

Solar Panel Suitability on Roofs at Colby College

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Abstract

This study used GIS to assess photovoltaic panel suitability on roofs at Colby College through using information provided by the Physical Plant and solar calculations from online resources. The roofs were modeled using a Geographic Information System (GIS) program. Buildings were selected based on direction the buildings faced, angle of the roofs, and the building's energy use. The roofs are Goddard-Hodgkins (GoHo), the Green House, Drummond and Treworgy. GIS allowed south facing roofs to be selected out and their visibility from a few chosen spots on Colby campus to be computed. By consulting online solar calculators to assess the potential sun radiation in Waterville and opportune angle for panel placement, the number and size of panels was estimated and energy gain in kilowatt hours (kwh) was computed. Additionally, a viewshed analysis was performed with GIS to assess the visibility of potential solar panels.

Introduction

Solar as an alternative energy source has become a more viable, attractive option due to the current focus on lowering net carbon emissions and other greenhouse gases both locally at Colby College and globally in efforts such as the Kyoto Protocol. At Colby, the idea of placing photovoltaic panels on top of roofs has been raised and discussed.

Using GIS modeling and information from the Physical Plant as well as online resources, we modeled three roofs to determine their aspect, which is a crucial factor in determining the potential solar energy captured, and performed a viewshed analysis to determine their visibility on campus.

Figure 1. Aerial View of the Colby Campus



Methods

Data for our analysis was provided by Physical Plant (PPD) engineer Andy Gockel. These data were converted into a format that could be used with GIS, and were projected on aerial photographs of the Colby Campus. We were forced to enter much of the data manually into GIS in order to perform our analyses. After entering elevation data for each of the three buildings, GoHo, Drummond, and Treworgy we were able to create a Triangular Irregular Network (TIN) for each building, to display the topography of each roof, which allowed us to view them three-dimensionally. Using the TINs we were able to calculate the aspect (direction) of each roof in order to determine which roofs were best suited to solar panels. (South facing roofs are best, north are worst, and east/west roofs are usable but will capture less energy than south facing roofs.)

The next part of our analysis was to perform a viewshed on each of the buildings to determine the visibility of solar panels on each of the roofs, if they were put in place. In order to do this we had to convert our TIN to a raster file. This part of our analysis was the most technical and required creating a new shapefile in order to give values (in this case elevation) to the areas surrounding each of the three buildings. This shapefile was the frame of reference within which we performed the viewshed analysis. We chose a point in the center of frat row as our reference point. This point was chosen because it allows for a view of all three buildings and it is a point that is realistic in terms of where students would be viewing solar panels, if they were to be put in place on any of the buildings we assessed.

Lastly online solar calculators were consulted to assess the solar potential for Waterville, the optimum angle for panel placement, and the energy gained from panels one meter squared. Panels were then added on to the roof and total area of the panels was calculated. Using the equations researched online, kilowatt hours (kwh) and monetary gain were computed.

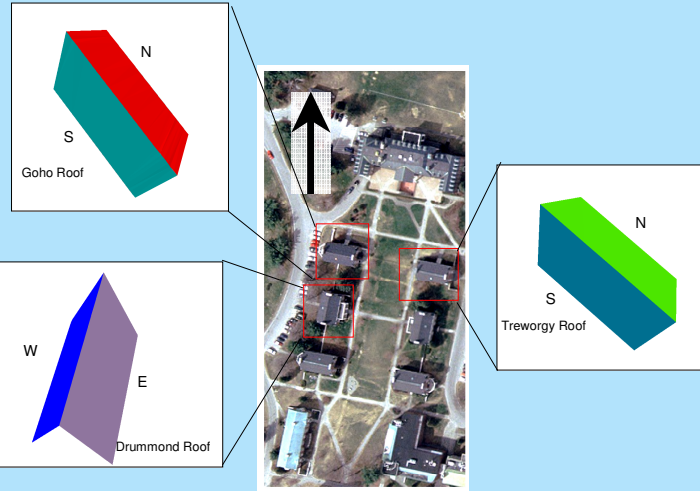
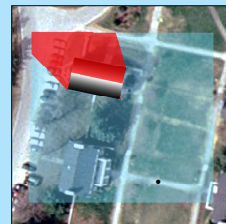


Figure 2. Frat Row, the three dorms we modeled, GoHo, Drummond, and Treworgy are highlighted with red boxes.

