Analyzing the Optimal Location of Solar Farms in the Northeast Corridor

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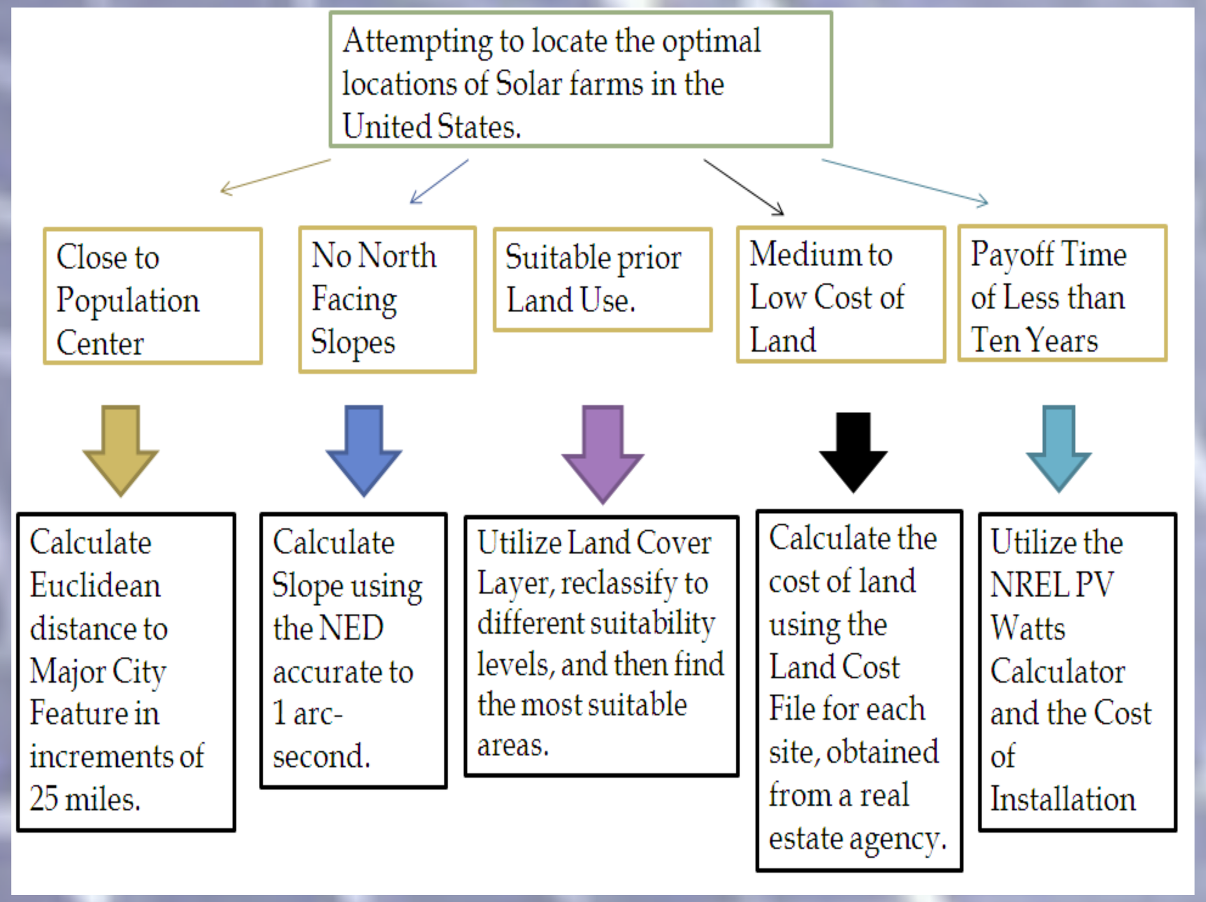
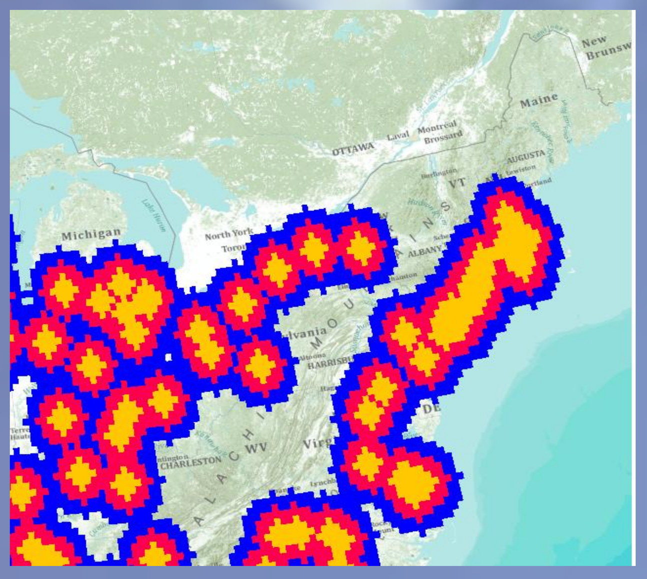
Abstract

