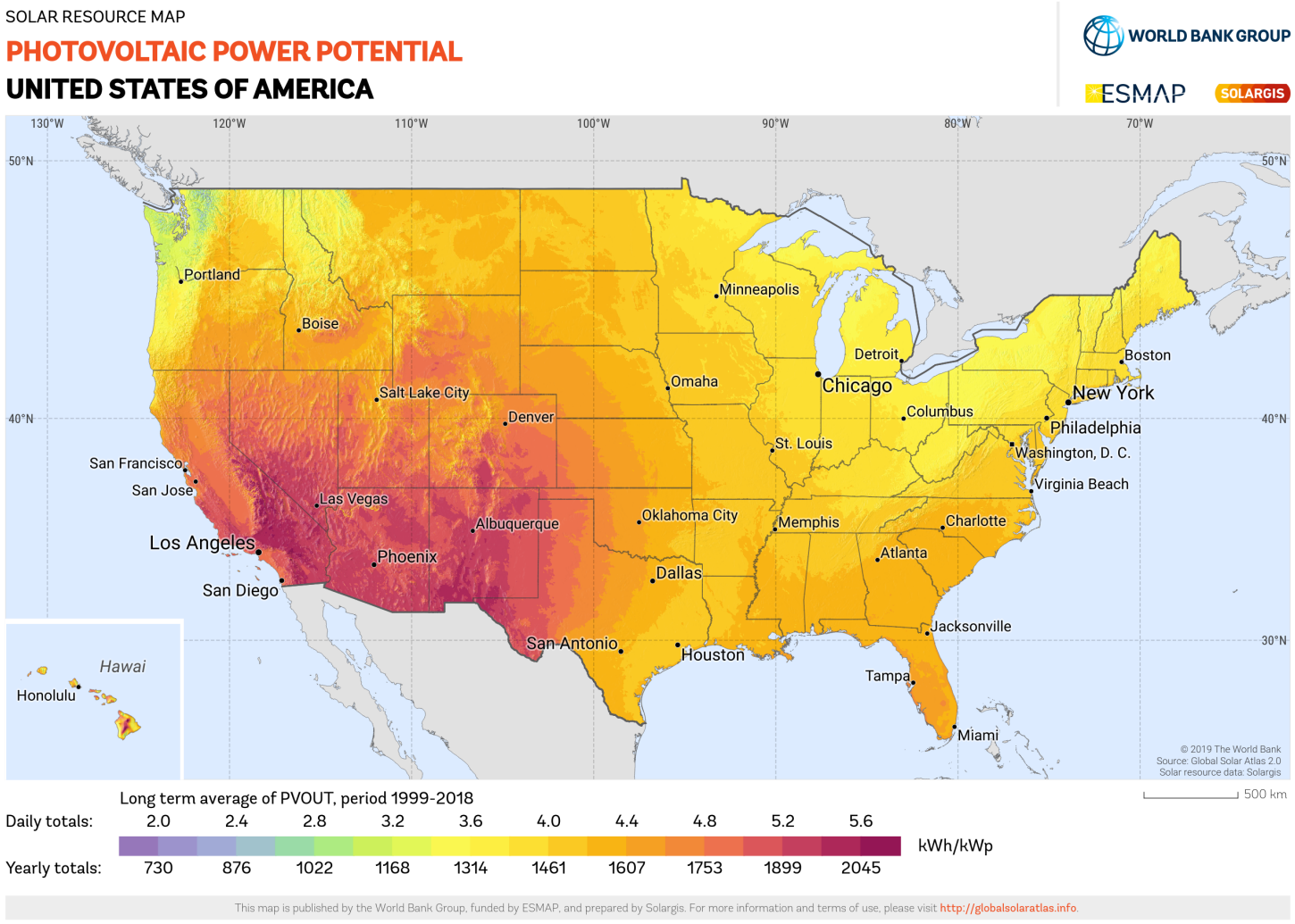
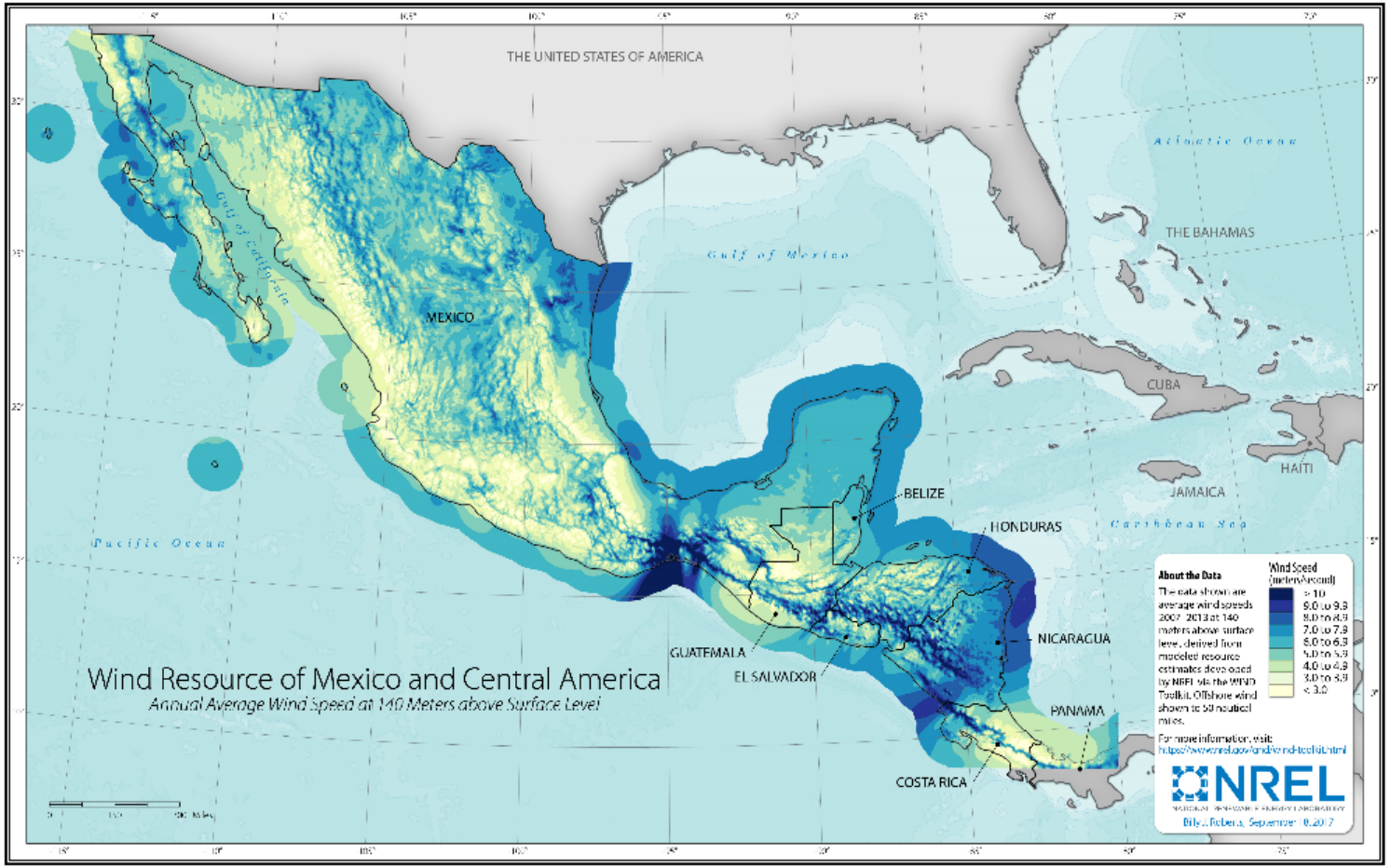
