**NASA DEVELOP National Program**

**Alabama – Marshall**

*Project Summary – Summer 2018*

**New Mexico Energy**

*Identifying Optimal Site Locations for Wind Energy Farms Considering Ecological and Social Impacts*

**VPS Title:** Carpe Ventum: Seizing Wind Energy Potential in the State of New Mexico

**Project Team**

***Project Team*:**

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***Advisors & Mentors*:**

Dr. Jeffrey Luvall (NASA Marshall Space Flight Center)

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**Project Overview**

***Project Synopsis*:** The wind industry has grown rapidly in the state of New Mexico with the most growth occurring in 2017, more so than any other state. Using NASA Earth observations, the team collaborated with the National Renewable Energy Laboratory (NREL), New Mexico Energy, Minerals & Natural Resources Department, Energy Conservation & Management Division (ECMD), and New Mexico Department of Game & Fish (NMDGF) to provide four Optimal Wind Farm Suitability maps based on three criteria: social impact, ecological impact, and power production efficiency. These maps will aim to identify the most suitable areas in the state for wind farm development.

***Abstract:***

With the increasing cost and declining availability of fossil fuels, renewable energy, specifically wind power, has become one of the fastest growing sources of energy in New Mexico. To assist with the goals set by the state’s Renewables Standard Portfolio established in 2004, the NASA DEVELOP team created three Optimal Wind Farm Suitability maps that consider social impact, ecological impact, and power production efficiency. Along with the National Renewable Energy Laboratory (NREL), project partners include the New Mexico Energy, Minerals & Natural Resources Department, Energy Conservation & Management Division (ECMD), and New Mexico Department of Game and Fish (NMDGF). The team obtained datasets from February 2013 – May 2018 using the Shuttle Radar Topography Mission (SRTM) and Suomi National Polar-orbiting Partnership (NPP). Taking into account vulnerable species, average wind patterns, and U.S. Air Force Bases, these three maps were combined into a final suitability map for optimal wind farm placement. The Fuzzy Logic and the Land-Use Conflict Identification Strategy (LUCIS) models were implemented in order to weigh these conflicting variables so that these maps can be used to assist with wind farm planning and development.

**Keywords:**

New Mexico, wind, renewable energy, site suitability, fuzzy logic, LUCIS, SRTM, Suomi NPP

***National Application Area Addressed:*** Energy

***Study Location:*** New Mexico, USA

***Study Period:*** February 2013 – May 2018

***Community Concern:***

* The government of New Mexico established a Renewables Portfolio Standard in 2004, which requires investor-owned utilities to generate 20% of total sales from renewable energy. The state’s goals will also contribute to the Department of Energy’s goal to have 20% of the nation’s electricity be generated by wind by 2030. To achieve these goals in New Mexico, wind power capacity must increase by 520%, according to the National Renewable Energy Lab (NREL).
* Species, such as golden eagles, bald eagles, and lesser-prairie chicken, could be negatively impacted by wind farm construction and environmental regulations; therefore, these species must be taken into consideration, as emphasized by the New Mexico Department of Game & Fish (NMDGF).
* Military use of airspace has a significant presence in the state. A modern defense system needs to be maintained, thus there is a greater possibility of land use conflicts between the military and wind developers as the state’s wind energy sector grows.

***Project Objectives:***

* Showcase NASA Earth observations from SRTM and Suomi NPP through site suitability analysis of possible locations for wind farm development
* Assess social impact of wind farms, specifically on Air Force bases, Protected Lands, and densely populated areas
* Assess ecological impact of wind farms on the golden eagle, bald eagle, and lesser prairie chicken
* Determine areas with the greatest wind power potential based on factors such as wind speed and vertical wind shear
* Produce four end product maps for decision makers to visualize optimal locations for wind farms in the state of New Mexico

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **New Mexico Energy, Minerals & Natural Resources Department, Energy Conservation & Management Division** | Jeremy Lewis, Bureau Chief | End User | Yes |
| **New Mexico Department of Game and Fish** | Ronald Kellermueller, Mining & Energy Habitat Specialist | End User | No |
| **Department of Energy, National Renewable Energy Laboratory** | Robi Robichaud, Researcher IV | End User | No |

***Decision Making Practices & Policies***

The ECMD utilizes a wind power program to foster wind energy sector growth in New Mexico, which provides information and *in situ* data, (i.e. wind speed) to support and assist in creating wind utilities to energy holding companies such as PNM Resources, land owners and other groups. The ECMD also utilizes information generated by NREL. The NMDGF primarily focuses on conservation of wildlife within New Mexico and follows the State Wildlife Action Plan (SWAP), which was approved by the department in 2017. The plan explains what actions are needed for wildlife conservation, as well as other possible actions, through 2025.

