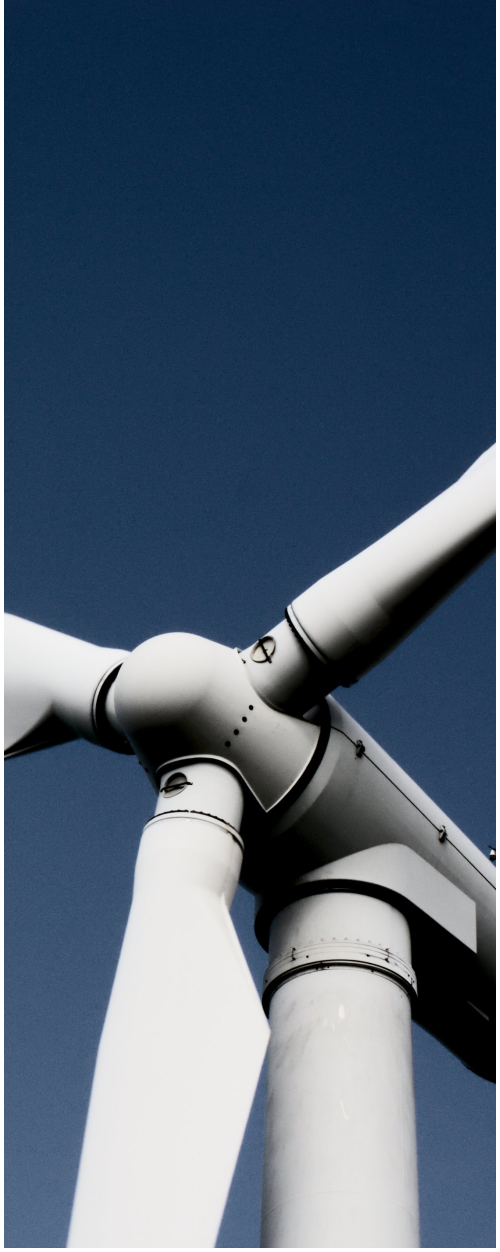
RE-ENERGIZING THE BORDER: RENEWABLE ENERGY, GREEN JOBS AND BORDER INFRASTRUCTURE PROJECT



Project Summary

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Prologue

This study focuses on the prospects for positive spillovers from renewable energy projects into border states and examines three main areas of activity. Leaving aside hydroelectric and geothermal power generation areas that have received substantial attention in the past, we focus instead on the development potential to be gained from wind, solar and Municipal Solid Waste (MSW) projects. The research contained in this series of reports evaluates the potential impact of investment in these projects in border communities in terms of employment, infrastructure, human capital and social participation.

An underlying assumption of this research is that it is crucial that local, state and federal governments, as well as private businesses, recognize the potential for utilizing renewable energy projects as a motor of development in the border region. We can look here to the example that has been set by Texas in this regard. Over the last ten years, the state has developed its wind energy resource to the extent where it has created over ten thousand jobs and has become self-sufficient in wind energy, in the sense that it has satisfied its own renewable energy standards. The building of wind farms has been matched by the construction of transmission lines, the development of knowledge-based clusters and the establishment of one of the world's leading wind energy industries. The town of Sweetwater in Nolan County alone has more installed wind capacity than all of Mexico. Known as the "Wind Turbine Capital of Texas," Sweetwater has benefited from the creation of over 1,300 jobs directly related to the wind energy industry, the payment of over $18,000,000 in royalties to landowners, and the collection of over $12,000,000 in local taxes each year.[1] If states such as Tamaulipas (which benefits from the same wind patterns as Texas) were to follow this example, the impact on living standards and economic development would be considerable.

The research employs an interdisciplinary approach, incorporating researchers and research approaches from the fields of public policy, international relations, economics and engineering. It is hoped that this adds to the richness of the study and will produce not only a positive contribution in terms of the energy and economic potential of renewable energies, but also a more nuanced understanding of how public policies can be crafted to maximize their positive impact on local communities.

In addition to adopting an interdisciplinary approach to the research, extensive travel, interviews, site visits and outreach work were also undertaken, both to gather data and insights and to promote a greater understanding of the broader implications of the project's findings. Presentations made to the Good Neighbor Environmental Board in Las Cruces, New Mexico in September 2011, the Border Energy Forum in El Paso, Texas in October 2011, the Council of State Governments in Seattle in October 2011, the Border Legislators Conference in Saltillo in November 2011, and at the Woodrow Wilson International Center for Scholars in December 2011 have helped to spread awareness and understanding of the project goals. Extensive cooperation, interaction and resource pooling with Rick van Schoik and Erik Lee of the North American Center for Transborder Studies (NACTS) at the University of Arizona, has helped enormously in defining the scope of the project and ensuring that only minimal overlap has occurred.

