Master's Thesis Engineering Technology

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Optimization of photovoltaic generation for the buildings at the Montilivi campus of the University of Girona

Hermans Pieter-Jan

Master of Energy Engineering Technology

Context

The master's thesis is conducted in cooperation with the **University of Girona** within the faculty "Superior Polytechnic School". The University of Girona is located in the north of Spain in the province of Catalonia and exists on four campuses located in different places in Girona.

This thesis examines for one of the four campuses**,** the Montilivi campus (see figure 1), the possibilities of using **photovoltaic generation to provide electricity to the buildings**. The Montilivi campus consists of twelve buildings of which four belong to the faculty "Superior Polytechnic School".

Figure 1: Map of the different buildings on the Montilivi campus [1]

When **building a PV installation, several factors** need to be considered:

- Solar panels
- Inverters
- Battery pack
- Support structure
- Cabling
- Loads
- Grid connection
- Energy management tools

Figure 2 gives an overview of the elements used in a regular PV installation.

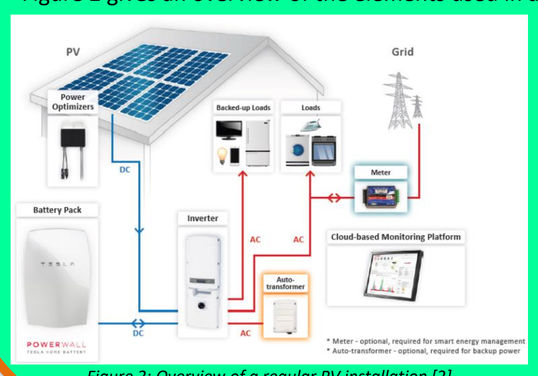

Figure 2: Overview of a regular PV installation [2]

The Montilivi campus of the University of Girona is equipped with a 20-year-old photovoltaic installation consisting of 96 solar panels (Canadian Solar CS6K-280P). It has been found that the installation is operating with **a low efficiency** and that it generates a very **limited supply of energy** (5970kWh/year) while the Montilivi campus consumes a total of 4565493kWh/year. Due to the low photovoltaic generation, the University in Montilivi is obliged to use electricity from the grid. This power often comes from non-renewable energy sources which result in global warming (see figure 3).

To solve these problems, the **objective of this thesis is to design the most optimal PV system for the different buildings on the Montilivi campus**. To meet this objective, the following goals need to be achieved:

- A PV installation that supplies the Montilivi campus with electricity most efficiently and economically possible.
- A more environmentally friendly campus.

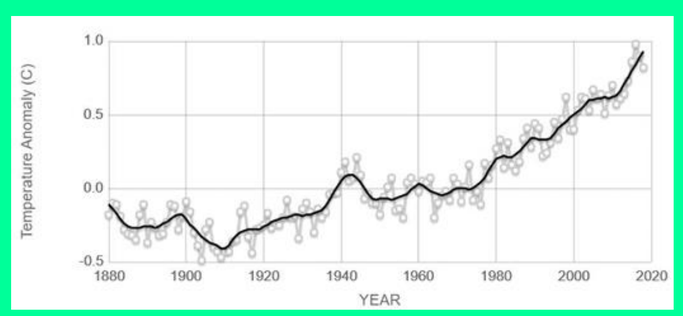

Figure 3: Temperature anomaly over the last decades [3]

Problem & objectives

Results & conclusion

- The decision matrix showed that the SPR-MAX3-400, the VERTEX PERC, and the JKM390M-6RL3-B have the best characteristics (figure 6). For each of these solar panels, the panel works most efficiently if positioned perfectly to the **south** with a tilt angle of **36°**. Additionally, the distance between the rows of each solar panel was determined (see table 1).

Table 1: Minimum row distance between the solar panels

	SPR-MAX3-400	VERTEX PERC	JKM390M-6RL3-B
Tilt angle (°)	36	36	36
Portrait panel minimum row distance (mm)	3052	4305	3350
Landscape panel minimum row distance (mm)	1889	1979	1858

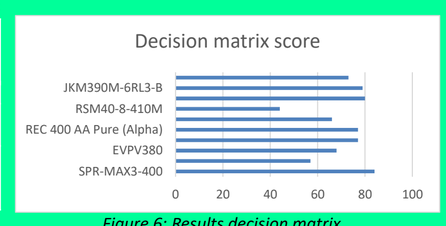

Figure 6: Results decision matrix

- Comparison of three types of inverters showed that the inverters from **SMA** had the best characteristics. Then, with the help of PVGIS, it was decided that for each the power of the inverter is allowed to be chosen **smaller** (±13%) than the installed power of the PV installation.
- Calculations showed that cables of **4 and 6mm²** should be purchased.
- It was demonstrated that using a **battery system is not advantageous** for the installation.
- Based on economic analysis and CO2 emissions, **the JKM390M-6RL3-B** module is the best choice for the different buildings on the Montilivi campus.

Figure 7: EVBox charging station [7]

- A **cooling system** is not economically interesting.
- BIPV can be applied in the form of a **photovoltaic curtain wall** and **photovoltaic balustrades.**
- For a solar charging station on the campus, a 7.4kW **EVBox charging station** would be the ideal choice (figure 7).

Methods

During the elaboration of the project, several methodologies were used to meet the predefined objectives. Figure 4 shows which software and simulation tools were used to solve the problem.

Figure 4: The software and simulation tools used [4] [5] [6]

Using **Python**, a code was created that determines the **sun's position** during a whole year in Girona. Based on this code it is possible to determine the **correct position of the solar panels** (figure 5).

The **PVGIS** and **Sunny Design** software make it possible to **create a model** for the ideal PV configuration for the different buildings on the Montilivi campus. PVGIS takes into account the climate and weather conditions in Girona over the last year, providing **accurate data** about the generation of a PV installation in Girona. With the help of this data and Sunny Design, the **ideal configuration** (solar panels, strings, inverters, and energy management) **of a PV installation** can be determined. In addition, Sunny Design provides a visual presentation of the different PV installations (see the figure in the middle of the poster).

Besides using these simulation tools, a **lot of research** is done. This research work is necessary to gain more insight into the properties of different solar panels, inverters, cables, support structures, and batteries. However, in some situations, the **calculations** are also based on known literature.

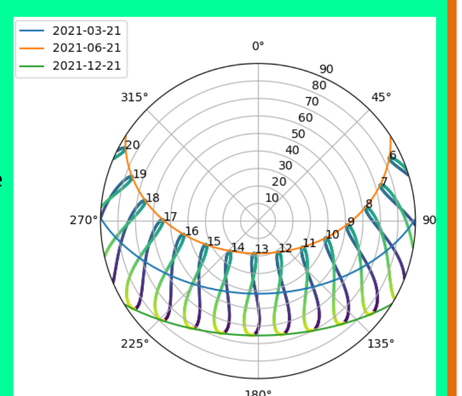

Figure 5: Solar position in Girona for March, June, and December

Supervisors / Co-supervisors / Advisors
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[1] "The campus Montilivi," Universitat de Girona, [Online]. Available: https://www.udg.edu/en/coneix/La-UdG/Campus-universitari/Montilivi. [Accessed 7 March 2022].
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