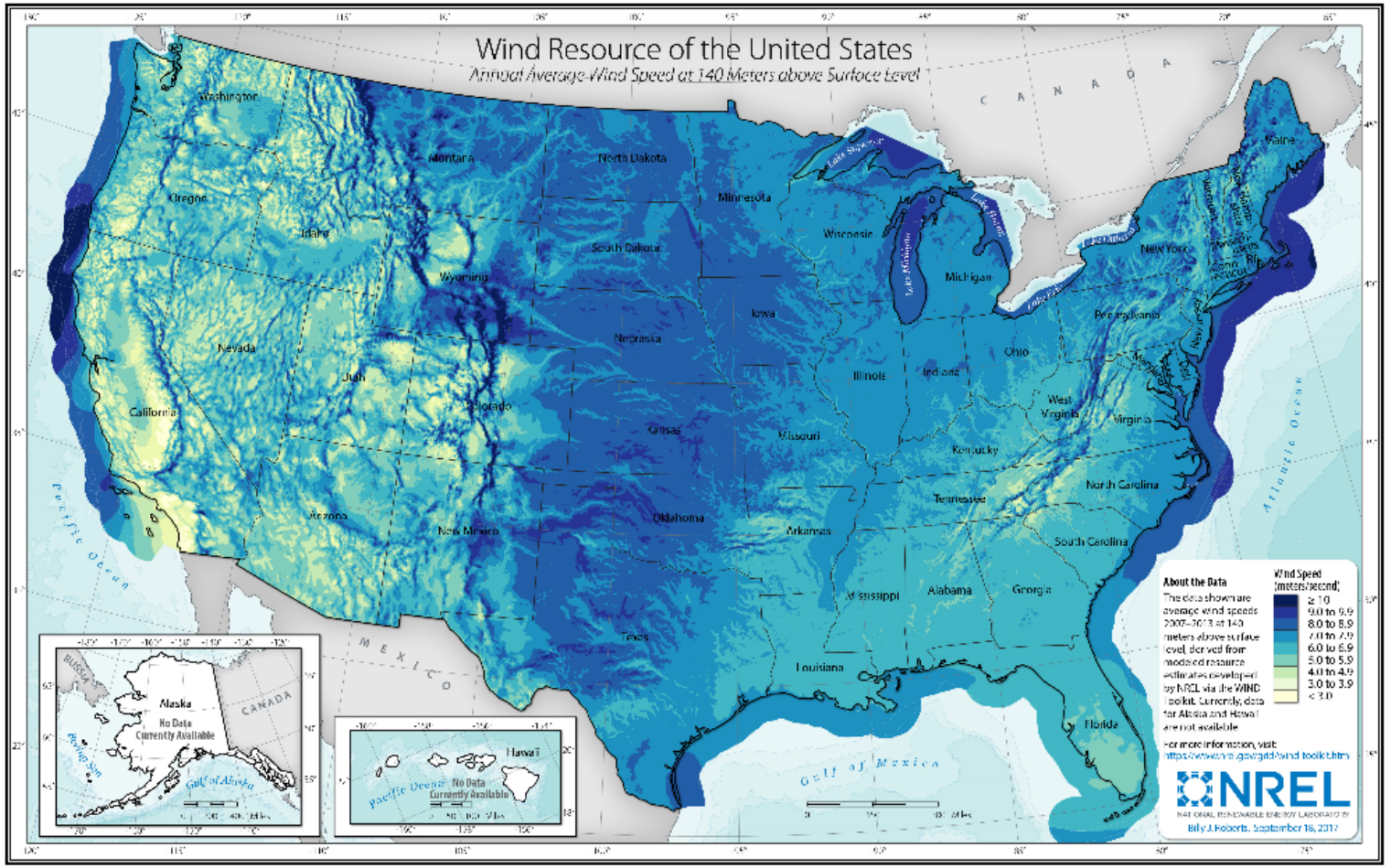