Engagement with key stakeholders in border states, with representatives from the energy sector (in both public and private spheres), and with other researchers has greatly enriched the project. Furthermore, there has been engagement in the form of one-on-one meetings with five Mexican senators, and a presentation made to the Mexican Senate Commission on Border Affairs in March 2012 has secured greater interest and the possibility of leaving a deeper footprint on Mexican public policy. What remains is to share the published results of the study not only with the Mexican federal government (before and after the July 2012 elections) but also with its U.S. counterpart, with state-level governments and with municipalities in Mexican border states.

RE-Energizing the Border: Renewable energy, green jobs and border infrastructure

BACKGROUND

The potential for renewable energy (RE) development in Mexico has become a subject of growing interest inside and outside of the country in recent years. A number of important studies led by governments and academia[2] have emphasized the incredible diversity and richness of renewable energy resources in Mexico and have called on business, government and civil society to work toward a more effective exploitation of this potential.

In the north of the country, the issue of RE exports from Mexico to the United States has attracted interest from both the public and private sectors. Focused primarily on wind power generation in northern Baja California, it has become clear that Mexico has natural endowments and structural factors (especially low land and labor costs) that make the cross-border trade in RE an exciting and potentially highly profitable sector. Though significant barriers still exist to the large-scale development of this potential, the effective coordination of efforts from both the private sector and governments operating at all levels (federal, state, municipal) would provide a much needed boost.

The U.S. and Mexican governments, both individually and jointly, have noted the possibilities for making a positive impact on the border through mutually beneficial RE projects. USAID-sponsored work, in conjunction with efforts from Mexico's Secretaría de Energía (SENER), have identified investment opportunities in both geothermal and wind energy sectors for exporting clean energy to the Californian market, where unsatisfied demand for renewable energy exists thanks to the Renewable Portfolio Standard (which mandates one-third of California energy come from RE by 2020). The Border Governors Conference (BGC) has identified RE development as a central component of their Strategic Guidelines for the Competitive Sustainable Development of the United States-Mexico Transborder Region. Energy firms from the United States, Mexico and Europe are already involved in developing RE resources at the border in the expectation that demand will continue to rise. There is an obvious interest in this work; what is lacking is a comprehensive strategy to both integrate these efforts and identify the most effective paths forward.

Key stakeholders in the energy sector have suggested that a focus on renewable energy in the border region requires much more than a focus on the potential for exporting green energy to the United States. Instead, a more in-depth understanding of how renewable energy projects impact on the short, medium, and long-term prospects for development in local communities will improve the chances for sustainable growth in, and community support for, RE projects. Linking RE generation to economic development in Mexico requires a focus on value chain creation for providers and services. Information needs to flow from

*Table 1: Project Areas of Interest**

Economic benefits	Knowledge spillover and development of human capital	Social participation
■ Direct creation of temporary and permanent jobs. ■ Indirect creation of temporary and permanent jobs - services sectors. ■ Local and state government energy savings through self-supply projects — benefits passed on to tax payer. ■ Energy subsidies for local inhabitants. ■ Infrastructure investment (roads, water, etc)	■ Knowledge and information networks that permeate through mulitple social spheres. ■ Specialization in institutes of higher education. ■ Creation of research and training centers. ■ Increased interaction between government, business and civil society.	■ Communication between government, business and local populations. ■ Ensure that local community becomes stakeholder. ■ Secure acceptance of projects as driver of local development.

* In addition to evaluating the potential for green energy.

developers to universities and authorities to develop training and certifications for technicians and engineers. Local enterprises have already responded to an expanding market, but with effective coordination, there is far greater potential.

PROJECT OBJECTIVES

The study proposes an analytical framework that addresses three main areas of interest beyond the potential for generating green energy. It seeks to evaluate the prospects for a positive impact from wind, solar and MSW projects in terms of each of the three areas outlined in the above table.

This comprehensive approach has not been adopted before in any study of Mexican renewable energy, and herein lies one of the major contributions of the research that we have carried out.

Economic spillover: It is clear that the development of renewable energy projects brings economic benefits to the areas in which they are located, not merely through the generation of electricity or the production of fuel, but also through the spillover effect in terms of employment, infrastructure spending, services, and the potential for creating industries focused on manufacturing equipment and components. Renewable energy technologies tend to create more jobs per unit of energy generated than their conventional energy counterparts. This is because the RE sector tends to create jobs not only in the generation of electricity and fuel and in the manufacture of equipment and parts, but also indirectly in the form of maintenance, repairs and services. It is estimated that more than three million people are employed in the RE sector worldwide, and in Mexico the government has suggested that the sector could employ up to 100, 000 people if it were implemented alongside a complementary industrial policy.[3]

A second level of economic benefit stems from the potential for energy cost savings for local authorities who decide to purchase their electricity from renewable energy

sources. In Mexico, for example, the lower cost of wind energy in relation to power generated through conventional means by the Comisión Federal de Electricidad (CFE), has encouraged municipal authorities to purchase wind energy for public lighting and buildings. These cost savings mean that the government has the opportunity to use those funds for other public purposes. If public authorities such as state governments are themselves partners in green energy generation projects, the resulting profits may be employed as a way of providing subsidies to the local population. This will help to secure local approval of RE projects.

