Agro-Forestry and Photovoltaics: Innovative Production and Utilization of Energy for Autonomous Agricultural Processes

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Abstract

Since the beginning of the solar boom, photovoltaics has expanded to a previously unsuspected extent due to a significant drop in prices. As the area for installation is limited and the occupation of agricultural land for installation is undesirable, experiments have begun with a combination of agricultural production and photovoltaics - agrophotovoltaics. However, a further reduction in the price of photovoltaic components means that even where the installation does not seem to make sense, it is possible today to build a system that finds its use. Such an example can be the installation of modules between trees of agroforestry systems, which are innovative and multifunctional farming managements aimed at adaptation of agriculture to impacts of the climate change.

Keywords: agrovoltaics; agroforestry; agricultural production

INTRODUCTION

While the price of photovoltaic installations in 2010 was around 3,200 EUR / kWp, today's costs can be estimated at around 600 EUR / kWp. Thanks to its easy availability, users who would not have considered it before also became interested in photovoltaics. An interesting concept may be the installation of modules within agroforestry systems, as will be described below.

AGROVOLTAICS AND AGROFORESTRY WITH PHOTOVOLTAICS

Agrovoltaics, or agrophotovoltaics is a term referring to photovoltaics installed on agricultural land without stopping agricultural production. This concept was first described by A. Goetzberger in 1981 [1]. There are basically two concepts used:

- classic orientation of modules on increased construction with larger spacings
- vertical construction

While in the past the rather classic orientation of the modules was used, thanks to the development of bifacial technologies, the vertical construction is starting to catch up with the second group.

Agroforestry systems (ASF) are agricultural or land use system in which trees are grown in combination with conventional agriculture on the same land plot (EU regulation no. 1305/2013). Modern agroforestry systems are considered as one of the promising adaptation and mitigation measures to minimise impacts of the climate change in agriculture [2]. In addition to having a positive effect on the yields of some crops or of quality of their products, this approach also has a positive effect on ecosystem services of agriculture including erosion control, buffering extreme weather (heavy rains, heat waves, strong winds), biodiversity improvement, or carbon (humus) sequestration [3], [4]. Within agroforestry, several planting scheme are applied including silvoarable alley cropping where trees are planted in the form of lines, and therefore it is possible to place photovoltaic modules between them.

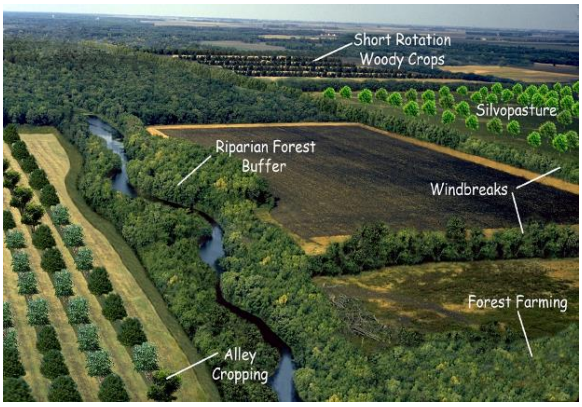

Fig 1: Main types of agroforestry systems USDA, 2010

Although placing modules between trees seems seemingly pointless due to the frequent shielding and minimal performance that such installations can provide compared to standard installations, there are a number of low-power applications where even a small amount of power can be useful. Such applications include, for example:

- post-drying (energy chips from fast-growing woody plants),
- pumping water into watering tanks,
- operation of small agricultural (mobile) facilities (slaughter, milking, etc.),
- charging stations for (micro) electromobility,
- charging stations for telephones and portable devices for e.g. agritourism.

Requirements are being collected and communication with farmers is underway as to whether and what applications they would be interested in.

EXPERIMENTAL SYSTEM AT RILOG

In order to investigate the interactions between the agroforestry system and photovoltaics, an experimental agroforestry-photovoltaic (AGFPV) system of 6.72 kW_p was launched last year at the Silva Tarouca Research Institute for Landscape and Ornamental Gardening (RILOG) complex in Průhonice within the experimental station Michovky (see Fig. 2). This system consists of panels installed on an inclined plane as well as on a vertical structure. Conventional monocrystalline silicon modules, bifacial PERC modules and CIGS modules are installed to compare technologies. This year, the system will be supplemented by bifacial HJT modules Meyer-Burger.

Irradiance and temperature sensors are installed to monitor the parameters of the photovoltaic system, and the performance is monitored via SolarEdge power

Fig. 2: Experimental AGFPV system at RILOG

optimizers. Other monitored parameters include, in addition to the temperature of the modules, the soil temperature around the modules and the growth of crops in comparison with areas without photovoltaics. First results of electricity production are shown on Fig. 3. During year 2021, 381 MWh of energy was produced, which represents energy yield of approx. 570 kWh/kW_p.

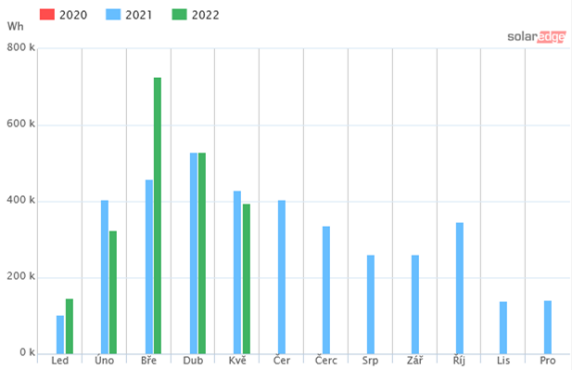

Fig. 3: Production from experimental AGFPV system in Michovky

CONCLUSION

The basic concept of the agroforestry photovoltaic system was described in the article. The first experiments showed about half the yield compared to conventional PV systems. Experiments on the RILOG system will continue in order to determine the appropriate configuration and technology of PV modules in combination with woody plants and the impact on agricultural production.

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