3.2.4: Design and Performance Demonstration of BIPV Systems for Bldg. 661

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Summary

Building 661 is adjacent to two buildings that restrict solar access during the winter months. The first building is to the West and the other to the South, at distances of 60 feet and 80 feet respectively. The building to the west restricts solar access on many surfaces during the afternoon hours while the building to the south restricts solar access on many surfaces during the morning hours. The result is very few surfaces on Building 661 that have an unrestricted, clear view of the sky for an adequate amount of incident solar irradiation for use in energy conversion systems.

Geographic Location:
Philadelphia Navy Yard on the corner of S 12th Ave and Kitty Hawk Ave.
Longitude: 39°53′26″ N
Latitude: 75°10′21″ W
Elevation: 15 feet
Rotation: 6° West of North

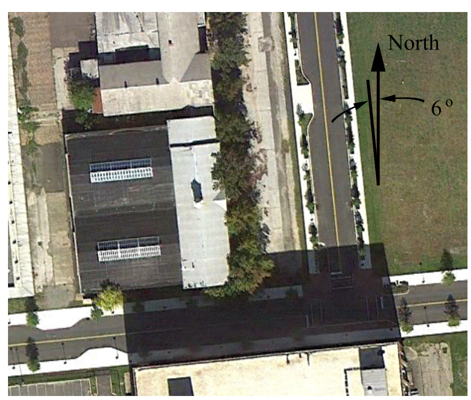

Figure 1: Assessment of the geographic location and rotation of Building 661.[2]

Shading Analysis

Figure 2: Rendering of Building 661 with previously proposed PV system.[1]

In various Greater Philadelphia Innovation Cluster (GPIC) publications and presentations over the past year, large rooftop photovoltaic arrays have been shown in renderings of the renovated Building 661. One example of this is shown in Figure 2. Based on the length of shadows in Figure 2, it is apparent that the lighting in this rendering is from sunlight sometime in the late morning in mid summer.[4] As shown by this site survey and shading analysis, such systems would have extended payback periods because of the significant level of partial shading of each of these arrays at various times throughout the year. On any electrical PV systems that are employed, in order to reduce the impact of partial shade, micro-inverter systems must be employed. As shown in Figure 3, most of the roof of Building 661 is in full sun for most of the year. However, the periods of shade during the winter can extend payback periods of solar energy conversion systems by years if systems are not designed and implemented correctly. Four different satellite and arial images have been compiled in Figure 4 to further depict the variability in the potential shading of various surfaces on Building 661.

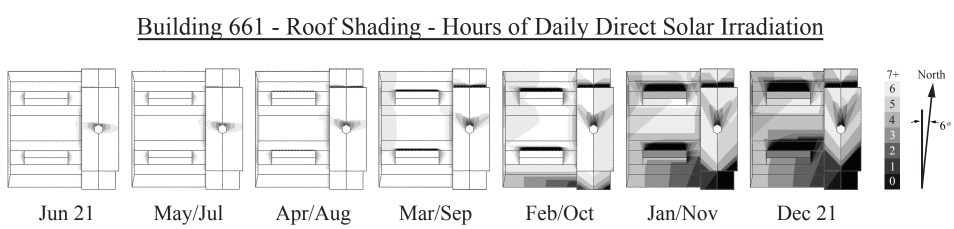

Figure 3: Shading Results for Building 661.

Shading analysis has shown that the area directly above the basketball court is the best suited roof space for a solar energy conversion system. The best surfaces on Building 661 that receive six or more hours of direct sunlight, centred around noon, at all times throughout the year, is highlighted

Figure 4: Satellite and Arial Imagery of Building 661 at different times of the year.[2, 3]