Lastly, we should point to the significant infrastructure investments that often accompany renewable energy projects. As wind and solar plants are often located in remote areas, it may be necessary to build roads and bring in water supplies to make them viable. Of course transmission lines will also be needed to transport the electrons generated to market. All of this infrastructure spending is another potential source of employment and income for local citizens and businesses, but also implies a potential obstacle due to financing limitations.

Knowledge spillover and the development of human capital: Renewable energy development has enormous potential for creating synergies with universities, research institutes, and technical and vocational training institutes that will drive the creation and strengthening of human capital in the border region. If effective collaboration between governments, business and educational institutions can be achieved, a mutually beneficial relationship will develop in which local employment levels and wages rise, businesses have access to local skilled labor, and universities benefit from access to new financial and technical resources.

An example of where this model has already been successful in Mexico is in the city of Querétaro. There the federal and state governments have worked alongside universities and businesses to create an aerospace cluster that groups industry corporations with partners in higher education to design undergraduate and graduate programs. The Parque Industrial Aeroespacial located at the Querétaro Airport has been the center of this growth, and more than 3,300 jobs have been created in the sector. In 2006, the state government and the Universidad Tecnológica de Querétaro (UTEQ) announced the creation of new academic programs to train aerospace engineers. Bombardier, the largest aerospace firm operating outside Querétaro, has worked closely with the university to develop courses that match the human resource and technological needs of the company. Of even greater significance was the creation, in 2008, of the Universidad Nacional de Aeronáutica de Querétaro (UNAQ), Mexico's only university entirely dedicated to the aerospace sector.

States such as Baja California have already begun to think along these lines and are well positioned to benefit from public policies that promote such collaboration. Baja California has a well-developed system of higher education and has some experience in working with the private sector to drive innovation and knowledge transfer.[4] The potential for expanding the experience across the Mexican border states and creating inter-university, interdisciplinary programs that cover all aspects of renewable energy is an issue that should be taken up by public and private actors alike.

Social Participation: The experience of renewable energy projects around the world with regards to their relations with local communities is mixed. Whereas small scale projects, bringing electricity supply to off-grid communities, have generally been welcomed by the local

population, large-scale projects involving the construction of giant wind or solar plants have been more controversial. A variety of concerns, from environmental considerations to questions of rents and profit sharing, have often marred the reputation of renewable energy projects, leading to their rejection and a negative attitude toward local RE projects.

Mexico has been no exception to this general rule. As is discussed in the paper on wind energy, the development of Oaxaca's wind resource has been marred and complicated by disputes among local landowners and between landowners and Independent Power Producers (IPPs) over the distribution of rents and economic dividends. A 2009 study by USAID[5] attributed this problem to various causes:

- Ignorance or lack of reliable information on the part of the local community about the projects and/or about prevailing international practices in the sector;
- An absence of, or ineffective advice given to the community about how to approach the issue;
- Limited information sharing on the part of the IPPs about the real impact of wind farms with the social groups who would be directly affected;
- A lack of clear and immediate regulation regarding land ownership from local authorities;
- Legal problems in establishing ownership of the land;
- The rise of opposition groups and the use of professional agitators who sought to take advantage of social discontent
- A negative media impact due to a failure to adequately measure public opinion prior to the construction phase of the projects.

Partly in response to this growing problem, Mexico's most recent renewable energy legislation, the 2008 Ley para el Aprovechamiento de las Energías Renovables y el Financiamiento de la Transición Energética (LAERFTE), includes a clause that calls on all RE power generation projects over 2.5MW installed capacity to

> "Ensure the participation of local and regional communities…to promote community development, in the areas where projects are located, according to best international practices and to follow the relevant legal requirements with regards to sustainable rural development, environmental protection and agrarian rights."[6]

Of central importance is effective communication between IPPs and the local community, as well as a clear legal framework that reduces the probability of social and economic conflicts arising after the construction of renewable energy projects. Furthermore, seeking the involvement of the community, not only in the planning phase, but also using local companies and labor in the construction and operation of renewable energy projects, is likely to smooth relations with the local population. Local, state and federal governments must take the lead in this regard, facilitating a more effective communication and protecting the rights of both citizens and corporations. However, it is incumbent on the IPPs themselves to anticipate the possibility of these kinds of social conflicts and to take the measures required to avoid them.

