AgriPV Controller - Prototype development

Graduate

Nils Wöcke

Damian Brauchli

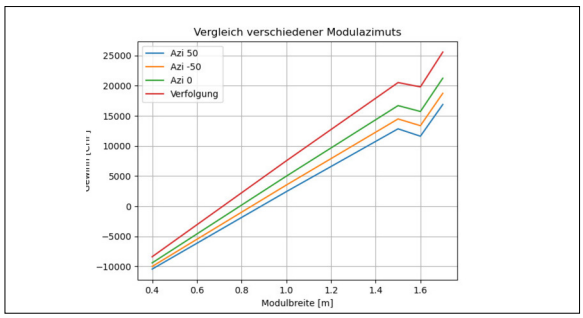
Introduction: The present Bachelor's thesis is dedicated to the planning and development of a prototype for a dynamic photovoltaic system with a specific focus on application in viticulture. Due to a lack of financial resources, a model of the planned prototype is constructed for illustrative purposes. The main objective of the system is to protect grapevines from late frost, hail, and other environmental factors.

Approach: As of now, only systems that are static or overly heavy dynamic designs exist. This leaves a gap which this thesis offers to fill.
During the winter months and when sufficient sunlight is available during summer, the system presented in this thesis is intended to be utilized for electricity generation. To assess the feasibility and profitability of such a system in viticulture or agriculture in general, a profitability analysis is conducted. Using weather data for Buchs, a Python program is developed to simulate various scenarios. With this program, the costs of a system of any scale, as well as the anticipated profits over numerous years, can be calculated.
In the process of concept development, various concepts are formulated and analyzed using different ideation techniques. Through an iterative elimination process, some ideas are discarded, leading to the emergence of new ones. A pivotal aspect of the work concerns the construction of a robust substructure. Through simulations and calculations of mechanical loads and wind forces, a sufficiently strong substructure is designed to ensure stability even during extreme conditions such as storms.
A design is chosen that allows the solar panels to pivot on a central axis, positioning them between the rows of grapevines. Bifacial solar panels are planned, as the rear side of the panels can also capture a significant portion of sunlight when tilted, thereby enhancing electricity production. The prototype is designed, and quotations for all components are obtained to facilitate future construction.
The model is derived from detailed blueprints of the prototype and is created using 3D printing technology predominantly. Boards are mounted in place of solar panels to simulate shading effects. The system is controlled by a compact PLC (Programmable Logic Controller), which allows various scenarios to be simulated with the push of a button. Thanks to an encoder on the motor, different scenarios can be precisely executed, enabling exact adjustment of the panel orientation to provide optimal protection of the grapevines or to maximize electricity generation.
With the aid of the model and spotlights, the shading effects on the plants are visually demonstrated. The presentation highlights how, despite the planned setup, grapevines can still be economically cultivated and grapes can be harvested.

Conclusion: This thesis contributes to the advancement of renewable energy applications in agriculture, showcasing the potential of a dynamic photovoltaic system. The presented outcomes establish a foundation for future research and development in the promising field of Agri-PV.

Model of the prototype in CAD
Own presentment

Expected profit after 25 years with different orientations of the vineyard
Own presentment



Model with wild grapes
Own presentment

Advisor
Dr. sc. Martin Stöck

Co-Examiner
Markus Markstaler

Subject Area
Computational Engineering, Electronics and Control Engineering, Mechanical Engineering