Potential Electricity Production of Vertical Solar Photovoltaic Arrays

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1. Introduction

In most of the commercial buildings, façade area of building envelops could be a significant opportunity to achieve net zero carbon emission of buildings by 2050.Estimating the potential impact on local electricity generation for buildings can provide guidance in their application.

Objective

Identify quantitatively how significant PV systems on building facades can be in comparison with the energy production of same area PV panels on horizontal rooftop.

Limitation

This study is limited to full unblocked surfaces, it doesn't consider any shading affects, which is known can be found on most of urban building's walls, though for some tall buildings can be a very important factor to consider in the future for electricity generation.

2. Methodology

In this study, quantitative methodology was used to conduct simulations for five United States cities: Boston, MA, College Station, TX, San Diego, CA, Miami, FL and Seattle, WA. Thirty simulations, five for rooftop solar PV array generation and twenty-five for vertical tilted solar PV Array, were conducted in this study. The result of each scenario for vertical tilted PV array was compared with the baseline: horizontal rooftop PV array -tilted zero degree.

Table 1. Parameters Setting for PVWatts Simulations

Module Type	Standard
PV Module Efficiency	19%
Array Type	Fixed (open rack)
Array Tilt (deg)	90
System Losses (%)	14.08
Invert Efficiency (%)	96
DC to AC Size Ratio	1.2

The tool used for the simulation of the solar photovoltaic system electricity generation is PVWatts. The PV system used in this study is based on a standard 19% module efficiency. The PVWatts parameters used for the simulation analysis are shown in Table 1.

3. Results

All the five cities have some similarities; 90-degrees tilted PV arrays facing to south, southwest and southeast generate more electricity than the ones facing to west and east in general. PV arrays facing to the south in Boston, MA, and Seattle, WA, can generate more energy than those facing to other orientations.

The baseline case is the monthly generation of horizontal rooftop PV array. For Boston, vertical tilted PV array facing to south (VW-S) has advantages over horizontal rooftop PV array (HRf) in wintertime, as it shown in figure.2.

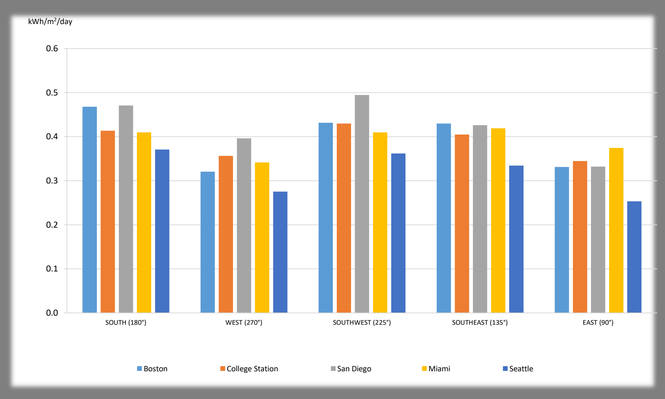

Fig. 1. Comparison of vertical array electricity generation for different orientations in five cities

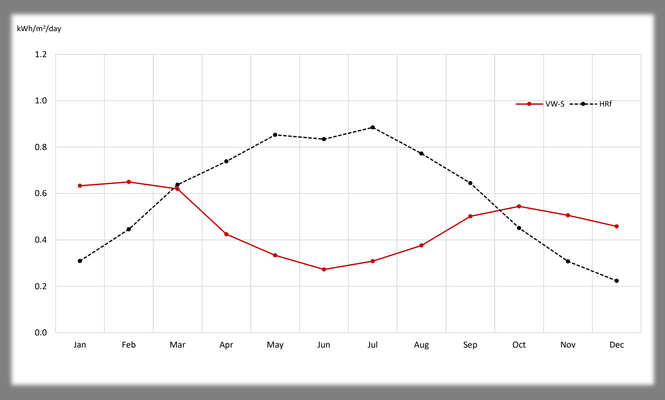

Fig. 2. Comparison of electricity generation of vertical south facing PV array and horizontal PV array in Boston, MA