THE PROJECT FINDINGS

Wind Energy

Mexico is on the verge of experiencing a second boom in wind energy development, this time in the north of the country. The

research findings highlight the enormous potential of, and growing interest in the impressive wind resources in Tamaulipas, Nuevo León and Baja California. With the right management, effective public policies and large-scale investment, Mexico's border region stands to benefit from wind energy development at a level similar to what has been seen in Texas over the last decade.

One area that is commonly discussed is the potential for exporting wind energy to the United States. This will indeed be a significant driver for the industry in Baja California, but other Mexican border states are unlikely to benefit to the same degree due to Texas's impressive domestic wind energy industry. In order to make wind energy exports come to fruition, the crucial question of transmission must be resolved. At the time of writing, there is insufficient capacity in cross-border transmission lines, and a seeming lack of political will on the part of the federal governments in the United States and Mexico to move forward with an agenda to address the problem. A largely stagnant bilateral dialogue on the issue, through the Cross-Border Electricity Task Force, has failed to produce meaningful results and requires a new injection of energy to re-boot its efforts. In the interim, one company, Sempra, has decided to go ahead and build its own private transmission line to transport electrons from its wind plant currently under construction in the La Rumorosa region. This line will be sufficient to carry the electricity generated from that plant, but will not be open to other IPPs. This sub-optimal solution is not the way to proceed for future wind energy export projects, as it would result in duplication of resources and inefficient allocation of investment capital and other resources. Large-scale transmission capacity is required to take advantage of California's need for renewable energy, and this means that the CFE must sign on as a central partner.

Both in Baja California and other border states, however, the main driver for wind energy development will come from domestic demand as IPPs sign contracts with private companies and public authorities to sell green electricity at substantial cost savings. The CFE's pricing structure means that, for both public and private consumers, wind energy from IPPs in Mexico is more cost-effective than traditional energy sources, even without the application of a subsidy. Demand from municipal governments and large industrial consumers is growing, and will continue to provide an expanding market for electricity from wind farms. Here again, the question of transmission is key. Major wind projects in Baja California and Tamaulipas will benefit from the security of knowing that transmission capacity will be provided by the CFE. The recent use of "open seasons" in determining demand for transmission has been effective in providing certainty for investors and for the CFE itself, which in turn justifies (for the CFE) and guarantees (for the IPPs) financing.

The prospects for employment from wind energy development are also tantalizing. In the projects that are already operating or under construction, hundreds of jobs have been created in the construction phase and a small number of high quality permanent jobs (around 3–5 per 10 MW of installed capacity) have left a permanent imprint on labor markets. The border states have thousands of megawatts of potential wind development (Tamaulipas, for instance, projects that almost 2000 MW will be developed in the next decade), meaning there exists the potential for many thousands of construction jobs, as well as hundreds or thousands of permanent positions in the operation, management and servicing of wind plants. It is vital to

recognize that in both the construction and operational phases of wind farm development, skilled and white-collar positions are created in the technological, consulting, financing and legal aspects of the projects.

The experience of the La Rumorosa I project in Baja California has shown another important aspect of wind energy development. There the state government insisted on the use of local firms and local labor in the construction and operation of a 10 MW wind farm. This helped to smooth relations with the local community, created a longer-lasting positive imprint in the local economy, and set an important precedent for future wind developers.

In the area of wind turbine and component manufacturing, border states (particularly Tamaulipas, Chihuahua and Coahuila) have attracted investment from foreign firms. These investments, however, which employ hundreds of people, have been focused on manufacturing wind turbine components for export to the United States and beyond. If the Mexican border states are to develop a large-scale wind industry, we can speculate that there is the potential for Mexican and foreign firms to produce turbines and components within the region, benefiting from the industrial infrastructure, skilled labor and manufacturing experience of the *maquiladoras*. It is important to note that this did not occur with the wind boom in Oaxaca. Foreign firms led the way in that state, importing the most valuable and capital intensive machinery and components–a missed opportunity for the Mexican economy in general and national firms in particular.

But the potential positive benefits of wind energy development go far beyond investment and employment creation. The La Rumorosa I wind project has been designed in such a way that the profits from the venture are returned to the residents of the state through two methods. First, the energy produced is sold to the city of Mexicali, where it is used to power public lighting. The city benefits from electricity at a significantly lower cost than that available from the CFE, saving the municipal authority money which can then be used in other public projects. Second, an innovative subsidy scheme has been created, called "Tu Energía," whereby low income families receive a payment that can be used to reduce the monthly cost of their electricity. Although the subsidy is relatively small, it is received by 35,000 families in Mexicali, helping them to defray the cost of much needed air conditioning during the summer months. The families participating in the "Tu Energía" program are families with single mothers, handicapped members or old age pensioners. This smart targeting of the subsidy has prevented potential criticism of encouraging excessive energy use or being regressive.

