Facades, roofs and solar parking yield estimation at Utrecht Science Park

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Abstract

In this paper a methodology is described combining 2D height maps with 3D building simulations and PV performance software to assess the solar potential at Utrecht Science Campus. Results show that adding facades and parking lots doubles the roof potential, with levelized cost of energy values of 0.068 – 0.092 €/kWh.

Key Innovations

- Building attached photovoltaic (BAPV) at the roofs and facades on the existing buildings where is not possible to change the structure to integrate it and use those “non-useful” spaces to install solar panels.
- The solar parking lot is a good way to use the parking lots to produce energy, besides, protect the cars from weather conditions.
- Charging station to attach them inside the solar parking lot to fully charge the electric vehicles (EV), electric bikes, but also electronic devices.

Practical Implications

Revit has a great tool called “solar analysis tool” that helps to highlight the best places (the simulation takes into consideration the shadows from other buildings and the solar angle throughout the year) to install the solar panels to avoid losses with the shadows. Drawing 3D buildings inside AutoCAD is easier comparing when we do inside PVsyst.

Introduction

The ambition of the Utrecht Science Park is to be fully climate neutral. Solar panels will be a large contributor to that. The objective of the present study is to estimate the yearly yield potential and the number of charging stations on the Utrecht Science Park campus located at Utrecht, Netherlands, which includes buildings of Utrecht University (UU), University of Applied Sciences Utrecht (HU) and the academic hospital University Medical Center Utrecht (UMCU). Additionally, the economic viability of grid-connected solar parking is analysed using the software tool PVsyst for dimensioning and design.

Three layouts (VC0, VC1 and VC2) will be used to compare energy production using the solar PV system attached to the facades and roofs, and solar parking lots. VC0 is a more traditional solar power plant, and only includes solar panels on roofs, for VC1 and VC2, we use roofs, facades and solar parking lots. For the azimuth, VC0 and VC1 have the solar panels turned to South direction (azimuth 0°), and VC2, with West and East side direction (azimuth -90° and 90°) plus South direction (azimuth 0°), even though we have specified azimuth, some buildings are not turned to the South direction. Regarding the tilt angle, for the facades this is 90° and for roofs and solar parking lots, the tilt angle is 34°, based on a study done by Jacobson (Jacobson, 2018).

Methods

The step-by-step method starts with the selection of the locations where the PV system will be installed, see Figure 1. The first part is a 2D task that describes the process to take the raster file based on the actual height map of the Netherlands (AHN, 2021) from which it is possible to create a shapefile with buildings and solar parking lots. The second step is the 3D part that involves the usage of the software AutoCAD, Revit (Figure 2), and PVsyst, to build the buildings in 3D, select the best locations to install the PV system around the entire campus on the facades, roofs, and project the system and design the system (Figure 3) to estimate the yearly yield production. The third task relates to estimate how many charge stations can have inside the solar parking lots for the VC1 and VC2, as VC0 doesn’t have it. The fourth task details the input data for the economic viability calculations considering the total cost of initial investment and operation/maintenance costs.

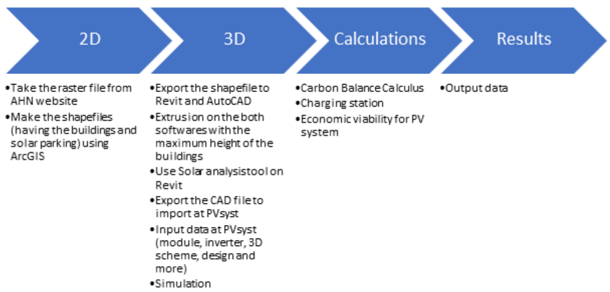

Figure 1 - Method steps (Oliveira,2020)

Results

For the results, we can split it into three parts:

- ➢ Solar potential

The solar potential basically describes the results from the simulations using PVsyst. We estimated the yearly yield

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production, in MWh, for each layout, as is shown in Table 1. Definition of performance ratio was taken from Reich et al. (2012).

Table 1: Overview of performance results.

Results	VC0	VC1	VC2
System production (MWh/yr)	13 549	19 708	24 083
Performance Ratio	0.71	0.70	0.65

➢ Charging stations

The calculation to estimate the number of charging stations is simple, we take the area of solar parking, multiply by the cosine of 34° (the tilt angle) [this calculus represents the "Area at X" on the Table 2], dividing by the parking space area (width of 2.5 m and length of 4.8 m). Table 2 displays the quantity of charging stations for VC1 and VC2.

Table 2: Number of charging station on solar parking

Result	VC1	VC2
Area (m²)	11 095	23 132
Area at X (m²)	9 198	19 177
Quantity	767	1 598

➢ Economic analysis

Table 3 shows the output data for the layouts, for the net present value (NPV), all of them have positive values, the total lifecycle costs (TLCC) which represents the sum of CAPEX (which represents the investment) and OPEX (operation and maintenance) during 25 years. The payback times are 5.54 year for VC0, 6.53 for VC1 and 8.02 for VC2. This reflects the fact that the return of CAPEX is lower than the life-time of the solar cells, the internal rate of return (IRR) represents profit for the projects. And the levelized cost of electricity (LCOE) represents the unit cost (€) to produce energy (kWh).

Table 3: Economical results.

Output	VC0	VC1	VC2
NPV (€)	35 607 018	48 327 191	52 572 801
NPV Excel (€)	35 689 356	48 446 813	52 718 468
TLCC (€)	16 063 180	26 710 243	38 862 820
Payback (Years)	5.54	6.53	8.02
TIR (IRR)	14.06%	11.83%	9.27%
LCOE (€/kWh)	0.068	0.078	0.093

Conclusion

The Utrecht Science Campus represents an enormous potential for using solar panels as there are many locations where solar panels can be installed based on the solar energy analysis using Revit software, especially on the roofs as we have a great number of solar PV used.

Looking on the production side, VC2 has the highest production, as have a greater number of solar panels, but if we talk about performance ratio, VC0 and VC1 are better.

On the economic analysis side, VC0 has the best parameters, but talking about innovation, VC1 goes further because the parameters are better than for VC2, in addition we did not count the economic returns with the charging of the EV.

Acknowledgement

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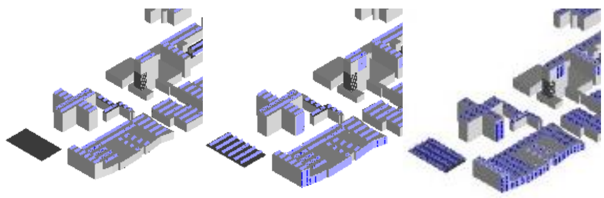
Figure 2 - Solar analysis tool (kWh/m2) [author]



(a) *(b)* *(c)*

Figure 3 – (3a) VC0 project, (3b) VC1 project, (3c) VC2 project

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