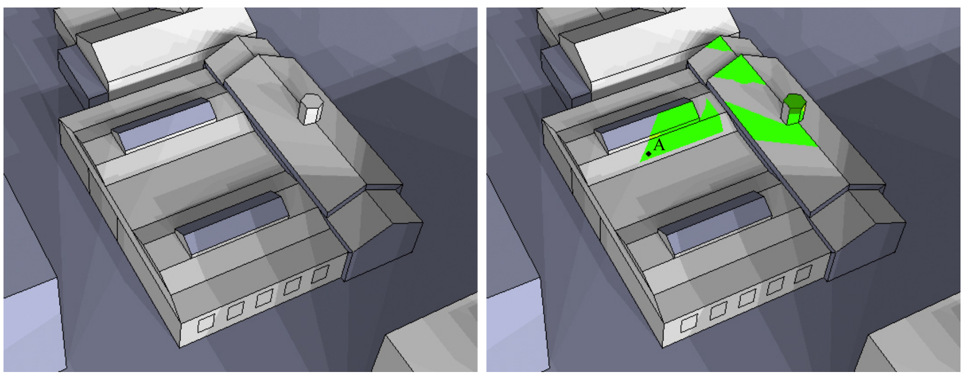

Figure 5: Depiction of usable area if six hours of direct solar irradiance year-round is required. Point A is selected as a good location for a shading diagram.

in Figure 5. We recommend that the skylight areas, particularly the skylight area above the north bay currently containing the basketball court, be redesigned to accommodate a solar energy conversion system above the eastern half of that skylight. A new skylight with clerestory windows and a roof would be a good solution that does not impact the daylighting benefits of this architectural element. As a sample, point A in Figure 5 has been studied further, yielding a shading diagram, Figure 6.

Building 661 is not in an ideal location for year round solar energy conversion systems. However, it does have some small areas that have a sufficient amount of annual incident irradiance to justify smaller systems on the order of 20kW or consisting of as many as fifteen large ($10' \times 4'$) solar thermal flat plate collectors. If the system is intended for primarily summer use, for solar cooling, larger systems could be employed, but would be partially shaded

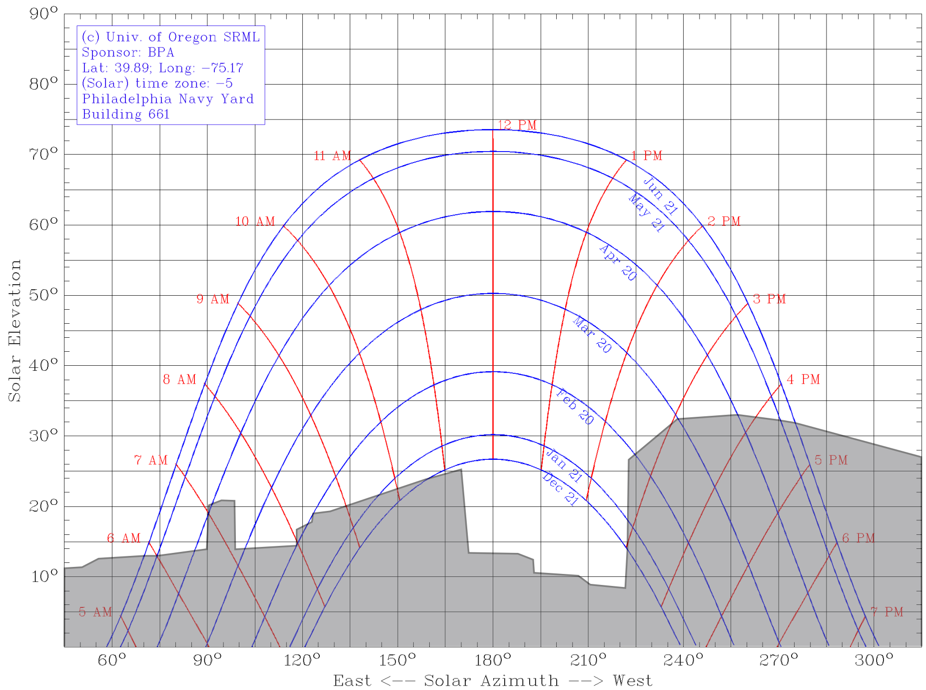

Figure 6: Shading Diagram for Point A on Building 661.

during the winter months. The various regions of varying solar irradiation have been outlined in this report and should be studied further during the design process of any solar energy conversion systems.

References

[1] Carnegie Mellon University, GPIC Year 1 Condensed Report (2011)

[2] Google Earth Satellite Imagery (2012)

[3] Microsoft Bing Maps Arial Imagery (2012)

[4] Duffie, J. A. and W. A. Beckman (2006) Solar Engineering of Thermal Processes, 3rd ed., John Wiley and Sons, Inc.