While this report does not suggest that all wind energy projects involving the private sector should follow this model, it is an ingenious way for state and municipal governments to encourage renewable energies, save money, and provide social assistance. Tamaulipas has declared that the Los Vergeles wind development (at 161 MW, more than 16 times the size of La Rumorosa I) will provide energy for public buildings, but there is no indication that the savings or the profits will be used for social programs. A profit sharing model (for wind projects enforced by government regulation) that allocates a small percentage (around 3%) of the proceeds to the local population, and a similar percentage to social assistance programs would be a step in the right direction. It would be unlikely to be a deterrent to developers, given the

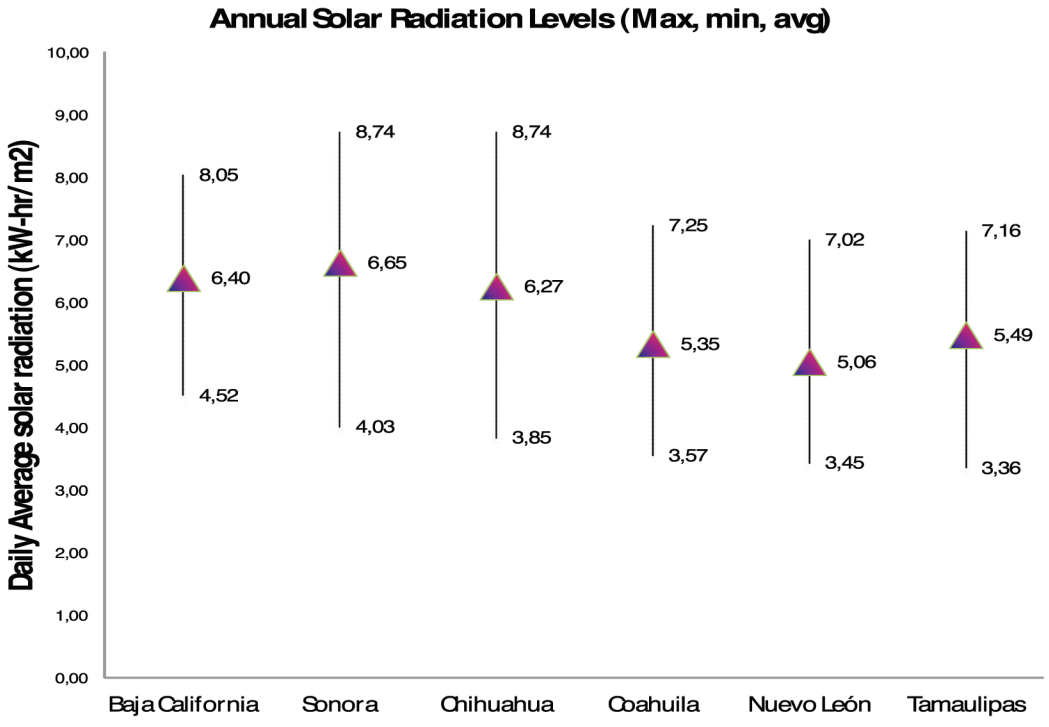
high profit margins due to the quality of the wind resource in areas like Baja California and Tamaulipas, for example.

Solar energy

Solar energy is undeniably the energy source of the future, with massive and inexhaustible supplies of solar radiation hitting the planet each and every day. Until now, though, this has remained a largely untapped resource by energy utilities due to the high cost of installing photovoltaic and/or solar thermal generation facilities. Recently, however, government and public concerns over climate change and the possibilities for mitigation have spurred countries to make solar energy more competitive with conventional energy sources and with other renewables through the application of generous subsidies. Current developments in Europe, the United States and China bear testimony to this tendency, with the construction of giant solar energy facilities and heavy investment in the development of new and improved technologies.