***Product Benefit to End User***

The end products will provide the end users with a visual display of suitable locations in New Mexico for wind farm expansion while having considered the three main criteria - ecological impacts, social impacts, and power production efficiency. The team will analyze these factors, incorporating available datasets and partner feedback to make the results relevant to the project partners. The ECMD will consider the end products when identifying areas of potential wind energy development. The NMDGF will utilize the end products in their conservation efforts, specifically regarding the three species of focus in the project. NREL will consider the results and methodologies of the end products and their potential replication in other areas of the country. These maps will allow the end users to share this information easily with interested parties, without GIS software. This identification of optimal areas for wind power expansion is crucial as New Mexico continues to work towards the goals outlined in their Renewables Portfolio Standard, and these four end product maps will aid the state in reaching this goal.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **SRTM** | Elevation | SRTM elevation models were used for land cover classification and site suitability of New Mexico based on wind productivity and efficiency. |
| **Suomi NPP VIIRS** | Night time light | Night time lights were used as a proxy for population and urbanization in order to assess social impacts of wind farm growth |

***Ancillary Datasets:***

NASA Surface Meteorology and Solar Energy (SSE) Dataset – Provide wind speed and direction for

determining optimal wind farm sites

USDA National Resources Conservation Service (NRCS) US General Soil Map (STATSGO2) – Provide soil

types using Landsat imagery and in situ data to determine optimal turbine foundation sites

USGS National Land Cover Dataset (NLCD) – Supplementary dataset for land classifications

New Mexico Natural Heritage Database – Distribution and abundance of golden eagles, bald eagles and

lesser-prairie chickens

Center for International Earth Science Information Network (CIESIN) Socioeconomic Data and

Applications Center (SEDAC) U.S. Census Grids Summary File 1 v. 1 – Provide socioeconomic data

and demographic information to determine populous areas in New Mexico that could be impacted

by wind farm growth

***Modeling:***

Land-Use Conflict Identification Strategy (LUCIS) (POC: Dr. Rosanna Rivero, University of Georgia) – Optimal Wind Farm Suitability Map creation

Fuzzy Logic Model (POC: Helen Baldwin, DEVELOP) – Suitability Map creation

***Software & Scripting:***

ESRI’s ArcMap – Used to analyze and display data and generate suitability maps

Microsoft Excel – Used to conduct data calculations

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Optimal Efficiency Wind Farm Development Map** | SRTM | This map will provide NREL and the ECMD with an additional tool for identifying potential wind farm sites considering optimal wind power production throughout New Mexico. | N/A |
| **Low Social Impact Wind Farm Development Map** | Suomi NPP VIIRS | This map will provide the ECMD with an additional tool for identifying restricted areas and areas where placing wind farms might affect large population centers. | N/A |
| **Low Ecological Impact Wind Farm Development Map** | N/A | This map will provide the NMDGF and ECMD with an additional tool for identifying areas where local vulnerable populations won’t be heavily affected by wind farm development. | N/A |
| **Optimal Wind Farm Suitability Map** | SRTM, Suomi NPP | This map will provide the end user with an additional tool for planning wind farm site development with the considerations into wind power efficiency, effects on the local populations and US Air Force restrictions, and impact on local vulnerable species. | N/A |

**Project Handoff Package**

**Transition Plan:**

The project materials were handed off to the project partners on August 10th, 2018. A presentation over video-conference was given, and a package was sent out via email containing the four end product maps in GeoTIFF format to ensure that each project partner can view the maps in their preferred GIS software. During the presentation, the team discussed methods and results, and answer questions from the partners.

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**Handoff Package:**

* Presentation FD
* Project Video
* Tech Paper FD
* Optimal Efficiency Wind Farm Development Map
* Low Social Impact Wind Farm Development Map
* Low Ecological Impact Wind Farm Development Map
* Optimal Wind Farm Suitability Map

**References:**

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