An Energy-Water Corridor Along the US/Mexico Border: ***Changing the Conversation***

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Abstract

Over the last decade, migration has become a divisive issue around the world. A large number of countries have erected barriers along their borders to prevent migration, leading to geopolitical tension. Climate change effects will likely exacerbate migration tensions, which will require bold and creative solutions to this difficult social predicament. Here we detail a plan to construct an energy-water corridor along a border that has been the focus of much attention recently: The U.S.-Mexico border. Our proposed solution helps to alleviate some of the negative effects of climate change, while providing energy and economic stimulus to an area that begs for sustainable development. The energy-water corridor will take advantage of the unique renewable energy resources along the border states and will use state-of-the-art water desalination and treatment systems to provide the resources for economic development in the region.

Major advances in technology offer unprecedented opportunities to bring the world together. However, recent mass migrations due to violence, lack of economic opportunity and war have left many countries unprepared, and raised geopolitical tensions that led to man-made border dividers. About one-third of the countries around the world have built some type of border fence [1]. Physical barriers also generate internal disagreement in many countries and exacerbate the rhetoric of “us” versus “them”. For instance, the immigration enforcement policies along the United States–Mexico border have become a source of continued controversy in American politics, leading to political resentment and gridlock. Such issues call for alternatives that generate partisan-free, sustainable solutions capable of addressing the pressing socio-economic challenges of the border, the Southwest states and of Central America. In this article, we detail the rationale for leveraging natural resources to produce renewable energy and water to create an economic corridor along the U.S.–Mexico border that will stimulate the economy and develop infrastructure that mitigates migration while also offering border protection.

As climate change continues to bring more extreme weather (e.g., droughts, hurricanes, coastal degradation, tornadoes, floods) migration will likely increase around the world [2]. With regards to the U.S.–Mexico border, for instance, crop yields in Mexico are negatively correlated with the rates of migration from Mexico to the United States, where even a 10% reduction in crop yields may lead to increase migration [3]. Reduced water availability under climate change scenarios will likely exacerbate this population shift to the U.S. Thus, this region may be further challenged by undocumented immigration, human trafficking and lack of employment opportunities. Therefore, the need for new solutions to these border problems become imperative.

To cope with severe to exceptional meteorological drought conditions, the border states of California, Texas, New Mexico, and Arizona are living beyond their means when it comes to groundwater resources [4]. Current state water plans focus on conservation and sustainability. These laudable objectives do not represent a blueprint for growth and prosperity, and without a long-term, sustainable water supply, border communities may run out of water, triggering economic instability, human suffering and mass migration to areas with greater water availability.

With data from the National Drought Monitor [5], we computed the drought severity coverage index (DSCI) in every county of the U.S. border states from 2000-2018 (Figure 1(a)). The DSCI is a weighted average of the severity and the percent area under one of the six levels: No Drought, Abnormally Dry (1), Moderate Drought (2), Severe Drought (3), Extreme Drought (4), and Exceptional Drought (5). A value of DSCI = 0 represents 100% of the county under “No Drought” conditions, while DSCI = 100 indicates 100% of the county under “Exceptional Drought”. Figure 1a shows that California, Arizona, New Mexico, and Texas have experienced severe to exceptional drought conditions, and some regions in California and Arizona are in exceptional drought regimes. Such severe levels of droughts lead to increase in water scarcity, and could indeed lead to more competition for resources in the future [2]. Climate change also represents a threat to water resources shared by Arizona and the Sonoran Desert [6].

