TRES MESAS WIND PROJECT
ALTERNATIVES ANALYSIS

In its current conditions, Mexico is facing a challenge not only to generate energy required for national economic growth, but also to generate this energy as efficiently and as clean as possible, minimizing harmful effects of fossil fuels generation and consumption on the environment (Salinas Treviño, 2013[1]).

Benefits of Wind Energy vs. Other Energy Sources

Wind energy has clear advantages as compared to conventional energy sources, mainly because it is non-contaminating energy coming from an inexhaustible source.

Generating electric power without combustion processes or thermal transformations represents, from the environmental perspective, a most favorable procedure, as impacts caused by the extraction, conversion, transport and combustion of fuels get radically suppressed, avoiding damages on the atmosphere, soil, water, wildlife, and vegetation, among others.

Benefits of wind energy generation can be defined as the number of non-caused impacts attributable to other energy alternatives:

- In comparison with other energy alternatives, wind farms do not consider any mining processes, i.e., there are no significant land movements (negligible incidence on soil erosion), no sediments carrying, no disturbances on water bodies, no air emissions, and no accumulation of radioactive waste.
- There are no metallurgic process nor fuel conversions, i. e., no huge energy consumption nor radioactive waste, no transportation issues, black tides or air pollution from refineries, no gas explosions, and no aggressive chemical agents.
- There is no fuel combustion or fusion, meaning no nuclear accidents, no "controlled" discharges of radioactive products, no atmospheric emissions of CO_2 or other greenhouse gases leading to climate change, acid pollutants, toxic gases, thermal contamination.
- There is no waste generation requiring debris deposits which may ignite, and no radioactive waste to be controlled.
- Risks and accidents associated with fuel transportation are suppressed (for example, gas, oil, radioactive material and coal), and there is no need for installing supply lines (as refinery oil or gas ducts).

[1] http://www.sdpnoticias.com/local/tamaulipas/2013/11/12/reportan-avance-de-95-en-proyecto-de-parque-eolico-en-el-porvenir-tamaulipas

Based on different studies on benefits of wind energy[2] conducted in Spain, it has been found that 1 kilowatt/hour (KwH) generated with wind instead of coal, prevents the emission of:

- 0.60 kilograms of CO_2 (carbon dioxide) to the atmosphere
- 1.33 grams of SO_2 (sulfur dioxide)
- 1.67 grams of NO_x (nitrogen oxides).

Power produced by one wind turbine generator avoids burning thousands of liters of oil and thousands of kilograms of lignite black coal in thermal centrals, on a daily basis. The same wind turbine generator produces an energy amount identical to that obtained from burning 1,000 kg of oil every day. By not burning those coal kilograms, 4,109 kg of CO_2 are not sent to the atmosphere, with effects similar to having 200 trees; and 66 kg of SO_2 and 10 kg of NO_x, primary causes of acid rain, are also saved.

Now, it is important to consider that wind energy is independent from any policy or trade agreement, it is obtained by mechanical means and, therefore, directly usable. Even more, after finishing its useful life, decommissioning a wind farm leaves a very small footprint.

On the other hand, from the economic perspective, wind energy is a competitive alternative, and its profitability can compete with other traditional energy sources, such as coal thermal power plants (usually considered as the cheapest fuel), fuel oil generation centrals and even nuclear energy, if we consider mitigation of environmental associated damages.

The following is a comparative table of environmental impacts generated by different energy sources (in terms of atmospheric emissions and waste). It can be observed that alternatives with lower environmental impacts are solar thermal, photovoltaic, hydraulic and wind energies.

Table 1. Comparison of Environmental Impact Caused by Different Power Generation Alternatives (in tons per GWh produced)