Lower Costs from Wind with High Wind Speed



Lower Costs from Wind with High Wind Speed



CFE argues that the Low Bids are “a Lie”

- CFE argues that a proper cost accounting must include
  - the cost of backup power for when the sun does not shine and the wind does not blow (intermittency);
  - the cost of integrating clean energy onto the grid; and
  - the cost of new transmission capacity to support clean energy.
- The accepted bids do not include these items. Hence, they are “lies” as to the full cost of renewable energy.

The Arguments in Response

- Even taking account of CFE's concerns – intermittency, grid integration and transmission (properly analyzed) - electricity from renewable energy sources can be cheaper than electricity from conventional power plants.

Intermittency and Grid Integration

- Energy storage is key to management of intermittency and grid integration issues for renewable energy.
- Focus here on lithium ion batteries, although other technologies may be lower cost for long-term storage.

Intermittency and Grid Integration

- Batteries can “smooth out” intermittency in the course of a day
- Can extend the supply period, e.g. for solar projects after the sun goes down
- Can assist with grid integration
  - Absorbing excess power
  - Frequency regulation
  - Voltage regulation

Intermittency and Grid Integration

- "Hybrid projects" – renewable energy plus energy storage – are now common in the US
- Bid prices have come in very low. E.g. Xcel in Colorado – 2017 "All Source Solicitation"
  - 11 bids for wind plus storage with a median price of $21.00 per MWh
  - 87 bids for solar plus storage with a median price of $36.00 per MWh
  - 7 bids for wind plus solar plus storage with a median price of $30.60 per MWh
  - "Median price" - mid-point of the pricing, i.e. ½ above, ½ below

Intermittency and Grid Integration

- Xcel bids lower than Lazard LCOE for gas-fired generation
  - Lazard prepares annual LCOE analysis for various technologies, predicated on stated assumptions
  - US LCOE for combined cycle gas turbine (CCGT) in 2019, without tax subsidies, is $44-$68 per MWh over 20-year life, assuming gas cost of $3.45/MMBtu.
  - Key assumption is cost of natural gas over life of project. EIA projects Henry Hub average of $2.14/MMBtu for 2020, $2.89/MMBtu for 2021. Hard to project over 20 years.