According to the Energy Information Administration, solar power is the least produced form of renewable energy in the United States, and generally is currently used in locations far from the existing electrical grid and large population centers. Because fossil fuels are projected to run dry within 200 years, there is an increased need for renewable energy. If photovoltaic (PV) plants were constructed near major population centers, they could provide a cost effective replacement of power currently generated by fossil fuels. The purpose of this research is to determine the optimal location of potential solar farms taking into account distance from population centers, aspect, PV intensity, and land cost. Using ArcGIS, a suitability map of the Northeast Corridor of the United States was created based on distance to population centers, land usage, and slope direction. Then an estimate of the solar irradiation at each suitable site was calculated. Finally, by using the cost of land, the cost of solar farm installation based off an existing solar farm, an estimated price of PV electricity, and the estimated solar irradiation, the theoretical payoff time of each potential site was calculated. Twenty-four possible sites were located which yielded estimated payoff times of less than five years. The total estimated power output of the entire system was kWh. It was concluded that, because of the low overall power output of the system compared to the US 2008 energy production and imports, solar power was not viable as a large scale fossil fuel power replacement method. Further research is promising in the application of solar power on smaller scale projects such as schools, office buildings, or residential solar installations.

Method

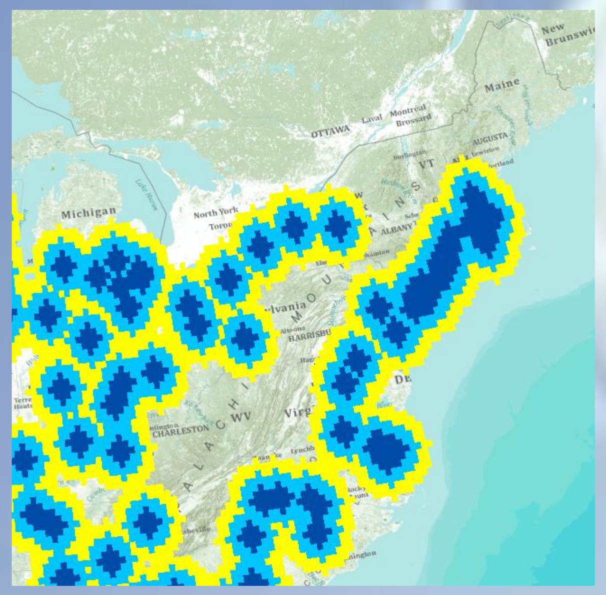


Euclidean Distance

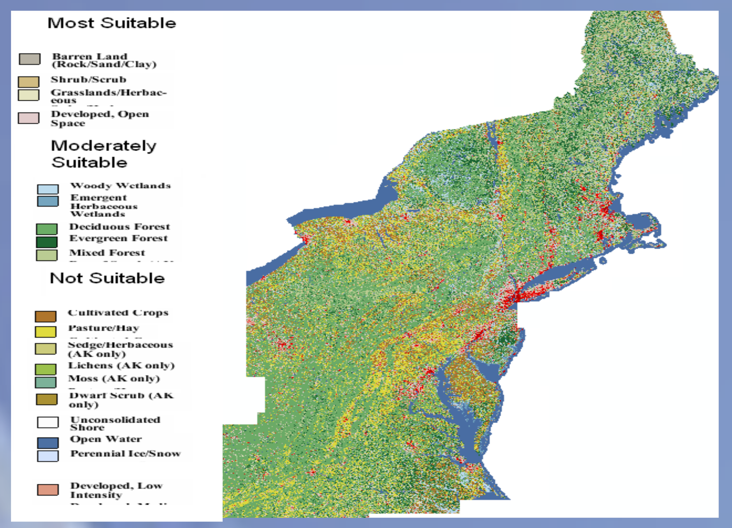


Euclidean Distance Reclassified

Clear = 0
Yellow = 1
Light Blue = 2
Dark Blue = 3

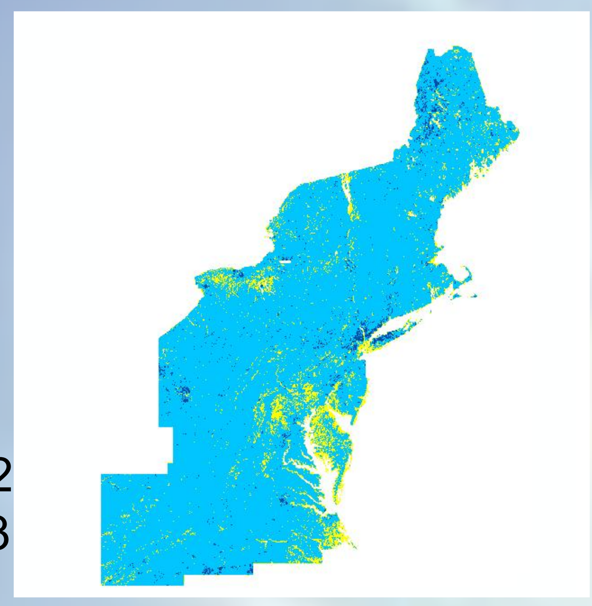


Land Cover

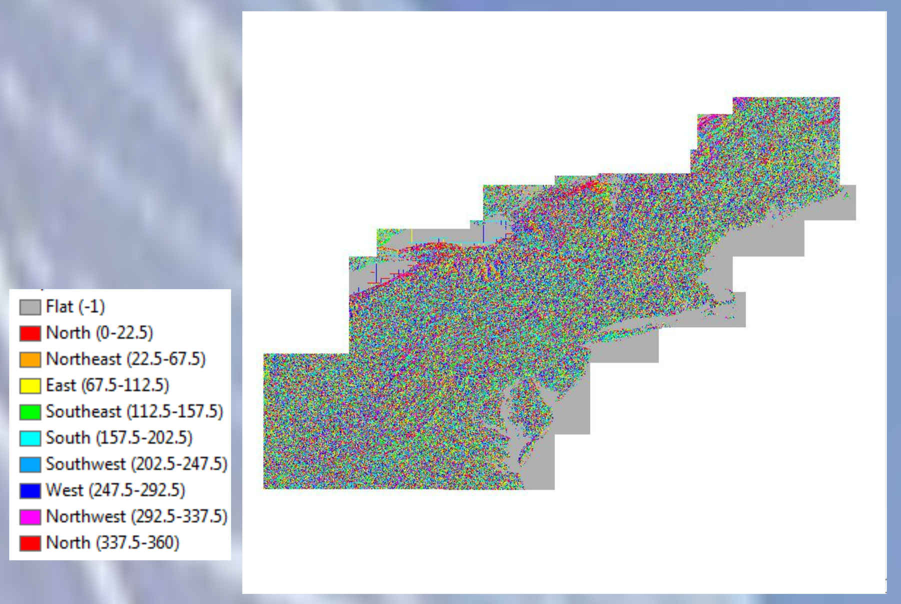


Land Cover Reclassified

Clear = 0
Yellow = 1
Light Blue = 2
Dark Blue = 3



Aspect

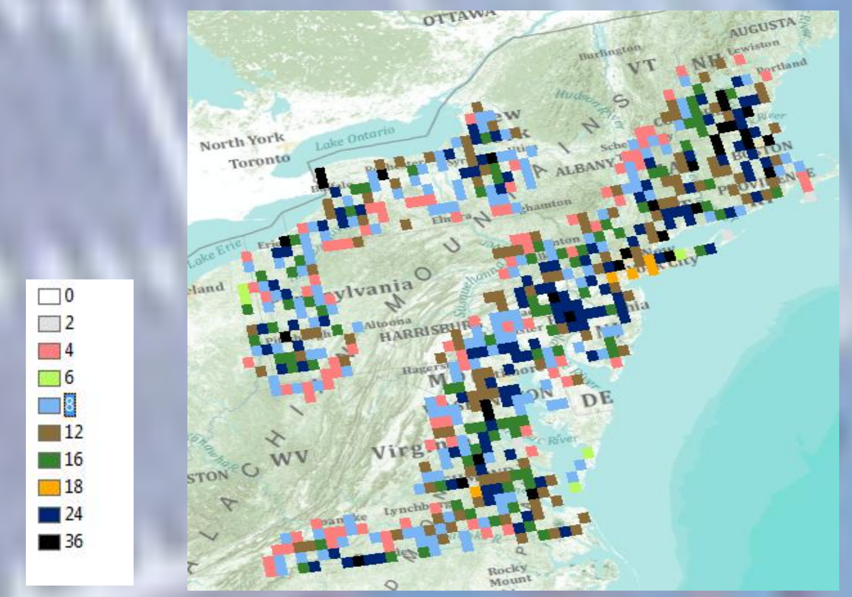


Aspect Reclassified

Clear = 0
Yellow = 1
Light Blue = 2
Dark Blue = 3

The Reclassified Rasters were combined using the Equation (2 * Reclassified Land Cover) * Euclidean Distance Reclassified * Aspect Reclassified. This gives double weight to the land usage while also eliminating all areas of zero suitability in any of the maps. Then all of the sites with the highest calculated suitability value were selected and labeled for analysis.