To date, Mexico has not been an important participant in this tendency. Despite the country's geographic location within the world's most important sun-belt (between 15°N and 35°N), and knowledge that large parts of the country receive enough solar irradiation to make solar power generation economically viable, governmental policy and businesses have, until recently, focused on other areas of renewable energy development. One of the main reasons for this neglect is that the cost structure of solar photovoltaics (PV) has made generation prohibitively expensive without the application of subsidies or feed-

Figure 1: Solar Radiation Levels in Mexican Border States



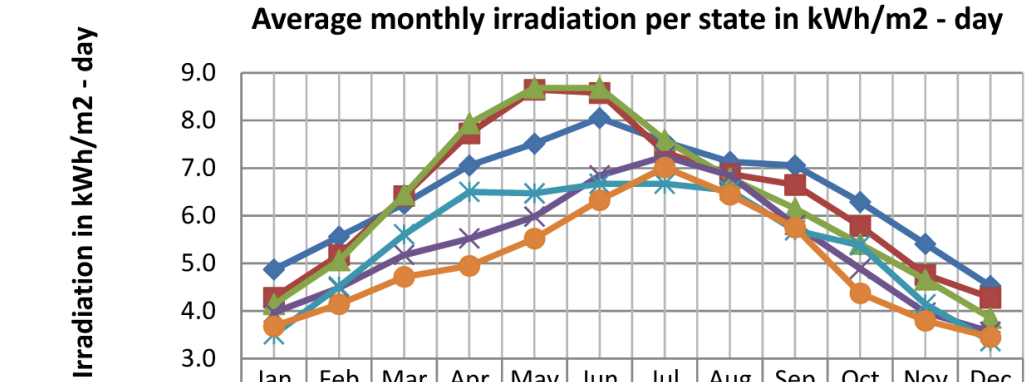
Source: Comisión Nacional para el Uso Eficiente de la Energía, 2008

in tariffs, and the Mexican government has been unwilling to legislate the provision of such support.

This is not to say that the Mexican federal and state-level governments have not recognized the importance of solar power. The Federal government has frequently referred to estimates showing that, assuming an efficiency factor of 15% from solar PV, a 650 km^2 area of either Sonora or Chihuahua covered in photovoltaic (PV) panels would generate sufficient electricity to satisfy national demand. A 2009 government-sponsored study estimated that "one should regard the fact that a mere 0.06% of the Mexican national territory would be sufficient to generate the overall electricity consumption of Mexico by the means of photovoltaic, assuming the consumption data of the year 2005" and argued that, despite minimal development of the resource to date, there was the prospect of rapid and large scale growth in the near future if the costs of installing PV panels came down due to technological advances.[7] Other studies have shown that Mexico's potential for generating electricity from solar PV, measured in terms of kilowatt hours per meter squared (kW-hr/m^2) is around twice as high as that in countries such as Germany, which has been a global leader in solar PV development.

The potential for solar energy production is even higher in the north of the country. Whereas on average Mexico has a solar irradiation level of around 5 kW-hr/m^2, the border states have average daily rates of between 5.06 kW-hr/m^2 in Nuevo León and

Figure 2: Average Monthly Irradiation per State in Border States



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baja California	4.9	5.6	6.2	7.1	7.5	8.1	7.6	7.1	7.1	6.3	5.4	4.5
Sonora	4.3	5.2	6.4	7.7	8.6	8.6	7.3	6.9	6.6	5.8	4.8	4.3
Chihuahua	4.1	5.1	6.4	7.9	8.7	8.7	7.6	6.8	6.2	5.4	4.7	3.9
Coahuila	4.0	4.5	5.2	5.5	6.0	6.8	7.2	6.8	5.8	4.9	4.0	3.6
Tamaulipas	3.5	4.5	5.6	6.5	6.5	6.7	6.7	6.5	5.7	5.4	4.1	3.4
Nuevo León	3.7	4.1	4.7	4.9	5.5	6.3	7.0	6.4	5.8	4.4	3.8	3.5

Source: Comisión Nacional para el Uso Eficiente de la Energía, 2008

6.65 kW-hr/m^2 in Sonora. This suggests that northern Mexico is the region where solar projects stand the best chance of success, and the private and public sectors appear to recognize this fact. Across the border region there has been a recent surge in project planning and investment in the solar sector in the states of Baja California, Sonora and Chihuahua as technologies have advanced to the point where, even without state subsidies, it is possible to generate electricity on a large scale that can compete with power from traditional sources.

The projects that are planned or already in operation range from a CFE project that combines solar with combined cycle generation, to large scale private plants for industrial consumption. They even include projects to integrate solar energy into high technology industrial parks and municipal developments.[8] Given the enormous potential for solar energy in Mexico, however, the current array of projects is disappointing. We have not seen the wholesale movement of solar-based IPPs into Mexico, either for the national market or for export to the United States.

