**Douglas County Energy**

*Identifying Areas with High Solar Power Potential in Kansas via NASA Earth Observations and LiDAR*

**VPS Title:** Sunny Side Up: Mapping Solar Power Potential in Douglas County, Kansas

**Project Team**

***Project Team:***

Robert Cecil Byles (Project Lead)

Thomas Crimmel

Erica O’Connor

Charlotte Stanley

***Advisors & Mentors:***

Qing Yue (NASA Jet Propulsion Laboratory, California Institute of Technology)

**Project Overview**

***Project Synopsis:*** The NASA DEVELOP Douglas County Energy project used NASA Earth observations to identify regions of high solar insolation in Douglas County, Kansas. The team analyzed rooftops in the City of Lawrence to determine the solar energy potential on city-owned and privately-owned properties and identified underutilized open land in Douglas County with high solar potential. Solar insolation maps were overlaid with external land cover factors to help Douglas County select optimal locations to install rooftop solar panels and ground-mounted solar farms, ultimately helping the County meet its goal of reducing greenhouse gas emissions.

***Abstract:***

The City of Lawrence and Douglas County, Kansas, are working to reduce greenhouse gas emissions and achieve 100 percent renewable energy. The NASA DEVELOP team used Shuttle Radar Topography Mission (SRTM) and LiDAR elevation data along with Landsat 8 Operational Land Imager (OLI) surface reflectance data and National Agriculture Imagery Program (NAIP) aerial imagery in order to create a solar insolation map, which identifies areas of high solar energy potential in both the City of Lawrence and Douglas County. Using this solar insolation product, the team created a solar panel site suitability map that incorporates factors such as land cover/use, building footprints, parcel ownership, floodplain extent, and protected land areas. This product both identifies solar potential and determines the most feasible and effective properties for the installation of rooftop solar panels and ground-mounted solar farms. Our team found that Douglas County, Kansas, receives an average solar insolation of 1,982 kilowatt-hours per square meter annually and building rooftops in Lawrence receive an average of 950 kilowatt-hours per square meter annually. Additionally, we found that Douglas County and Lawrence have a great capacity for solar power, with 30% of Douglas County’s land area and 52% of Lawrence’s building rooftop area being highly suitable for solar panel installation. The results of this project will be utilized by Douglas County to better understand the factors that dictate solar potential and suitability, enabling personnel to make informed decisions about the ideal placement of solar panels.

***Keywords:***

Landsat 8 OLI, LiDAR, NAIP, SRTM, photovoltaic potential, solar insolation, solar radiation, solar panels

***National Application Areas Addressed:*** Energy, Urban Development

***Study Location:*** City of Lawrence and Douglas County, KS

***Study Period:*** January 2018 to December 2018

***Community Concerns:***

* The City of Lawrence and Douglas County, Kansas, are pursuing strategies to reduce their greenhouse gas emissions and aspire to reach 100 percent renewable energy use.
* Both residents and elected officials have voiced their support in the community’s transition away from coal power.
* Transitioning toward solar energy will help the community mitigate the threat of the changing climate and improve air quality while also reducing electricity costs for local residents.
* The municipal government wants to install solar panels on city-owned properties to power city operations, and local renters are interested in developing community solar facilities.

***Project Objectives:***

* Analyze the yearly average solar insolation across Douglas County
* Calculate the solar power potential per building in the City of Lawrence based on the maximum rooftop area available for photovoltaic panel installation
* Analyze site suitability for solar panels based on solar insolation, land ownership, land protection status, proximity to floodplains, and distance to transmission lines in order to identify suitable open spaces in Douglas County for solar photovoltaic farms
* Produce maps representing solar power potential and high impact opportunities in the City and County

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Douglas County, Department of Sustainability** | Jasmin Moore, Sustainability Director | End User | Yes |

***Decision-Making Practices & Policies:***

The Sustainability Department for the City of Lawrence and Douglas County takes an ad hoc approach to solar installation as it is still in the process of developing its long-term renewable energy goals. Decisions regarding past solar panel installation on city-owned properties have been based on site feasibility and available funding but not a structured methodology that incorporates solar insolation. The City and County are now pursuing opportunities through the US Department of Energy SolSmart program to identify and remove barriers to solar permitting. They are also working with local policymakers and the City’s Sustainability Advisory Board to identify potential policies to incentivize the use of solar energy. There is no remote sensing currently involved in their decision-making processes.