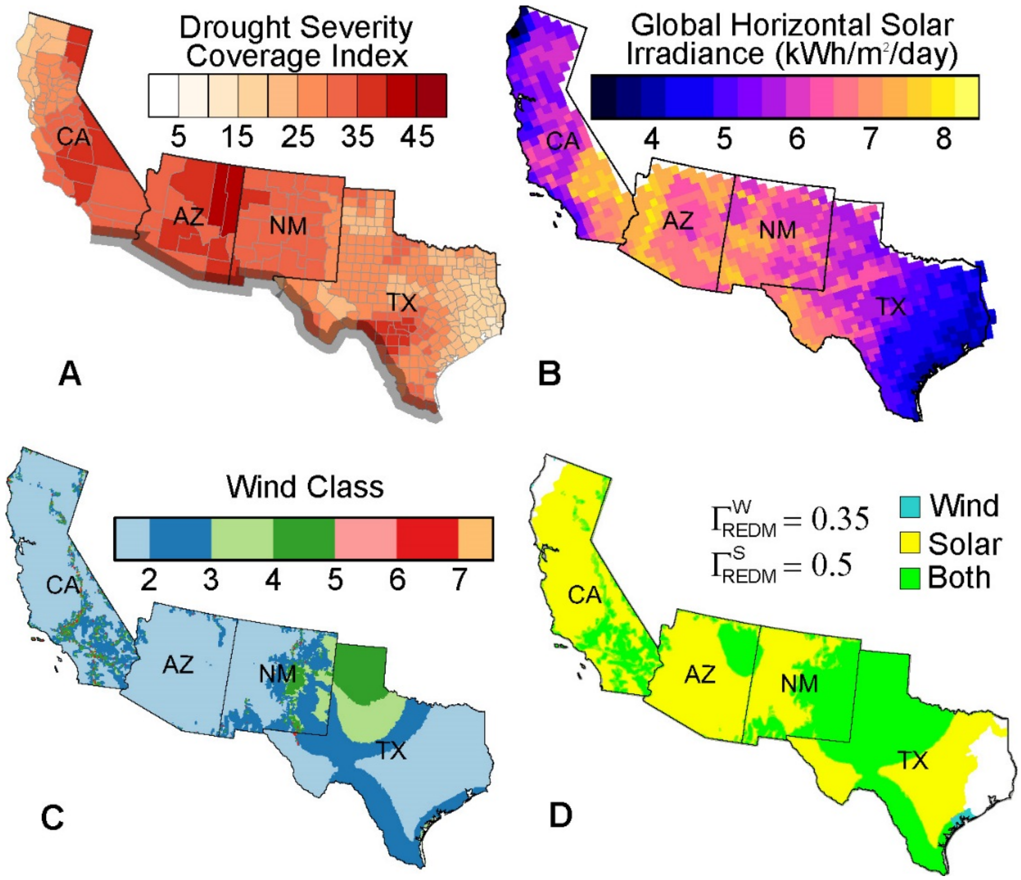

Figure 1. (a) Drought Severity and Coverage Index (DSCI) (data from U.S. Drought Monitor [5]); (b) Global horizontal solar irradiance in the southern border states. (c) Wind class at 50m height, (**Class 1:** up to 5.6 m/s; **Class 2:** up to 6.4 m/s, **Class 3:** up to 7.0 m/s; Class **4:** up to 7.5 m/s; **Class 5:** up to 8.0 m/s; **Class 6:** up to 8.8 m/s; **Class 7:** up to 11.9 m/s), and (d) Map of drought-energy resource correlation parameter Γ.

Border states, however, have abundant energy resources that, if properly utilized, could change the existing semi-arid land into a fertile, economic corridor and benefit the population on both sides of the border. Figures 1(b-c) highlight that the Southwest has unique solar and wind resources that can be readily tapped using existing technologies. Texas already leads wind-energy electricity production in the US, with California, Arizona and Texas among the best regions for solar generation of electricity (1st, 3rd, and 5th, respectively) [7]. In Figure 1d we identify regions that are drought prone but also rich on renewable resources using the Gutierrez Renewable Energy Drought Mitigation (REDM) index, ΓR (eq.1), which locally characterizes the level of coexistence of average drought severity and energy resource. The Gutierrez Index is defined as:

$$\Gamma^{w}_{REDM} = \sqrt{\frac{WC - WC_{min}}{WC_{max} - WC_{min}} \times \frac{d - d_{min}}{d_{max} - d_{min}}} \quad \Gamma^{s}_{REDM} = \sqrt{\frac{PV - PV_{min}}{PV_{max} - PV_{min}} \times \frac{d - d_{min}}{d_{max} - d_{min}}}$$

eq. (1)

Where the superscripts *w* and *s* stand for wind and solar, *WC* and *PV* represent the wind class and photovoltaic resource, respectively, and *d* is the drought severity. Areas in green color represent zones where using wind and solar energies can help significantly mitigate droughts. It can be observed that along the Texas and New Mexico border, both wind and solar (green) can be used for electricity generation, while also saving water since these are also regions of high droughts. In Arizona, however, it is best to employ solar energy (yellow) which will also preserve water. Moreover, California as shown in Figure 1(d) the zone in green shows that we can employ wind and solar, while in west of California (except offshore) it is more favorable to employ solar energy. Consequently, the new coefficient, can indeed helped us identify where one deploy renewable resources that minimize water in drought prone regions. Furthermore, the areas in color white does not means that there is not wind or solar resources, but these are regions where there is not high levels of droughts (as shown in figure 1a).

In addition, there are significant natural gas resources along the Texas border (Western Gulf, Eagle Ford and Permian basins) that can be synergistically integrated with these renewables to boost state economies along both sides of the border, while mitigating the impact of intermittency of renewables on the power grid.

