Enhancing Agrivoltaics Synergies Through Tracking Optimization

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Simulation are performed for a specific agrivoltaics system in Bavendorf, Southern Germany, part of the **Modellregion Agrivoltaics Baden-Württemberg project** [1]. The site is dedicated to organic **apple** cultivation.

Various **tracking strategies are** designed to dynamic balance energy production and crop growth, thereby enhancing overall system efficiency.

- ***Diffuse-Track*** aims to maximize the Plane of Array (POA) irradiation of solar panels during overcast days

Results show an average daily increase of 1.7% in POA irradiance, even considering days when the gain is null due to clear-sky conditions. During overcast conditions, POA can increase by more than 7%, highlighting the relevance of this optimization especially during the winter months.

- ***Trees-Track*** strives to minimize PAR (Photosynthetically Active Radiation) reduction

The optimization effectively minimizes PAR reduction for the apple trees; however, it results in yearly reduction of 50% in PV yield.

- ***APV-Track*** aims at optimizing both PV and crop's yield, minimizing the deviation from ideal condition. Hence, maximum PV yield and target PAR values.

With this strategy values close to the absolute PAR targets are achieved in almost every month, except May, where PV yield is prioritized, and August, which in the selected year is particularly diffuse. The total PV yield is reduced by 8%.

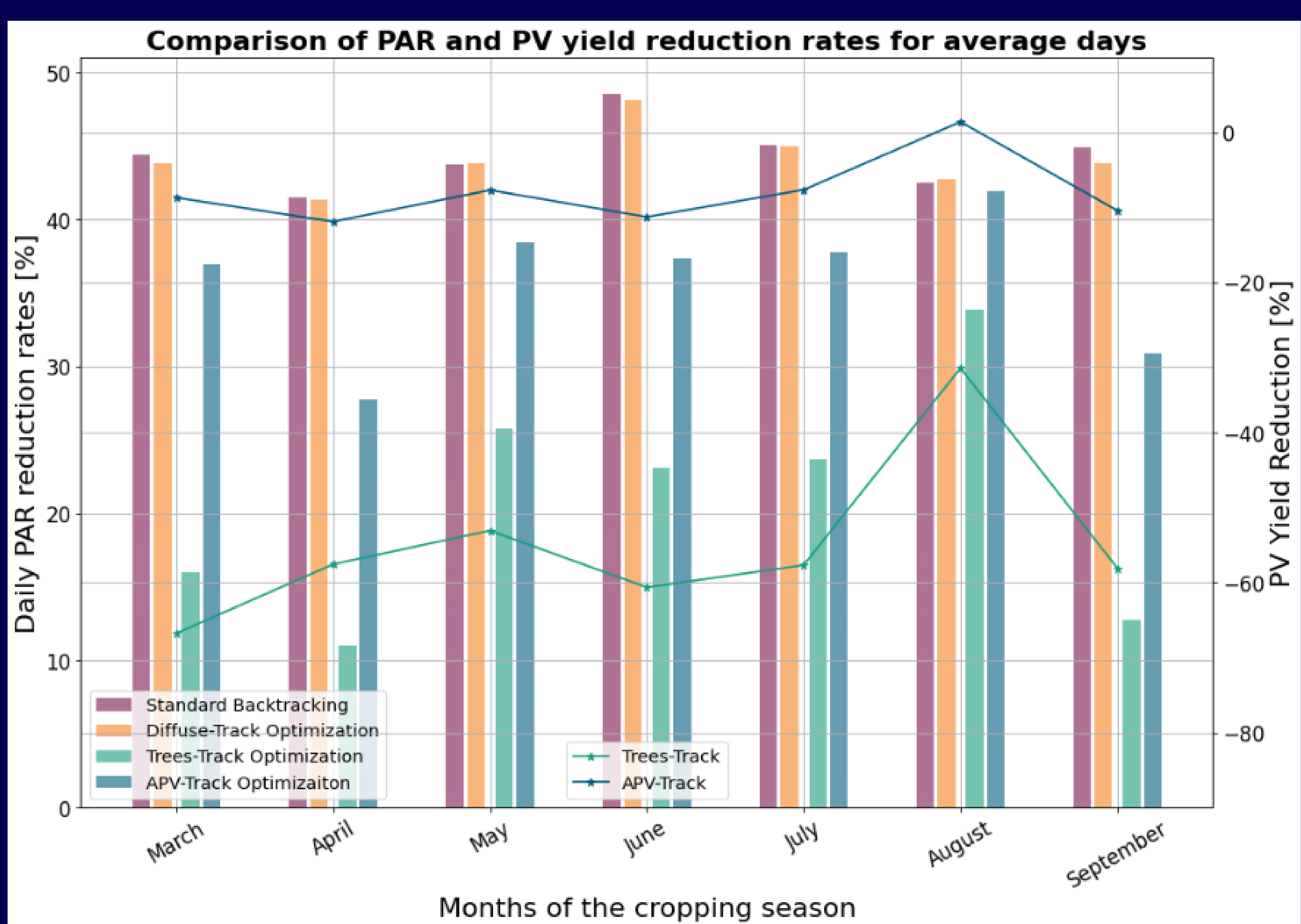

Figure 1: Comparison of daily PAR reduction rates achieved with different tracking strategies and corresponding PV yield reduction rates for average days of the cropping season