The report on solar energy points to a number of factors that explain this lack of growth in this sector in Mexico. On an institutional level, the government has not set targets for solar power, and its focus on non-hydroelectric renewable sources has been dominated by wind and geo-thermal. Financial barriers include the lack of subsidies, feed-in tariffs or soft-loans to encourage solar operators. On a technical level, the experience of the sector in Mexico has been with unreliable, expensive systems that wear down very quickly in the heat of the northern climate. The lack of reliable batteries and the question of storage in general have been particularly damaging. This negative experience in Mexico was compounded by the problems of the Solidaridad and Alianza para el Campo programs under the Salinas and Zedillo administrations, where solar power was encouraged for agricultural and residential applications in remote areas but without sufficient technical backup or maintenance programs. Lastly, the lack of awareness of the potential for solar development among Mexico's decision-makers has meant that the issue has been avoided for ignorance of the potential environmental, energy and economic benefits.

Perhaps the biggest niche that will see growth in the near future is the residential market for solar panels. Residential applications of solar PV panels in Mexico benefit from the peculiar pricing structure applied by the CFE for electricity. Throughout the country, the CFE applies two different energy pricing depending on consumption levels. The first tariff applies to residential customers who consume less than 800 kWh every two months, which is subject to a subsidy that brings down the cost to the consumer to 2 pesos per kWh. The second tariff, which does not receive a subsidy and rises to $4.00 pesos per kWh consumed, applies to households that consume more than 800 kWh every two months. Customers who consume more than 800 kWh bimonthly must pay the higher rate on all of the electricity that they consume. This means that there is a significant incentive to reduce bimonthly consumption from the CFE below the 800 kWh mark in order to reduce the price of each unit of electricity. Installing solar panels in high consumption households may thus lower the consumption of electricity from CFE to below the 800 kWh mark, in turn lowering the price of each unit to 2 pesos rather than 4 pesos.

Should a more extensive market for solar energy develop in Mexico, it is expected that the impact on employment will be considerable. The calculations

included in our paper on solar potential in the Mexican border states point to the possibility of creating thousands of jobs in the border region in the coming years in the manufacture, installation, operation, and servicing of solar panels. For large-scale projects such as that at Tecate, we estimate that more than seven jobs per MW of installed capacity will be created. Given that the long-term plans announced by SolFocus prevision 350 MW of installed capacity, we can predict the creation of more than 3,000 jobs. In the residential market, the Kyocera plant in Tijuana employs 350 people in the production of 300 MW of capacity of PV panels every year for export, equating to more than one job year per MW of capacity manufactured. Management at the factory believes that it would be easy to double that amount if a strong national market were to develop in Mexico. Even more intriguing is the calculation that, for every MW of installed solar PV capacity, 35 jobs are created in installation and servicing/maintenance.

Municipal Solid Waste (MSW)

A comparatively unexplored source of renewable energy that has acquired new importance around the world in recent years is methane and liquid fuels from Municipal Solid Waste (MSW). The increasing pressure on landfills and subsequently on local and national authorities to find solutions for garbage disposal, combined with the harmful social, environmental and health impact from open landfill sites has generated an interest in finding new methods of addressing the issue.

Harnessing the energy from MSW in the form of gas and liquid fuels is one such method. It provides a way of turning garbage into power for the electrical grid and motor vehicles. Technological and logistical advances have made it possible to extract these fuels in such a way as to:

- reduce the overall footprint of landfills and to dramatically reduce their negative impact in the form of greenhouse gas (GG) emissions (methane escaping from landfills is a major climate change contributor);
- diminish the offensive smell that often emanates from them (causing a beneficial effect on nearby communities; and,
- reduce the possibility of water table contamination from run-off that would be harmful to the health of local populations.

Furthermore, exploiting the energy potential of municipal landfills creates new employment and income opportunities for the local population and local entrepreneurs without the need for massive infrastructure investment that might otherwise act as a deterrent and raise the cost of the final product. Our report on MSW potential in border states quotes Professor David Bransby of Auburn University who has noted that, "the infrastructure for collection of municipal solid waste (MSW) is already in place and paid for, and those who collect and dispose of it get paid for their services. This results in very low cost and low risk, making MSW a no-brainer feedstock for launching the cellulosic biofuels industry."[9]

Two main fuel energy products can be derived from MSW. Using first generation technologies, methane can be captured in the form of landfill gas (LFG) which can then be burned in the same way as natural gas to produce electricity, either for immediate consumption at the plant or to be sold to a client. This capture of methane has a doubly-beneficial impact in terms of climate change mitigation: first, the methane molecules (an important GG component) are prevented from escaping

into the atmosphere, and then, their use to generate electricity substitutes for traditional fossil fuels that may generate more pollution. Another form of fuel energy can be derived using second generation biofuel technologies that extract liquids from the organic components of landfills and then convert them into ethanol using cellulosic conversion techniques. Ethanol can be produced at stunningly low costs: a 2009 University of California study[10] shows that ethanol can be produced from MSW at a minimum cost of between 60–91 US cents per gallon in California. We should expect this total to be much lower in northern Mexico, given greater land availability and lower labor costs.