Combined Suitability



Sites for Analysis

Results and Conclusion

Site Analysis

Site	PV Output per m2 (kWh/m2)	PV output For Entire Farm (kWh)	Cost of Land at Site ($)	Cost of Installation ($)	Total Cost ($)	Price of Regular Electricity ($)	Price of PV Electricity ($)	Yearly Income ($/year)	Payoff Time (years)
1	5141	14394800	9740	9990000	9999740	0.125	0.25	3598700	2.779
2	5141	14394800	9740	9990000	9999740	0.125	0.25	3598700	2.779
3	5174	14487200	69117	9990000	10059117	0.118	0.236	3418979	2.942
4	5174	14487200	69117	9990000	10059117	0.118	0.236	3418979	2.942
5	5190	14532000	26139	9990000	10016139	0.122	0.244	3545808	2.825
6	5079	14221200	69117	9990000	10059117	0.118	0.236	3356203	2.997
7	**4674**	**13087200**	**51350**	**9990000**	**10041350**	**0.145**	**0.29**	**3795288**	**2.646**
8	4528	12678400	51350	9990000	10041350	0.145	0.29	3676736	2.731
9	4476	12532800	51350	9990000	10041350	0.145	0.29	3634512	2.763
10	4465	12502000	46372	9990000	10036372	0.096	0.192	2400384	4.181
11	4814	13479200	193360	9990000	10183360	0.116	0.232	3127174	3.256
12	4814	13479200	193360	9990000	10183360	0.116	0.232	3127174	3.256
13	**5070**	**14196000**	**51350**	**9990000**	**10041350**	**0.145**	**0.29**	**4116840**	**2.439**
14	**5070**	**14196000**	**51350**	**9990000**	**10041350**	**0.145**	**0.29**	**4116840**	**2.439**
15	**5070**	**14196000**	**51350**	**9990000**	**10041350**	**0.145**	**0.29**	**4116840**	**2.439**
16	**5070**	**14196000**	**51350**	**9990000**	**10041350**	**0.145**	**0.29**	**4116840**	**2.439**
17	4966	13904800	46372	9990000	10036372	0.096	0.192	2669722	3.759
18	4966	13904800	46372	9990000	10036372	0.096	0.192	2669722	3.759
19	4573	12804400	46372	9990000	10036372	0.096	0.192	2458445	4.082
20	**5126**	**14352800**	**85906**	**9990000**	**10075906**	**0.08**	**0.16**	**2296448**	**4.388**
21	**5267**	**14747600**	**85906**	**9990000**	**10075906**	**0.08**	**0.16**	**2359616**	**4.270**
22	**5267**	**14747600**	**85906**	**9990000**	**10075906**	**0.08**	**0.16**	**2359616**	**4.270**
23	**5290**	**14812000**	**85906**	**9990000**	**10075906**	**0.08**	**0.16**	**2369920**	**4.252**
24	**5557**	**15559600**	**85906**	**9990000**	**10075906**	**0.08**	**0.16**	**2489536**	**4.047**

System Analysis

Total PV Output (kWh)	EIA Estimated 2008 Energy Output (Quadrillion BTU)	EIA Estimated Energy Imports (Quadrillion btu)	EIA Estimated 2008 Energy Output (kWh)	EIA Estimated Energy Imports (kWh)	% of Estimated Energy Output	% of Imported Energy	Yearly Electricity Use Per Person (Million btu)	Yearly Electricty Use Per Person (kWh)	People Supported through the entire system
335893600	73	30	2.1389E+13	8.79E+12	0.00157	0.00382	308	90244	3722

Conclusions

All of the sites had a payoff time of less than ten years, so they can be considered feasible.

Top Five Solar Potential Sites: 13, 14, 15, 16, 7

Top Five Payoff Times: 24, 23, 22, 21, 20

However, the entire system only supports 3,722 people, and didn't "replace" a significant amount of either power production or imports.

While it is economically feasible, solar power simply isn't very efficient on a macro scale.

On a micro scale, such as rooftops on small towns or a small business, it has potential to be an effective investment and power source.

Sources of Error: The cost of installation was assumed to be constant, but in reality local costs will be either cheaper or more expensive than the estimate. Also, the NREL uses statistical data to estimate the power output at each location. The actual yearly power output will be either lower or higher than the estimate.

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