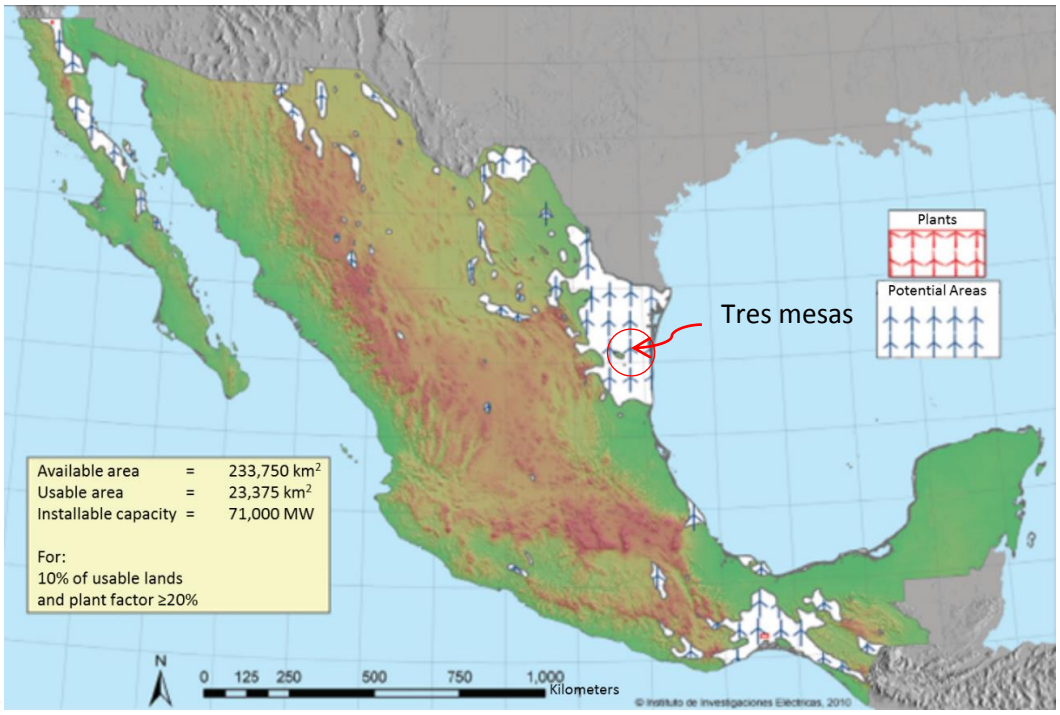
Energy Source	CO_2	NO_2	SO_2	Particles	CO	Hydro-carbons	Nuclear Waste	Total
Coal	1.058,2	2.986	2,971	1,626	0,267	0,102	-	1.066,1
Natural Gas (combined cycle)	824	0,251	0,336	1,176	TR	TR	-	825,8
Nuclear	8,6	0,034	0,029	0,003	0,018	0,001	3,641	12,3
Photovoltaic	5,9	0,008	0,023	0,017	0,003	0,002	-	5,9
Biomass	0	0,614	0,154	0,512	11,361	0,768	-	13,4
Geothermal	56,8	TR	TR	TR	TR	TR	-	56,8
Wind	**7,4**	**TR**	**TR**	**TR**	**TR**	**TR**	**-**	**7,4**
Solar	3,6	TR	TR	TR	TR	TR	-	3,6
Hydraulic	6,6	TR	TR	TR	TR	TR	-	6,6,

