# Analysis of potential of AV in Thuringia

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## WHY AGRIVOLTAICS

In Germany, an expansion target of 22 GW/a has been set to achieve the climate change mitigation goals. The available areas for renewable energy systems are limited: the installation of solar systems on roofs is not sufficient to meet the expansion targets for various reasons, such as the protection of historical monuments, statics and economic viability. On the agricultural side, there is an urgent need for action. Dry soils are the main cause of crop damage in Germany (figure 1). But other weather extremes, such as heavy rainfall events, also pose a threat to food production in Germany. Therefore, agri-photovoltaics offers an opportunity for dual use on one area in order to secure food production and reduce the effects of climate change, as well as to create income security for farmers.

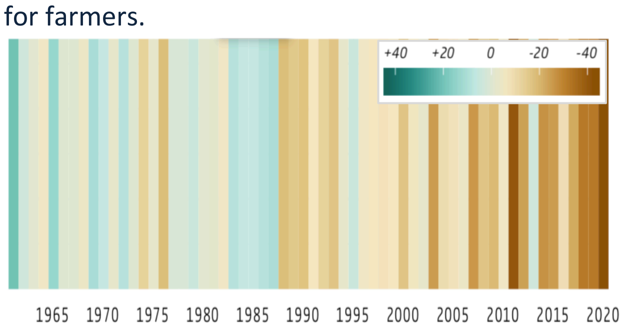


**Figure 1:** „Drying Stripes“ – Deviation of soil moisture unter winter wheat in percent of usable field capacity (reference period: 1961-1990 – april, mai, june).

## STATE OF THE ART

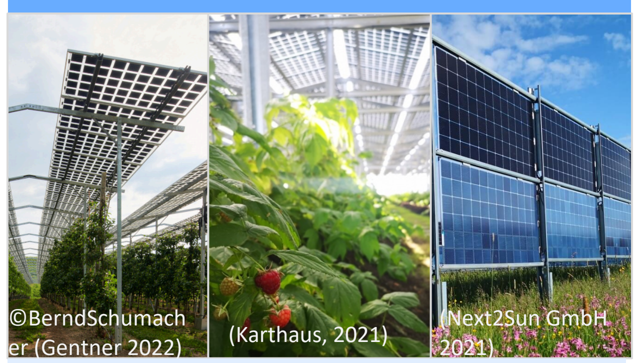


**Figure 2:** a) high elevated, b) low elevated, c) vertical agrivoltaic system.

There are numerous possibilities for adaptation to optimal use for agriculture and energy production. The high-mounted systems have a height of approx. 5 m and the cultivation takes place between the modules, which makes these systems particularly suitable for large agricultural machines. This means that there are hardly any restrictions on cultivation (max. 10% loss of area) (figure 2a). In the case of lightly supported systems (minimum height 2.1 m), the material costs are lower and the protective effect of the crops is maintained (figure 2b). In vertical systems cultivation takes place between the modules. Here there are no height restrictions for machinery and the plants receive a high incidence of light. However, the protective roof effect for the crops is missing (figure 2c).

## AV SYSTEMS


**Figure 3:** a) rope construction, b) wood construction, c) tube panels.

Tracking systems offer the possibility of maximising the electricity yield or photosynthetically active radiation (PAR) for the plants. Optimised light management is possible and higher electricity yields of up to 45%. Rope suspensions are a particularly favourable solution for elevation of AV systems, as the substructure needs to be erected less massively (figure 3a). Wooden constructions do not optimise the function of the AV system, but reduce investment costs and are more sustainable than steel elevations (figure 3b). There are also a variety of innovations in the modules. Semi-transparent modules offer higher light penetration and can thus increase PAR. Bifacial modules also produce electricity from the rear and thus have a higher electricity yield on the same area. Tubular modules are particularly advantageous for optimal water distribution (figure 3c).

## ECONOMICS

Comparing the different systems, it becomes clear that the prices of AV are slightly higher than those of conventional PV plants (figure 5). An increase in the number of implemented AV systems leads to economies of scale and thus decreasing costs. Due to the advantages, AV systems already make sense today to secure the food supply.

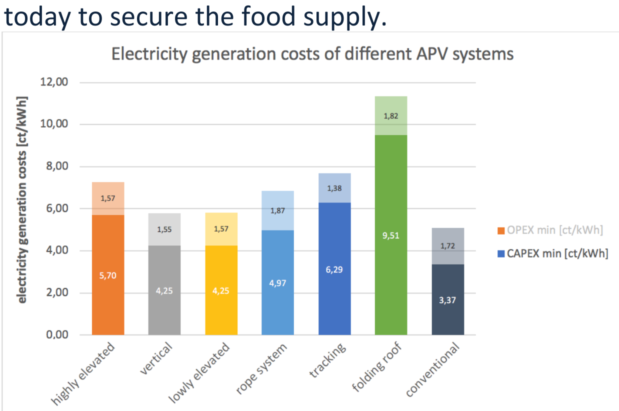


**Figure 5:** Economic comparison of the electricity production costs of different AV systems and conventional PV on one hectare in cents per kWh in Germany (own illustration).

## CASE STUDY - ROPE

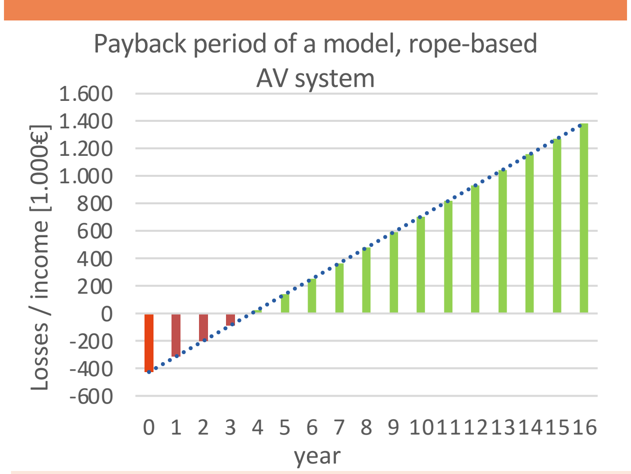


**Figure 6:** Amortisation period Calculation example of a rope-based AV system (own illustration).

A row spacing of 40 m and thus an area output of 530 kWp/ha on one hectare is assumed. Lightweight modules were selected. The specific electricity yield is assumed to be 923 kWh/kWp. On the area of 1 hectare, this would result in an electricity yield of 489,200 kWh/a with electricity purchase costs of 25ct/kWh.

## POTENTIAL THURINGIA

The crops grown in Thuringia are generally suitable for cultivation under AV systems especially in view of the expected, climate-induced yield losses. This results in the following: The area of arable land and permanent crops (agricultural area: **774,830 ha**; arable land: 604,086; permanent crops 2,280 ha, of which fruit crops 1,955 ha; total 606,366 ha) minus the fields in nature reserves (0.2 %) amounts to 605,153 ha; calculated with a production of 700 kWp/ha, this would result in a technical potential of **424 GWp**. Another potential would be the grassland of 168,399 ha (here, restrictions would have to be calculated in further studies, such as extreme slopes and orientation, small areas shaded by forest, etc.), for example with vertical modules and a production of 395 kWp/ha, on which **66.5 GWp** of electricity could be generated. The study recommends the promotion and construction of small and large-scale AV systems in Thuringia in order to realise the high potential of agri-photovoltaics and thus also contribute to improving the income of farmers and municipalities.



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