Intermittency and Grid Integration

- 2019 Case Study: 8minute Solar Energy-LADWP. 25-year contract, 200 MW of solar PV, plus batteries supplying 100 MW over a 4-hour period (i.e. total energy of 400 MWh) - US$19.97 per MWh for electricity plus US$13.00 per MWh for battery support = $32.97/MWh total.
- Tom Buttgenbach, CEO of 8minute, estimates that same deal in Mexico, with same insolation and strong off-taker, adjusting for ITC and US duties, would be up to 10% more for PV, 40% more for batteries. This increases cost to $41.97/MWh, still lower than CCGT.

Intermittency and Grid Integration

- Batteries cannot fully resolve all issues of intermittency, i.e. several-day loss of power or seasonable variations, nor can batteries resolve all issues of grid integration.
- But these issues can be managed, without 100% backup:
  - Increasing area for sourcing resources, via transmission
  - Integrating both wind and solar in different locations
  - Better wind and solar forecasting, to reduce reserves
  - Demand response programs
  - Increased flexibility of conventional generation backup
  - Renewable generation itself contributing to reliability
  - Ancillary services, including from battery energy storage

Intermittency and Grid Integration

- 2008 ERCOT (Texas) Study: Operational issues at 23% wind capacity "can be addressed by existing technology and operational attention, without requiring any radical alteration of operations."
- 2010 NREL Study of 11-State Western Interconnection Region: "The integration of 35% wind and solar energy into the electricity power system will not require extensive infrastructure if changes are made to operational practices."

Intermittency and Grid Integration

- 2011 Southwest Power Pool (SPP) Study: “No significant technical barriers or reliability impacts to integrating wind energy levels up to 20%,” with sufficient transmission upgrades.
- 2011 ISO New England Study: Wind energy could meet 24% of regional electricity requirements in 2020, with sufficient transmission upgrades.
- 2014 PJM Study: Wind and solar could provide up to 30% of power with expansion of transmission and minimal additional backup.

Intermittency and Grid Integration

- But at what cost? A 2015 survey of grid integration studies found "evidence that integration of large amounts of wind energy, up to 30 percent of total generation, is technically and economically feasible, with integration costs generally less than 10 percent of the cost per MWh of wind and often significantly less."

Intermittency and Grid Integration

- Transmission is fundamental, but who pays?
- Mexico needs to strengthen its entire national electrical system, including the transmission grid. In 2018, Mexico's electricity consumption per capita was 2.4 MWh. Compare Spain at 5.5 MWh, Chile at 4.1 MWh, and Argentina at 3 MWh.
- Analyses of transmission projects managed by ERCOT, SPP and another ISO showed benefits to users, e.g. reduced prices, of 2.6-3.9 times costs.
- Argument: Charge to all users, not to developers.

Intermittency and Grid Integration

- There is no “One Size Fits All” approach to management of renewable energy issues. Mexico needs to carry out its own studies:
  - Grid Integration Studies
  - Transmission Planning Studies
- Objective: Determine the system support needed and related costs for increased development of clean energy plus storage in Mexico, as well as the benefits in reduced electricity costs.

Intermittency and Grid Integration

- Studies can set the stage but market testing through a bid process provides a reality check:
  - Based on studies, take promising scenarios for renewable energy + storage;
  - Test scenarios though a bid process that identifies goals and leaves the approach for reaching these goals to the bidders (Xcel model in 2017); and
  - Evaluate bids not only on the specific financial terms offered, but also in terms of the all-in costs, including integration costs and any necessary transmission network upgrade costs for project.

Economic Development and Job Creation

- An adequate supply of cheap, reliable electricity is a necessity for economic growth across the entire economy.
  - An issue in Mexico, as shown by the per capita electricity consumption figures presented above.
  - Renewable energy can meet that need.
- Renewable energy projects can also provide direct economic benefits.

Economic Development and Job Creation

- Technical analysis of Direct Benefits:
  - With promising scenarios for renewable energy + storage, analysts can generate figures for investment amounts and the timetable for construction and investment
  - Based on these figures, using input-output models, e.g. IMPLAN, one can project, for each year of project, total industrial output, national value added, total labor income, and jobs created. IMPLAN has Mexico data sets.

Economic Development and Job Creation

- Even without technical analysis, it is possible to identify potential economic development and job creation opportunities.
- According to IRENA,
  - The renewable energy sector now employs at least 11 million people worldwide.
  - There are employment opportunities in installation and servicing of RE facilities and, to a lesser degree, in assembly and manufacturing.