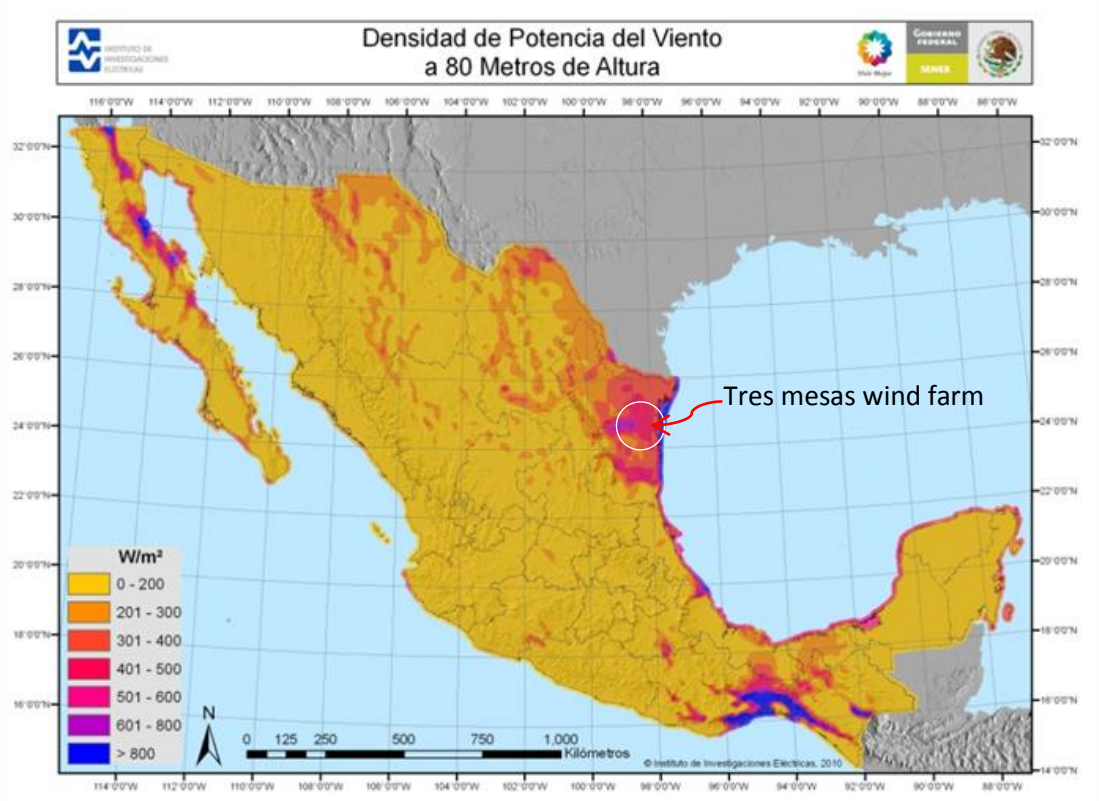
Sources: US Department of Energy, Council for Renewable Energy Education and AEDENAT.
TR= traces.
NOTE: Emission values are also considering those released during the equipment construction period.

[2] http://angelongo.en.eresmas.com/beneficios_de_la_energia_eolica.htm
http://www.revistafuturos.info/futuros14/energia_eolica.htm

Site Selection Criteria

As related to the site selection, areas with the highest wind energy potential in Mexico are located in the northeastern state of Tamaulipas, and in the Tehuantepec Isthmus, in the Southeast.





Source: Instituto de Investigaciones Electricas.

While there are areas in Mexico with high wind potential, the winds are irregular or intermittent in some months, and wind energy generation it is not attractive. In these areas with irregular or intermittent wind, it would require having, somewhere relatively close to the wind farm, a backup energy plant equal to the wind farm installed capacity, from a non-intermittent energy source. The required capital investment required for such a backup plant in addition to the wind farm typically means that such projects are not economically feasible.

In those locations in Mexico with the highest wind speeds, high winds often force the control systems of the wind turbine generators to stop the rotor to avoid damages to the wind turbine and to ensure project safety, which creates an issue for operation regularity. The Project site in Tamaulipas has strong and homogenous winds throughout the year, making it an ideal choice for siting a wind farm. A successful wind energy project also needs sufficient acreage and land control.[3] Not all of the suitable locations on the map for a wind energy projects offer land control with sufficient acreage and suitable terrain for construction. Land control of sufficient acreage for a commercial scale wind energy facility was acquired early on for the Project, and the mesas within the Project site provide an ideal height to capture the needed range of wind speeds while also providing relatively friendly terrain for construction and operations.

Selection of the Project site proposed for the construction of the "Tres Mesas Wind Project," utilized and considered the basic technical-economic, legal and environmental criteria specified on the "Guide of Best Practices," prepared by Dr. Herman Snel on April 2006, framed by activities conducted in the project "Action Plan to Remove Obstacles to Develop Eolo-Electric Generation In Mexico"[4], which are described in Table 1.

