University of Illinois Campus Rooftop Photovoltaic Master List

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Introduction

The purpose of this project is to identify the University of Illinois campus buildings that are capable of hosting a grid-tied rooftop solar photovoltaic (PV) array. Working in conjunction with Morgan B. Johnston, Paul Foote, members of the iSEE Solar Working Group, and University of Illinois' Facilities and Services, the identified buildings will then go through a process of elimination to move towards large scale campus rooftop PV installations. The installations will be a necessary step in reaching the iCAP goal of a carbon neutral campus by 2050 [1].

Development of Master List: First Iteration

The first list of buildings chosen to explore for potential rooftop PV arrays was developed by the Energy Generation, Purchasing, and Distribution SWATeam. This team consisted of Angus Rockett, Scott Willenbrock, Mike Larson, Tim Mies, Drew O'Bryan, Nathan Wells, and Rob Klein [2]. This initial list was developed to help Illinois' Facilities and Services begin working towards rooftop PV array installations on buildings that the SWATeam determined worth a deeper look. The SWATeam list consisted of 22 buildings that were mostly on campus, with a few off campus additions. Morgan Johnston aspired to take this list and ultimately expand upon it to create a larger pool of campus buildings to be considered for rooftop PV arrays. As a result, I volunteered to expand upon the original SWATeam list of buildings.

Master List Details

Before creating the electronic excel master list, I developed the following criteria for considering which campus building rooftops were fit for PV consideration. The criteria consisted of the following:

I. The building has an angled, south facing roof portion or flat roof portion.
II. The usable rooftop area is ≥ 100 m^2.
III. The building is contained within the Campus Map from Facilities and Services[1].

The usable rooftop area was chosen due to the difficulty of accurately measuring less than 100 m^2 using the PVWatts drawing tool [3]. No north, east or west portions of angled rooftops were considered due to their lack of generation potential.

To create the list, each building on the given map was identified, and the satellite image was found using the National Renewable Energy Laboratory's (NREL) PVWatts calculator. Figure 1 shows the PVWatts drawing tool.

[1] Map has borders of Hazelwood Drive in the south, Neil Street in the west, University Avenue in the north, and Lincoln Avenue in the east.

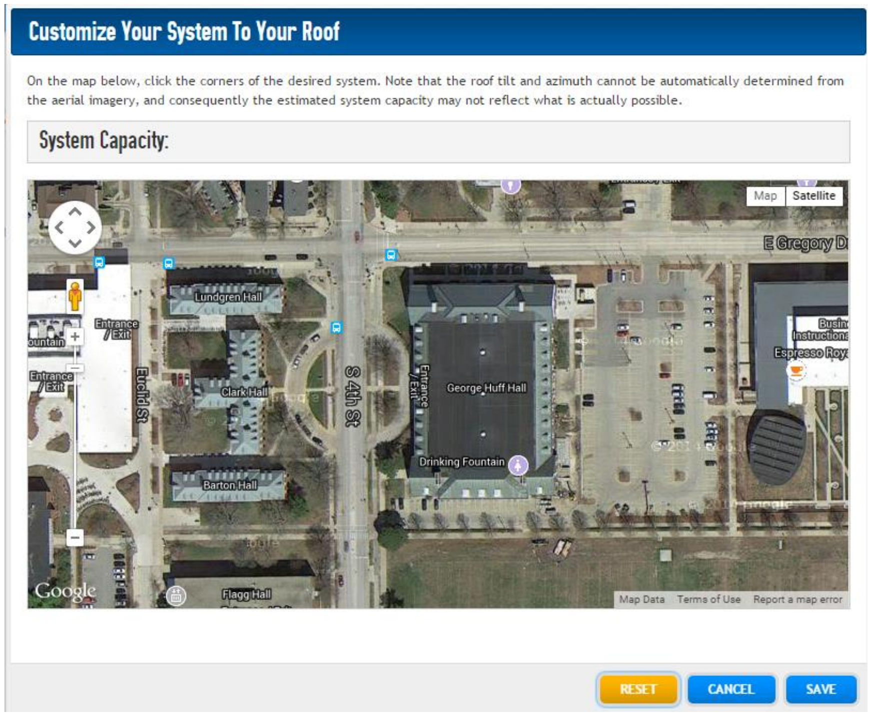

Figure 1: View of PVWatts satellite image of Huff Hall

Then, the drawing tool was used to estimate the area of the roof, shown by Figure 2.