Economic Development and Job Creation

- Mexico already has robust solar, wind sector.
  - Mexican Solar Industry Association (ASOLMEX) - Mexico currently has approximately 5,000 MW of installed solar capacity, with 62 projects in 16 states; 64,000 workers across value chain.
  - Mexican Wind Energy Association (AMDEE) – At the end of 2018, Mexico had 4,935 MW of installed wind capacity, in 54 wind energy parks; currently more than 11,000 permanent jobs, 7,000 in manufacturing, with the prospect of creating 35,000 more jobs in the next five years.

Economic Development and Job Creation

- US experience is indicative:
  - In 2019, ~ 335,000 people work in solar and >111,000 work in wind; ~ 139,000 work on grid modernization and energy storage.
  - U.S. Bureau of Labor Statistics forecast: two fastest-growing jobs through 2026 will be solar installer (105% growth) and wind technician (96% growth).
- Mexico should see growth in these areas, but also in assembly and manufacturing, and in the buildout of its transmission grid.

Economic Development and Job Creation

- Mexico has potential for substantial growth in assembly and manufacturing for its own domestic market and for export to US and Canada.
- But IRENA advises that national deployment and industrial policies, changes in the geographic footprint of supply chains and in trade patterns, and industry consolidation trends all shape how and where jobs are created. Not easy.
- Potentially attract existing low-cost manufacturers, e.g. from China, to establish facilities in Mexico?

Renewable Energy in Lieu of Natural Gas

- Of the natural gas consumed in Mexico, excluding PEMEX self-consumption, 90% is imported. If PEMEX self-consumption is included, 67% is imported. Substantially all imports are from the US.
- Of all the countries in the world that are highly dependent on imported natural gas, only Mexico relies on a single country for substantially all of its imports.
- Renewable Energy in lieu of natural gas would carry out the principle of energy sovereignty for Mexico, a core objective of AMLO.

Renewable Energy in Lieu of Natural Gas

- Data from the Mexican Ministry of Energy (SENER) and the National Hydrocarbon Commission (CNH) indicates that roughly 69% of imported natural gas is used for power generation.
- To the extent that clean energy replaces natural gas as a source of electricity, each additional bcfd of natural gas that would otherwise be imported could be reduced by 69%.
- Unless Mexico increases its own production. But unlikely based on Pemex E&P budget, EIA forecasts.

Mexico's Hydrocarbon Balance of Trade

- Mexico's imports of U.S. natural gas negatively affect its hydrocarbon balance of trade.

Mexico's Balance of Trade for Selected Petroleum Products
(thousands of US dollars)

	2018	2019
Exports of Crude Oil	26,512,106	22,552,194
Exports of Natural Gas	27,990	15,319
Exports of Petroleum Derivatives	2,932,627	2,299,129
Total Exports	**29,472,723**	**24,866,642**
Imports of Natural Gas	7,325,396	6,288,056
Imports of Petroleum Products	36,858,652	32,601,253
Total Imports	**44,184,048**	**38,889,309**
Net Balance	**14,711,325**	**14,022,667**

Source: INEGI

Mexico's Hydrocarbon Balance of Trade

- Both exports and imports of hydrocarbons declined from 2018 to 2019. Nevertheless, the negative hydrocarbon balance of trade was very high for both years, exceeding US$14 billion in each case.
- Further, since the balance of trade is in dollars, Mexico is subject to currency risk. Banxico: 1 Dollar = 18.8642 pesos, 12/31/2019; 24.6895 pesos, 4/6/2020. Atypical, but shows risk.
- Reduced gas imports improves balance of trade.

Mexico's Hydrocarbon Balance of Trade

- Also, with a reduction of foreign expenditures for natural gas, those expenditures could potentially be redirected to domestic purposes:
  - domestic employment in construction of wind and solar projects, battery installations, and transmission, and
  - purchase of Mexican products, equipment, and other inputs for such projects and facilities.
- The multiplier effect of these domestic expenditures could be significant.

Conclusion: Important Benefits for Mexico

- Renewable energy + energy storage could provide important benefits to Mexico:
  - A low-cost, reliable source of electricity.
  - Substantial investments to fund renewable energy + storage projects and related infrastructure, e.g. transmission.
  - New jobs and infrastructure, including a modern electricity grid.

Conclusion: Important Benefits for Mexico

- Reduced dependence on imported US natural gas.
- An improved hydrocarbon balance of trade.
- Redirection of a portion of the billions of dollars paid annually to the US for imported natural gas to expenditures in Mexico, i.e. for Mexican labor and purchase of Mexican products, equipment, and other inputs.

Thank you!

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