[3] *Source: Martín del Campo-Márquez, Wind Power in Mexico: Simulation of a Wind Farm and Application of Probabilistic Safety Analysis, March 2008*

[4] *This Project is funded by the Global Environment Fund (GEF), implemented by the United Nations Development Program (UNDP), and executed by the Electric Research Institute (ERI).*

Table I. Technical-Economic, Legal and Environmental Criteria Used for the Project Site Selection

Criteria	Project Location
Technical-Economic Considerations	
1. The site should have a good wind resource reflected in the average annual wind speed. Classifications of wind resources arise from different sources, such as the International Electrotechnical Commission (IEC). Quantification of the local resource can be made only from wind speed measurements onsite. An annual average speed of 5 m/s (measured at 10 m above the ground), can be considered as sufficient; but higher values are preferable. After 7.5 m/s, wind speed is very adequate, and around 10 m/s is classified as excellent.	When analyzing speed data in the study area, it can be observed that the installation of wind turbine generators for the Project is proposed in zones where wind speeds exceed 8 m/s, with averages of 7.57 m/s. Wind speeds over 400 W/m^2 indicate good potential locations for wind energy projects. The Tres Mesas Wind Project is within one of these good wind speed areas shown on the above maps.
2. The site must be near to an electric network. Power generated must be readily introduced into a distribution network via an electric substation. A long distance between the generation site and the network delivery point requires expensive conduction with significant losses. The network should have capacity enough to absorb and transmit electric power generated to a consumption center.	In the east limit of the Project area, on Road 83, north of the San Francisco community, a transmission line of 400 kV connects two CFE's substations, with capacity enough to receive energy from the Project.
3. The site must have adequate road access. The construction of a wind energy project requires large cranes and transportation of very heavy components. Access for turbine maintenance crews should also be considered.	The polygon of the Project area is limited, to the West, by Federal Road 85 (Mexico – Nuevo Laredo), and to the East by Road 83. The Project includes construction of new access roads; however, it has to be noted that there is a network of rural roads connecting different properties in the polygon, which will be usable after reconditioning and rehabilitation activities.
4. The property must have surface enough to install the potency required. In a roughly squared site, about 12 MW can be installed per square kilometer, regardless of the wind turbine generator size.	Areas where wind turbine generators will be installed are huge. For this Project, wind turbine generators will be installed with a minimum distance of 200 m (central axis to central axis). Considering that the blades will have a maximum diameter of 120 m, the wind turbines will have an approximate distance of 80 m from blade tip to blade tip among them.
5. In general, a simple plain or slightly rolled land, with low crops and buildings is more adequate than a complex one (very rolled) or with high crops or buildings. Besides the site access, inside the property an access road will have to be constructed, which is more difficult in a complex land. On the other hand, the turbulence intensity will be higher on a complex land, increasing the fatigue loads on the turbines.	The wind turbine generator rows will be located near the plateau borders, in practically plain and rocky lands, with low bushes and without buildings. It is also important to consider the existing network of rural roads inside the Project polygon, which will be reconditioned to comply with specifications set for this project type.

Criteria	Project Location
6. In general, it is better to place wind turbine generators on low lands. Air density decreases with altitude, proportionally impacting the wind potency. For example, at 2,000 meters above sea level (masl), wind density decreases around 20%. To offset this loss, an increase of wind speed from 6% to 6% would be required.	Wind turbine generators for this Project will be installed on property at an ideal altitude: Plateau La Sandía, at 445 masl, and on Plateau La Paz, altitude of 418 masl.
Legal Aspects	
7. The site selected must be adequate to obtain all permits required. At the same time, uses already defined shall not be in conflict with the development of an wind energy project. If the property is used for agricultural or livestock activities, power generation can be usually combined seamlessly, if having all legal permits. In general, the Project requires soil use and a construction permits (both granted by the Municipal Government); a generation permit issued by the Energy Regulatory Commission *(Comisión Reguladora de Energía)* (CRE), an interconnection agreement (issued by the CFE), and the environmental permit issued by the Secretariat of Environment and Natural Resources *(Secretaría del Medio Ambiente y Recursos Naturales)* (Semarnat).	The site proposed for the Project development is located on *Ejido* properties and some private lands. Most properties have no specific use, and some of them are used as grazing lands, which can be easily combined with wind energy generation.
8. It is important that the landlord is willing to sell or lease the property, all or in parts, to be used for a wind energy project.	Frontera Renovable already has all contracts with landlords and all legal documents required.
Environmental Aspects	
9. Selection of the right site includes detailed studies and assessment of measures required to minimize any potential effect of the wind power central on local flora and fauna, and bird migration routes, if applicable. Even when the impact of this type of facility on birds is insignificant, based on different studies conducted, measuring the potential impact – and implementing any preventive and corrective actions required – will minimize such impact.	Specific studies were conducted on flora and fauna, and especially on migrating birds and bats, to determine the potential impact of the Project on them. In addition, the corresponding mitigation plans and measures have also been developed.
10. Another relevant aspect to be considered is archaeology, which may determine the issuance of construction permits, as in some cases, archaeological sites can be found during the construction process, delaying the Project execution	The site selection included a revision of the Public Registration of Archaeological Monuments and Zones of the National Anthropology and History Institute *(Instituto Nacional de Antropología e Historia)* (INAH), finding that archaeological sites in the Municipality of Llera are considerably far from the site. However, Frontera Renovable, under the General Law of Archaeological, Artistic and Historic Sites, and its Regulation, shall notify the INHA if finding any site with such features during the construction stage, to take any required measures.