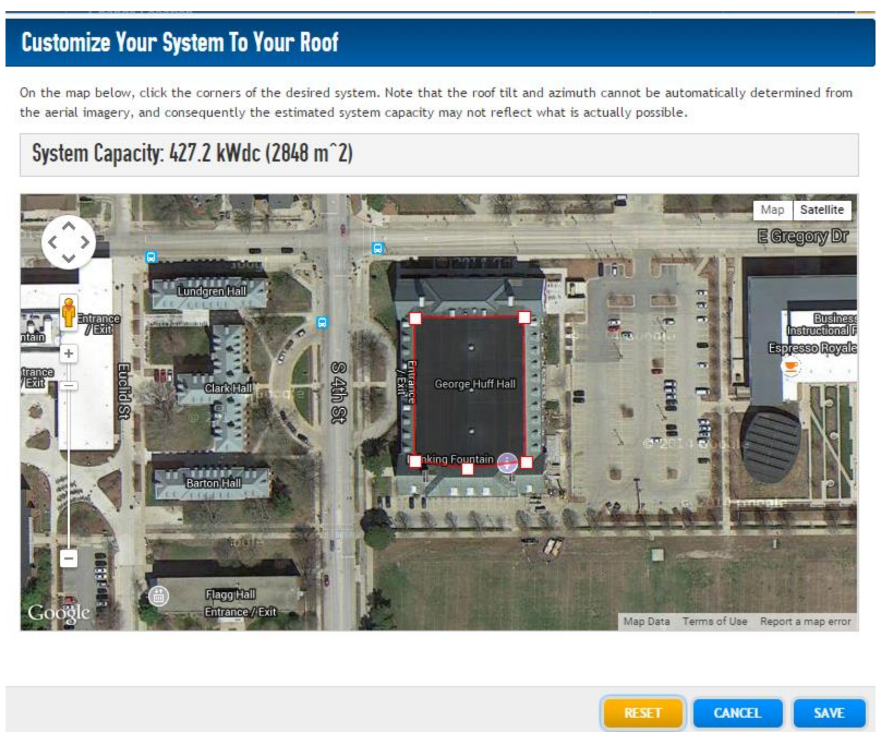

Figure 2: Huff Hall with roof area drawn in PVWatts

Then, using my best judgement of the obstructions on the roof from the satellite image, I estimated the usable rooftop area for solar panel installation. For this example, Huff Hall has very few rooftop obstructions, so the usable rooftop area in the spreadsheet is close to the measured rooftop area in PVWatts. To clarify, the usable rooftop area is the total estimated rooftop area that can be used for rooftop PV, whereas the total rooftop area is all of the area on the roof including obstructions and other building rooftop equipment. Since solar panels cannot be installed on rooftop equipment, the usable rooftop area is less than the total rooftop area.

After developing the list of potential buildings with their rooftop areas and numeric listing from Facilities and Services, the buildings were broken into three categories. Table 1 shows the listing of the three categories.

Table 1: Labels for building on map and in spreadsheet

Label	Criteria	Color Code
Small	Usable Area ≥100 m^2, <1000 m^2	Orange
Medium	Usable Area ≥1000 m^2, <2000 m^2	Blue
Large	Usable Area ≥2000 m^2	Green

Once the buildings were broken into labels on the spreadsheet, the corresponding buildings on the physical map were color coded to correspond to their label. This map has been made available to Morgan Johnston as a visual aid to the electronic list. The buildings that overlap with the SWATeam list on the master list are specially marked.

Estimation of PV Rooftop Arrays

The estimation of the sizing and yearly output of the rooftop arrays for each individual building was made. This estimation was done by using the PVWatts drawing tool and the available information about the Champaign-Urbana Mass Transit District (CUMTD) building and the Business Instructional Facility (BIF) rooftop arrays.