***Project Benefit to End User:***

NASA Earth observations can support the City of Lawrence and Douglas County in enhancing their solar siting opportunities. This project will support their decision-making by identifying the most effective rooftops and vacant spaces to install solar photovoltaic panels. By identifying optimal locations for both ground-mounted and rooftop solar panels, this project will allow the partner to maximize solar energy generation and could help reduce capital costs on the installation of solar panels. Furthermore, the City of Lawrence and Douglas County can use the project maps detailing high solar potential to increase support for renewable energy throughout the community and ultimately meet their sustainability goals.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **SRTM** | Elevation | This dataset was used to create a hillshade product used in calculating solar insolation. It was also used as an input into the Esri ArcGIS Area Solar Radiation Tool. |
| **Landsat 8 OLI** | Surface reflectance | Data were used to calculate the Modified Normalized Difference Water Index (MNDWI), which was used to mask out water in Douglas County. |

***Ancillary Datasets:***

* USGS LiDAR Point Cloud Dataset – Create digital elevation and surface models for the City of Lawrence
* NASA Prediction of Worldwide Energy Resources (POWER) – Identify the amount of diffuse proportion and transmissivity of our study area to use as a parameter in the Esri ArcGIS Area Radiation Solar Tool
* City of Lawrence and Douglas County Properties Shapefile – Quantify solar power potential for known city-owned and county-owned properties
* USDA National Agriculture Imagery Program (NAIP) – Identify trees obscuring rooftops using the Normalized Difference Vegetation Index (NDVI)
* USGS Protected Areas Database of the United States 2.0 – Identify existing protected areas to exclude land from potential solar farm development

***Software & Scripting:***

* Esri ArcGIS Pro – Create maps and run solar radiation tools
* Esri ArcMap – Create maps and run solar radiation tools
* Esri ArcGIS Online – Create interactive photovoltaic potential maps for the Douglas County website

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Douglas County Solar Geodatabase** | SRTM  Landsat 8 OLI | This end product is a geodatabase containing all relevant data used in the project, including insolation and suitability rasters, parcel and building footprint shapefiles, and any other analyses. All data collected in this geodatabase are finalized and ready to be used by the partners. | N/A |
| **Douglas County Solar Web App** | SRTM  Landsat 8 OLI | This end product is a web app created with Esri ArcGIS Online. This product will be transferred onto Douglas County's website, where it will be publicly accessible for the public and citizens of Douglas County to investigate solar potential and suitability in parcels and on building rooftops. | N/A |
| **Douglas County Solar Static Maps** | SRTM  Landsat 8 OLI | This end product consists of a number of static .pdf maps. These maps can be separated into two scales: county-level (Douglas County) and city-level (Lawrence, the largest city in Douglas County). At these two scales, static maps were created to show solar insolation as well as solar suitability. | N/A |

**Project Handoff Package**

***Transition Plan:*** The project handoff transition consisted of a video conference with the partner during the last week of the term in which the team presented project methods, results, conclusions, and end products. The final project Handoff Package, detailed below, was delivered to our partners via NASA Large File Transfer.

***Team POC:*** Robert Cecil Byles, cecilbyles@gmail.com

***Partner POC:*** Jasmin Moore, jasminmoore@douglascountyks.org

***Handoff Package:***

* Douglas County and the City of Lawrence Solar Radiation Map
* Douglas County and the City of Lawrence Solar Panel Suitability Map
* Poster
* Presentation
* Project Video

**References**

Fu, P., & Rich, P. M. (1999). Design and implementation of the Solar Analyst: an ArcView extension for modeling solar radiation at landscape scales. *Proceedings of the Nineteenth Annual ESRI User Conference.* Retrieved from http://www.professorpaul.com/publications/fu\_rich\_1999\_esri.pdf

Hamstead, Z., Abbey, A., Darcy, L., Gordon, C., Riley, D., Rivera, D., … Winters, C. (2018). *From vacant to viable: Reusing abandoned land to build resilience* (A Graduate Urban Ecology Studio from The State University of New York at Buffalo). Retrieved from https://issuu.com/zhamstead/docs/from\_vacant\_to\_viable\_-\_finalbook

Mahtta, R., Joshi, P. K., & Jindal, A. K. (2014). Solar power potential mapping in India using remote sensing inputs and environmental parameters. *Renewable Energy, 71*, 255-262. https://doi.org/10.1016/j.renene.2014.05.037