A forecast analysis was conducted with the overall Project development scenario and considering the implementation of prevention and mitigation programs required, and it was concluded that the environmental impact on different environmental components will be low:

- The area proposed for the Project has already been impacted by vegetation clearing procedures, mainly to develop agricultural and stock raising activities.
- The Project will require a permanent clearing of a surface smaller than 2% of the Project site. Additionally, with the implementation of the Restoration and Soil Preservation Program, and the Integral Flora and Faunal Management Programs, the temporary occupation areas that were cleared will be returned to their original soil, flora, fauna, and aquifer recharge capacity conditions, among others.
- The area selected for construction of this Project is a considerable distance from the closest community, San Francisco, located on the East limit of the Project impact polygon, at about 3 km from the closest wind turbine generator. The proposed Project will generate sound levels ranging between 25-33 dB(A) at the nearest noise-sensitive receptor locations around the Project site. These noise levels are well below the Official Mexican Standard limits of 50 dB(A) nighttime and 55 dB(A) daytime for sensitive receptors in the project vicinity.
- There are no permanent water bodies in the plateaus where the Project will be located, and with the implementation of the Environmental Supervision Plan, any stormwater draining works required will be executed to avoid water accumulation and land erosion during the site preparation and construction stages.
- Areas specific for the wind turbine generator installation are flat; the site geomorphology will have punctual impacts in some areas where roads shall be widened. However, it has to be considered that the Project is aiming to minimize geoform disturbance, trying to preserve the site topographic features as much as possible.

Social Benefits

Most properties to be impacted by the Project infrastructure are covered by natural vegetation (82.66%) with no current economic use, and only 17.34% are used for agricultural and/or livestock activities. Therefore, the largest part of the surface to be impacted has neither a profitable productive activity nor is generating employment for adjacent communities. It also has to be considered that when the park is operational, landlords will be able to use these lands for agriculture or livestock development, as wind turbine generators are fully compatible with them.

The Project implementation will bring socio-economic benefits to the influence area, especially as employment source, as local workers will be hired for the clearing and road opening works. For the operation stage, the wind park will use specialized employees, particularly for wind turbine maintenance and operation activities; but also to satisfy offices, warehouses and security and surveillance requirements.

Based on a study conducted by the ERI, 30% of human capital needed for the construction and operation of a wind farm is mainly integrated by non-qualified workers that will be trained on the job; 12% will work on commercial positions; 36% will be specialized workers; 8% of career professionals (administrators and lawyers); and 14% of specialized engineers and scientists. This assessment also estimates a generation of 240 direct jobs per each 100 MW5.

It also has to be considered that personnel working on different Project stages will demand services such as lodging, food, recreation, vehicles, machinery and equipment, that will reactivate local and regional economy.

On the other hand, owners of properties impacted will receive lease payments throughout the Project's useful life, estimated from 20 to 50 years, and a monthly installment during wind farm operation, meaning economic benefits for land owners and ejidatarios, which will also foster local and regional development.

It also has to be considered that the road rehabilitation within the Project polygon will give better and easier access to landlords to their lands, enabling them to better perform their activities.

[5] *Conference "El Capital Humano Especializado, Eslabón Crítico de la Cadena de Suministro Eólica". Unit for Non-Conventional Energies of the Electric Research Institute. Forum "La Energía Eólica, una Realidad en México" organized by Mexico Wind Power on January, 2013.*