First, the usable area of each campus building identified on the master list needed to have an estimate for the amount of area the PV array would take up. The percentage of panel area to total rooftop area was determined for the CUMTD and BIF arrays. Then, the two values were averaged. This average percentage, 39%, was then multiplied by each campus building's usable rooftop area in the spreadsheet. This yielded the approximate solar PV panel area on each building. From there, the size of each array (in kW_{DC}) and the average yearly output (in kWh/yr) for the CUMTD and BIF arrays were divided by their respective PV area. These numbers were then averaged to be used as a multiplier for the PV panel area that was estimated for each campus building[2]. The rooftop PV installation size (in kW_{DC}) and annual output (in kWh/yr) were then estimated for each campus building. The results are shown in the master list excel spreadsheet.

It is important to note why the array space area is so much smaller than the usable rooftop area. At 39%, the average panel area to rooftop area seems very small. However, after touring the 296.94 kW array at the CUMTD building, Jane Sullivan noted that the array size was the largest allowed for the given CUMTD rooftop, and the limitation was not the structural capacity of the building. The actual reason for this remains complicated: According to the engineering firm that helped determine the number of panels for the project, they believe that it was a combination of electrical service and/or switch gear limitations. There was also the

[2] These multipliers are made knowing that it will yield a rough estimate of both size and annual output given that the angle of all the panels will not be the same on each individual campus building as they are for the BIF and CUMTD arrays. They are available on the excel spreadsheet.

spacing of the panels to consider so that each row of panels would not shade the other. Lastly, there is a spacing requirement between panels so they can be accessed by foot.

According to Paul Foote, the National Electric Code has perimeter requirements that limit edge perimeters of PV arrays, which may have also had an effect on limiting the array size potential for the large usable roof area. I was unable to find anything in the code that stated edge requirement; however, I did find that the international fire code required a minimum 6 foot wide clear perimeter around the edges of roofs for PV arrays [4]. In short, because the CUMTD array was as large as possible given its usable roof area, it is a fair assumption to make that campus rooftops will come close to the 39% of usable roof area estimate.

Results

In total, 178 buildings are contained on the master list. Of these buildings, only four of the original SWATeam list did not make the master list, largely due to the consideration of off-campus buildings for the original list. If the solar PV installations were made on each building of the list, approximately 16,500 MWh would be generated per year from rooftop PV on campus, which would be 3.8% of the total campus usage of 432,450 MWh from the fiscal year of 2012 [4]. As as campus buildings and campus energy usage becomes more efficient, this percentage will grow. Of these arrays, five buildings on the list are projected to be able to have a larger PV rooftop array than the CUMTD array.

Recommendations

After creating this list, I conducted a few site visits to some of the buildings on the list. I came up with a list of five buildings to pursue in the very recent future due to what I observed:

1. Physical Plant Services Building: This building has an enormous flat rooftop area, and it is the site of the Facilities and Services office. Given these two parameters, it is a building that should be considered now as having the highest potential of any campus building for rooftop PV from a design build perspective.
2. Activities and Recreation Center: The ARC is another building that has an enormous rooftop area. It is also one of the most visible campus buildings. Many students use the ARC, and the panels would be viewable from Memorial Stadium. It would be a perfect way to raise campus awareness of the 2050 iCAP goal, and also generate a lot of energy throughout the year.
3. Ikenberry Dining Hall: For the same reasons as the ARC, I believe the Ikenberry Dining Hall should be considered as soon as possible for a rooftop PV array.
4. Abbott Power Plant: Given that Abbott is already a major campus energy producer for both heat and electricity, it would make sense to add a solar rooftop array that can also be an integral part of the campus grid.
5. Atkins Tennis Center: I believe this would work as a great producer of energy due to its large flat roof area. I also think given the Division of Intercollegiate Athletics ability to raise money through the I Fund, it would be possible to have donors help create a large rooftop PV array to offset campus energy usage.

Bibliography

[1] T. Abram, S. Barot, B. Deal and S. Lage, "A Climate Action Plan for the University of Illinois at Urbana-Champaign," Urbana-Champaign, 2010.

[2] "Institute for Sustainability, Energy, and Environment," University of Illinois at Urbana-Champaign, [Online]. Available: http://sustainability.illinois.edu/campus-sustainability/icap/swateams/energy-generation-purchasing-and-distribution/. [Accessed 14 July 2015].

[3] "PVWatts Calculator," Golden, 2014.

[4] "Facilities and Services," University of Illinois at Urbana-Champaign, 2015. [Online]. Available: http://fs.illinois.edu/services/utilities-energy/production/renewable-energy. [Accessed 11 August 2015].