Agrivoltaics for Coffee and Cocoa Farming in Indonesia

Project Thesis 02

Student

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Introduction: With the 2015 Paris Agreement, Switzerland made a commitment on the international level to reduce greenhouse gas emissions. As part of the federal government's energy strategy, the estimated electricity consumption in Switzerland in the year 2050 of 80 TWh/year is to be sourced mainly through renewable energies. Photovoltaics play an important role in this, as the potential on roof surfaces is considerable at 53.6 TWh/year. However, it is uncertain whether this potential can actually be exploited. An exciting alterna-tive to complement this is agrivoltaics, which takes advantage of electricity and food production being located in the same area for mutual benefit. Agrivoltaics has the potential to defuse the competition for land between arable land for energy and food production. Indonesia, where coffee and cocoa are grown on a large scale, is also a signatory to the Paris Agreement. Coffee and cocoa plants should not be exposed to direct sunlight and require varying degrees of shade depending on their growth phase and the variety. Today, this is done by shade plants, but could be done by agrivoltaics in the future.

Approach: In this project thesis, a feasibility study was conducted to show where synergies and challenges lie through the use of agrivoltaics in coffee and cocoa farming in Indonesia. For this purpose, the agronomic and technical status of agrivoltaics was discussed by means of literature research. This also involved research into the conditions under which the plants have the yield and health allowing for a constructive approach to solving the identified problems. Using an exclusion criterion, it was possible to limit the comparison to three agrivoltaic variants: Clear Height Installation with Narrow Module Width (1.45 m), Clear Height Installation with Medium Module Width (2.09 m), Clear Height Installation with Large Module Width (4.18 m).

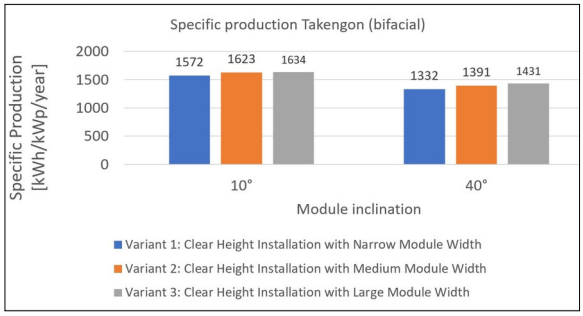
Result: The simulation of the irradiation showed that in the first two years of the coffee plants growth a module angle of 10° is optimal, in the following years an angle of 40°. The row spacing varies depending on the variant, but in all cases, it is below the factor of 2.8 times the module width which is suggested in the literature. Fur-thermore, it was possible to confirm the statement that a system orientation of 30° deviating from the south reduces the irradiation dispersion and thus possibly increases the crop yield. The specific PV yield for all variants per year for bifacial modules is 1'600 kWh/kWp (10° angle of inclination) or approx. 1'400 kWh/kWp (40° angle of inclination). If conventional monofacial modules are used, the yield is only insignificantly lower by 5%. This means, regardless of the module (monofacial or bifacial) used, the yield is approx. 33% or 16% higher than that of an agricultural PV system in Switzerland, which can be explained by the higher solar radiation at the location in Indonesia.

In general, agrivoltaics can be recommended for the case of coffee cultivation considered. Based on the results found, the variant with medium module width and monofacial modules is recommended. This offers a high PV yield and can be installed with reasonable effort. In addition, a rain gutter should be installed to prevent erosion. Furthermore, points such as grid connection, precipitation distribution or the effect of the omission of shade plants must be examined more closely in a specific pilot project.

Typical coffee farm in Aceh (Indonesia) with shade trees between coffee plants.
J. Ilham, „Gayo Coffee Farm", 14. November 2022

Variant 2: System with clear height and medium module row spacing (2.09 m) and an angle of inclination of 10°
Own presentment

Specific PV Production of the three variants at 10° module inclination for the location of Takengon (Indonesia).
Own presentment



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Subject Area
Energy and Environment