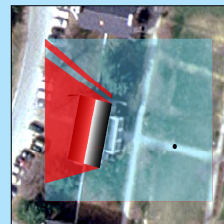
Viewshed Analysis

Our viewshed analysis shows where solar panels would and would not be visible from a central point on the Frat Row quad. The black point represents the observer, the blue area symbolizes what is visible and the red symbolizes what is not visible.

Note: the viewshed is bounded by the shapefile we had to create in order to perform the analysis, however, where the blue shading ends does not mean that the area is not visible, it simply represents the necessary simplification that we had to undergo in order to perform the analysis.



GoHo viewshed analysis



Drummond viewshed analysis



Treworgy viewshed analysis

The red sliver seen on the Drummond viewshed is unexplainable and attributable to both human error and error in the GIS computer analysis.

Results

We found that the roofs of GoHo and Treworgy are best suited for solar panels due to their north-south orientation, while Drummond, which faces east-west would produce capture less solar energy. Additionally we determined that the three roofs where solar panels would be located; the east face of Drummond, and the south facing faces of GoHo and Treworgy would all be visible from the center of Frat Row.

The number of solar panels that could be used per roof would be dependent on the area of the roof, area of individual solar panels, and to what extent support structures for the solar panels would be needed. For our calculations we assumed 1 meter squared panels lying flat on the roof. Our analysis supposed eight solar panels on the Green House, Treworgy, and Drummond respectively, which would leave ample roof space.

The calculator was based on solar radiation in Portland, so all numbers may be a little higher than the radiation and energy output that would occur in Waterville (National Renewable Energy Laboratory 2006). The angle inputted for the Green House, Treworgy and Drummond roofs was 58%, which is the angle of the roof and coincidentally around the recommended angle for winter panel placement. The panels would be tilted on the flat roofs to reach this degree slant.

Estimated Potential Energy Gain from Panel Placement

	Solar Radiation (kwh/m2/day)	AC Energy (kwh)	Energy Value (\$)
Eight Panels on Treworgy Roof	36.32	39,360	5,864.64
Eight Panels on Green House Roof	36.32	39,360	5,864.64
Eight Panels on Drummond Roof	26.48	27464	4,795.12

Discussion

Many limitations arose during the modeling and analytical process. The data we received was not complete enough for the GIS to read and therefore we had to manually enter data into the program in order that the GIS would produce the correct result. Specifically, the TIN we created uses points to form triangles to represent the roof three dimensionally, however the points that where part of our data set were not enough to obtain an accurate model so we were forced to enter many new points. Despite this the TIN that shows aspect for each of the three roofs is accurate. Lastly there is a limitation if the medium of presentation, on the computer we were able to view our results three dimensionally, but presented on a two dimensional medium such a view is impossible.

Our viewshed analysis also relied heavily on manual inputs in order to perform the analysis. Specifically it required the creation of a new shapefile in order to perform our viewshed, and also assigning an elevation value to this file. We were able to estimate the value of the this area (relevant for our observation point) from the different roof heights and our knowledge of the Frat Row area, however there was ample room for error in this assigned value. Also we lacked the time and resources to enter all other variables for our viewshed analysis, such as trees or buildings that would be obstacles to a direct view. However we attempted to compensate this by selecting a point where there were no obstacles to hinder a direct view or our selected buildings. Our results therefore are largely accurate, although there could be significant changes given different inputs. Given the emphasis the college puts on aesthetic appearance the visibility of solar panels is an important consideration.

The results still shed light on potential energy gain and opportune panel placement. Small angle differentials in relation to the sun do not greatly alter the potential energy.

This study only briefly assessed three buildings' potential for solar based on a limited number of variables. We recommend that the college undertake more extensive studies to assess all buildings' solar potential taking into account such variables as aspect, slope, and visibility, as well as more technical engineering studies that were beyond the scope of this study.

Literature Cited

National Renewable Energy Laboratory. 2006. Online. Available: <http://irredc.nrel.gov/solar/calculators/PVWATTS/> [accessed 4/15/06].

Acknowledgements

Andy Gockel, head engineer at Physical Plant Department