Rather than simply building an inert wall, we propose the construction of an energy–water innovation corridor that addresses the aforementioned challenges while leveraging the existing energy resources (Figure 2) in the region. This change in paradigm could *transform the U.S.–Mexico border into a corridor of opportunities—a 1,989-mile-long technology park.* In addition to some of the U.S.'s best wind resources (Figure 1c), the border region has one of the best solar irradiation levels (Figure 1b) in the World, according to the Global Solar Atlas [*7*]. These energy resources (including a mixture of solar thermal and solar photovoltaic) could easily provide 16 GWh of electricity per day. The cost of installing 16GWh the solar energy generation capacity, plus the 1.2GWh of wind energy capacity and two desalination plants (Gulf of Mexico and Pacific in California) with a 48-inch diameter water pipeline along the entire border is comparable to the cost of building the wall proposed by President Trump. However, the investment of this green-energy corridor is more like a loan since over time it will pay for itself. An option to invest in the region should be an integral part of the discussions on border security.

Contiguous water infrastructure could integrate water recycling, and maximize availability from storm runoff, agricultural wastewater, sewage water, groundwater, surface water, and seawater. By integrating the abundant wind energy and new technologies for reverse osmosis (RO) [8], the cost of desalination can be reduced by at least 30%. The capability of RO desalination membranes to reject the smallest contaminants has made them central for water re-use. Public/private partnerships in this corridor would desalinate wastewater and seawater and also transport fresh water and natural gas along the U.S.–Mexico border using the wind energy available in the Gulf of Mexico and in Baja California. Areas of strong winds exist in the Gulf and Baja California regions and are ideal for wind-farm deployment [9]. The estimated 600 MW wind power capacity from the Gulf Coast and Baja California is sufficient to operate reverse osmosis plants and provide 2.3 million acre-feet of water per year. To illustrate, this amount would be enough to satisfy the water needs for all of Texas' manufacturing, mining, livestock, and other power needs.

Harnessing renewable energy resources such as wind, concentrated solar power and photovoltaics to generate electricity, rather than relying on traditional thermoelectric plants, would have the added benefit of reducing the amount of water used for energy [10,11] in these arid, drought-prone regions. The modularity of solar photovoltaic energy provides an ideal opportunity for contracting individual sections separately and for private–public partnership opportunities for construction and operation. The expanded infrastructure necessary for power distribution (i.e., smart grids) is critically needed to handle existing and projected power requirements, particularly in California. The East-West solar corridor may also address power load shifting for the entire region; e.g., energy from the West can be used to alleviate load in the East during the early evening, while power from the East can provide pre-dawn generation to the West; thereby reducing the energy storage requirements and cost.

Figure 2. Conceptual Energy-Water corridor along the border.

In addition to the energy park, we propose a series of wind turbines with a hydraulic drive-train combination within this zone to desalinate the water via RO from the Pacific and the Gulf of Mexico (see Figure 2). Allocating a substantial fraction of the electricity generated to desalinization and pumping can ensure fresh water and energy for the region, plus an economic stimulus that benefits everyone in these diverse semi-arid regions. Water and energy availability along the border will create new market demand and economic development. This attractive opportunity offers Mexico a strong inducement to be a major partner and invest proper resources in such a project.

The water can feed major agricultural regions for both countries along the border. It will require construction of a transcontinental, interconnected super-pipe system along the 1,989-mile border. This pipeline would be constructed by a skilled-labor force from both the U.S. and Mexico. The desalinated seawater can be pumped from California and Texas to other southern states along the border. Such a massive project could indeed be appealing for Mexico since clean energy and fresh water will offer unique economic and social opportunities.

The proposed energy infrastructure can be incorporated into and be an integral part of border security installations. This secured technological buffer can, in turn, help protect the energy infrastructure and prevent undocumented immigration across the border. It has been decades since the U.S. undertook a project of such magnitude. This project would be parallel to that of the Panama Canal or the St Lawrence Seaway, and be worthy of two great nations. While expensive, these costs would be more than an order of magnitude smaller than the recently discussed infrastructure plans by congress, which have ranged from $200 billion to $ 1 trillion, with a call of $1.5 trillion plan from President Trump [12]. The proposed project would transform the arid Southwest states into a productive agricultural area that can also provide power sustainably for the future economic growth of both countries, while supporting regional economic expansion through a chain of industrial innovation centers along the U.S.–Mexico border—see Figure 2. A number of associated employment opportunities would increase prosperity, security and collaboration along both sides of the corridor while reducing undocumented immigration. In addition, it is important to stress that Texas has physical barriers in only 9% of its border with Mexico compared to 82% for California, 81% for Arizona, and 64% for New Mexico. On the other hand, Texas represents the larger economic trading share (34.6%) of any border state in the total US trade with Mexico, much greater than California (13.7%), Arizona (3.5%), and New Mexico (0.4 %). Therefore, by creating this energy corridor we could enhance the economic trading with Mexico rather than inert walls which reduces economic potential for the region.

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