Table 2. Vertical to Horizontal Annual Daily Average Electricity Generation Ratio

	Boston, MA	College Station, TX	Miami, FL	San Diego, CA	Seattle, WA
Vertical Wall - South (VW-S) [kWh/m2 /day]	0.47	0.41	0.40	0.47	0.37
Horizontal Roof (HRf) [kWh/m² /day]	0.59	0.70	0.75	0.75	0.50
Ratio = (VW-S) / (HRf)	80%	59%	53%	63%	74%

Also in some buildings, it should be considered that façade vertical envelops may have larger areas than roof area, which can be a potential to generate more electricity.

For San Diego, CA, Like Boston, it shows similar result. The difference is that for San Diego, PV wall facing to southwest maximize the annual electricity generation instead of facing to south. Furthermore, the comparative advantage of vertical PV wall over rooftop PV arrays in terms of electricity generation during winter in San Diego is not as distinct as it is for PV walls in Boston.

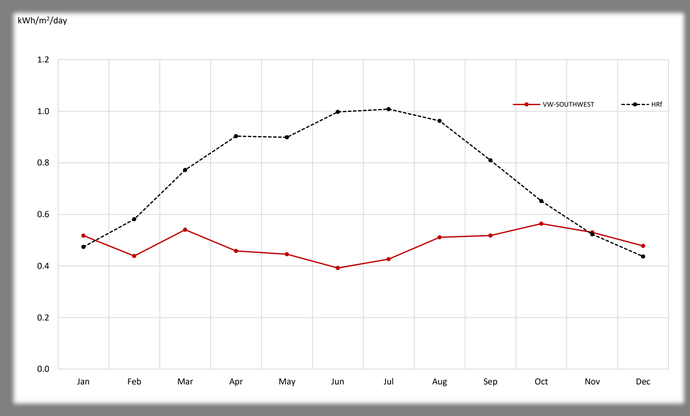

Fig. 3. Comparison of electricity generation of vertical southwest facing PV array and horizontal PV array in San Diego, CA.

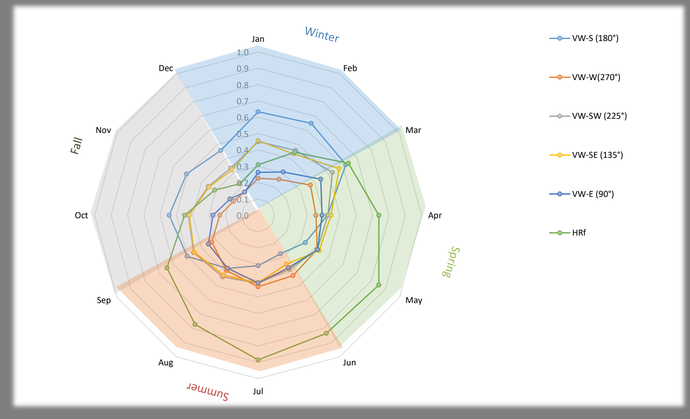

Fig. 4. Monthly average daily AC system output (kWh/m²/day) of 90-degrees solar PV arrays facing to different orientations and horizontal roof arrays, in Boston, MA.

4. Conclusion

1. For the five cities analyzed, the best orientations that present maximum potential of electricity generation annually for vertical PV arrays are facing to south, southeast, and southwest.
2. Although horizontal rooftop PV array has dominant advantage in summer and annual total energy production, a same area of 90-degrees tilted PV arrays are capable to achieve up to 80% of similar rooftop area PV annual production, especially in northern cities of United States.
3. In winter, the façade PV arrays are able to generate similar or even bigger amount of electricity than horizontal rooftop ones.
4. No further analysis has been done to compare the vertical electricity production with the most typical settings for the latitude tilted PV rooftop.