The abundance of the raw material in question, garbage, is universal. Mexico and its border region have a high level of organic matter in their garbage, making it possible to produce very high amounts of liquid fuel. As the bioenergy paper in this study argues, "the border region generates enough MSW feedstock to potentially make between 210 million to 380 million gallons per year of biofuel," depending on the technology used, the quality of the garbage and the rate of conversion.[11]

In Mexico there is already a well-documented case of methane capture from MSW that has been hailed as a success nationally and in the United States. The municipal authority in Monterrey has for the last nine years benefited from electricity produced by burning methane captured from one of the city's landfills, which it is able to purchase at a cheaper rate than the one offered by the CFE. The company that captures the gas and generates the power, Bioenergía de Nuevo León, is a joint venture between a private energy company and a waste management organization belonging to the Nuevo León state government. Beginning with limited production in 2003, the plant has since grown to the point where it is now generating enough power to satisfy 80% of the city's public lighting needs. The project was entirely self-financed, setting a precedent for future projects and highlighting the

Table 2: MSW Feedstock Potential in Border Region

State	Population	MT MSW Daily	MT MSW Annually	Potential at 120 Gals. per MT	Potential at 70 Gals. per MT	Potential at 40 Gals. per MT
Nuevo León	4,653,458	2,024	738,852	88,662,325	51,719,689	29,554,108
Chihuahua	3,406,465	1,481	540,861	64,903,365	37,860,296	21,634,455
Tamaulipas	3,268,554	1,421	518,964	62,275,716	36,327,501	20,758,572
Baja California	3,155,070	1,372	500,946	60,113,529	35,066,225	20,037,843
Coahuila	2,748,391	1,195	436,375	52,365,090	30,546,302	17,455,030
Sonora	2,662,480	1,158	422,734	50,728,196	29,591,447	16,906,800
Total	19,894,418	8,651	3,158,735	379,048,222	221,111,463	126,304,600

Note: MT: Metric Ton, Gal.: Gallon
Source: *Instituto Nacional de Estadística y Geografía (INEGI).*

attractiveness of such initiatives. It has also resulted in the mitigation of more than 800,000 t CO2e since 2003.[12]

Expanding the use of MSW for energy generation would also have a significant impact on labor markets. The bioenergy paper in our project estimates that 750–1500 job-years could potentially be created.[13] There may also be a serendipitous cross-over with existing skills in Mexican labor markets. Due to the imprint left by Pemex across the country in petrochemicals, there are human resources and skills available from which new bio-fuel ventures may benefit.

Our paper points to a couple of key factors that will determine the development of the market. First, there is a real need for a comprehensive documentation of existing resources and projects. Second, bioenergy projects from MSW will work best in larger urban areas across the north where infrastructure is already in place. Huge landfills can be used to create economies of scale and thereby lower costs in places where public authorities generally face high electricity costs. More importantly, cities in the border states can take advantage of markets for biofuels in both Mexico and the United States. California's Low Carbon Fuel Standard (LCFS) requires transportation fuels to have 10% lower carbon intensity by 2020, creating a market for biofuels such as ethanol. As this kind of regulation spreads throughout the United States, it will create a growing demand, particularly in areas of high population growth such as the border region in the U.S. Southwest.

CONCLUSIONS

Mexico's border states are blessed with renewable energy potential from natural and man-made sources. In the long-term, solar power will provide an inexhaustible and efficient energy supply, but in the short-term considerations of cost will hold back a massive development of the resource. Wind and biofuels from MSW, however, are ready to be developed now and provide reliable and comparatively low-cost alternatives to traditional energy supplies from hydrocarbons.

In order to maximize the benefits from these three energy sources for the local population, efforts must be taken to ensure that employment and business opportunities are created that will generate economic growth, contribute to the general welfare of society, and lead to long-term positive spillovers in terms of human capital. The example of the La Rumorosa I wind project in Baja California provides us with best practices that should be studied by state and municipal authorities and incorporated into their future plans for renewable energy. The private sector must also learn these lessons in order to increase the potential for social acceptance and community buy-in of their projects.

Employment prospects are highly positive, both in terms of numbers of jobs created and the quality thereof. The existence of skilled labor in the border region should be complimented by the promotion and development, by state authorities and universities, of undergraduate, graduate and vocational programs that focus on renewable energies. There is enormous potential for clusters of companies and institutes of higher education to develop that will foster the long-term growth of the sector.

Renewable energy development in the border states presents Mexico with a unique opportunity to make gains on a number of fronts: environmental impact, energy generation, employment and wealth creation, and social participation. In order to achieve this, governments, businesses and society must engage fully with each other to reduce frictions and benefit from complimentary capacities.

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