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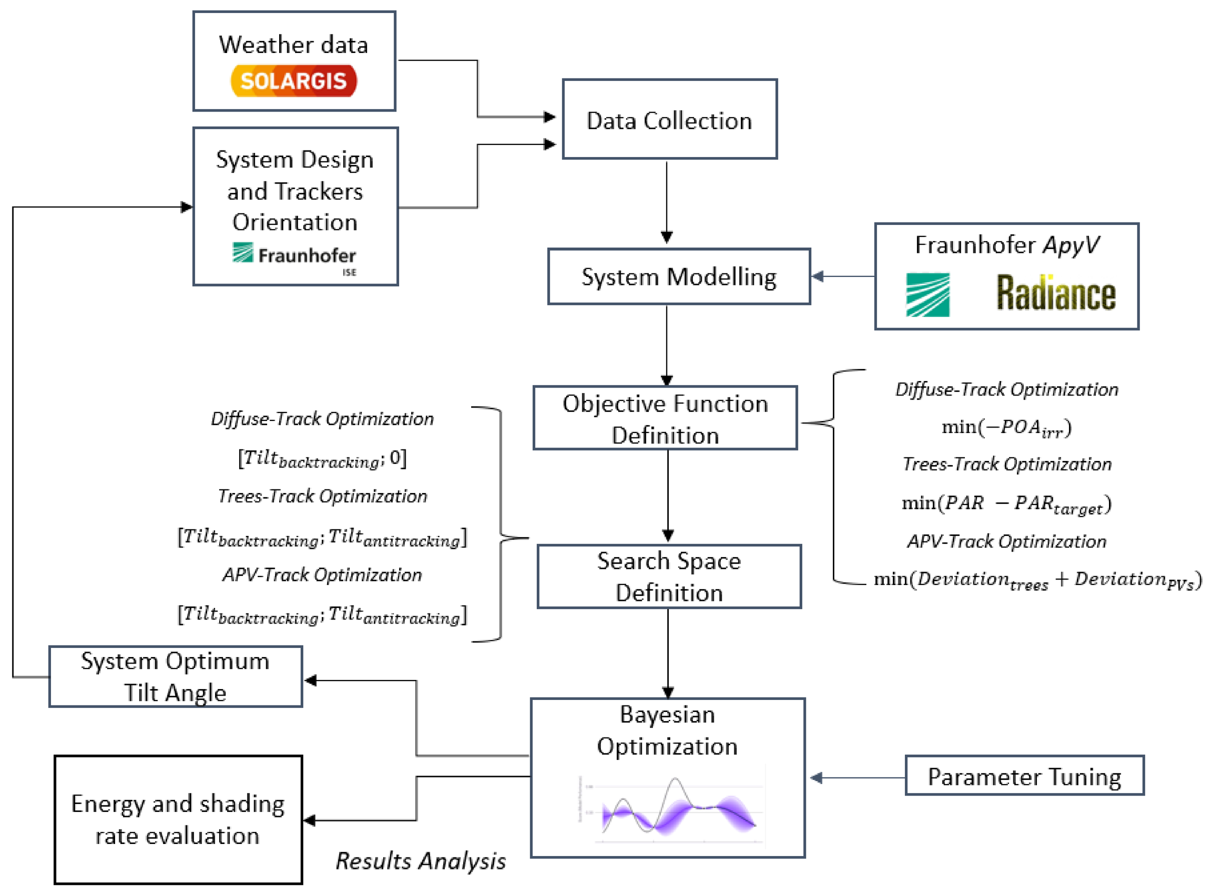
Introduction

- **Agrivoltaic systems** provide an innovative solution to land-use conflicts that often arise between agriculture and energy production.
- **Horizontal single-axis tracking (HSAT) agrivoltaic system** enable effective management of light distribution between solar panels and the underlying crops through innovative control algorithms [2].

Methodology



Results

- Empirically derived **PAR reduction rates** are provided by the agricultural partner, LTZ [3], for the different phases of crop's development.
- Using historical weather data from 1994 to 2014, **absolute PAR targets in W/m²** are established for the trees.

Month	Max PAR reduction [%]	Phase
March	40%	Budding/Sprouting
April	20-30%	Flowering sensitive to shading
May	20-30%	High importance of carbohydrate assimilation during flower formation
Juni	30-35%	Heat reduction for better fruit quality and sunburn protection
July until Mid-August	30-35%	Fruit ripening
Mid-August until September	20-30%	Fruit coloring

Discussion

- This study introduces an innovative approach by incorporating **crop shade sensitivity across various developmental stages** into the optimization process. As more data become available, the methodology can seamlessly adapt to consider variations in intraday shade sensitivity.
- The algorithm employs a straightforward approach, eliminating the need for complex interfaces with crop simulation software.
- The results demonstrate that efficient and sustainable dual land use is achievable through the implementation of a well-managed agrivoltaic system.

References

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