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Original
Agrivoltaic System: a Case Study of PV Production and Olive Cultivation in Southern Italy / Ciocia, A; Enescu, D; Amato, A; Malgaroli, G; Polacco, R; Amico, F; Spertino, F. - ELETTRONICO. - (2022), pp. 1-6. (Intervento presentato al convegno 2022 57th International Universities Power Engineering Conference (UPEC) tenutosi a Istanbul, Turkey nel 30 August 2022 - 02 September 2022) [10.1109/UPEC55022.2022.9917595].

Publisher:
IEEE

Published
DOI:10.1109/UPEC55022.2022.9917595

Agrivoltaic System: a Case Study of PV Production and Olive Cultivation in Southern Italy

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***Abstract* — The double use of the land in the AgriVoltaic (AV) sites allows to "doubly harvest from the sun", increasing the land use exploitation with lower environmental impact. This effect strongly depends on the system configuration for both the PV and agricultural sides. The choice is between a high-density PV module arrangement, with high PV production and low agricultural harvesting, or a highly spaced arrangement with lower PV production. The present work presents a case study in Southern Italy: the simulated PV plant can have two different layouts (rated power of 7.13 MW or 5.68 MW), and each hectare can include the plantation of about 900 Arbequina olive trees.**

Keywords — Agrivoltaics, Agrivoltaic technology, Photovoltaic plant, Crop productivity.

I. INTRODUCTION

The international treaties draw a common path toward carbon neutrality within 2050. The European Green Deal (EGD) [1] allocates more than 59 billion euros for the goal of a "Green revolution and ecological transition". According to this European Union goal, Italy developed the PNRR (*Piano Nazionale di Ripresa e Resilienza*) [2], which is a detailed action plan that permits access to European funds in large part for the ecological transition. The AgriVoltaic (AV) technology is consistent with the goals of both EGD and PNRR. This technology is the coupling of PhotoVoltaic (PV) and crop production, permitting a better land use with respect to the separate PV production and farming. The formulation of feed-in tariffs helps the development of the AV technology to speed up its widespread use.

The AV technology can be developed in different ways, ranging from using fixed PV plants to the use of tracking systems [3]: sun trackers allow the photovoltaic modules to be almost perpendicular to solar irradiance for many hours; in addition, backtracking logic avoids high shadow losses [4]. The best PV configuration depends on different factors, including the land morphology, the type of crops, and the availability of renewable energy sources (in this case, solar irradiation). In particular, the coexistence on the same portion of the territory of both PV structures and crops presents the problem of shadowing. The crop production is negatively affected by the PV modules shadowing. On the other hand, the presence of PV plants leads to a variation of the thermo-climatic parameters, which improves the well-being of the crop in arid environments and decreases the water use [5].

On the agricultural side, the choice of the agronomic species is relevant for PV generation. For instance, planting trees taller than PV structures would affect the electrical production. In general, herbs or small trees are the best crops considered for agrivoltaic purposes. The crops should be easily harvested by agricultural machinery even if they are among or under the PV strings. It has been proved that the selection of the most adequate layout may almost double the land productivity (for the energy system and the crops) with respect to separate PV system and agricultural activity [5].

The present work describes a methodology to design and evaluate the performance of an agrivoltaic system. A case study (the crops consist of an olive tree variety) is discussed showing how the energy generation, the crop production and the financial results are affected by the main characteristics of the AV system. The paper is organized as follows: Section II describes the procedure for the modelling of PV production, the effects of shadows on crops, and financial calculations. Section III presents the case study and the results. Conclusions are in Section IV.

II. MODELLING OF AN AGRIVOLTAIC PLANT

The AgriVoltaic (AV) plants have a double output: the PV energy production, and a seasonal harvest. The analysis of such a plant needs to be divided into two strictly linked flows (Fig. 1), because the layout of the PV plant affects the crops, and vice versa. In the first step of the procedure, the system is defined. The PV technology and the architecture of the PV modules-converters coupling are identified. The selection of the crop variety is made to avoid conflict with the presence of PV modules. The second step is the layout definition, which mainly consists of studying the distances between PV structures and crops; the third step is the shadow analysis with the calculation of the energy and crop losses. Fourth step is the calculation of energy production, while fifth is the financial assessment. Finally, the land saving is calculated.

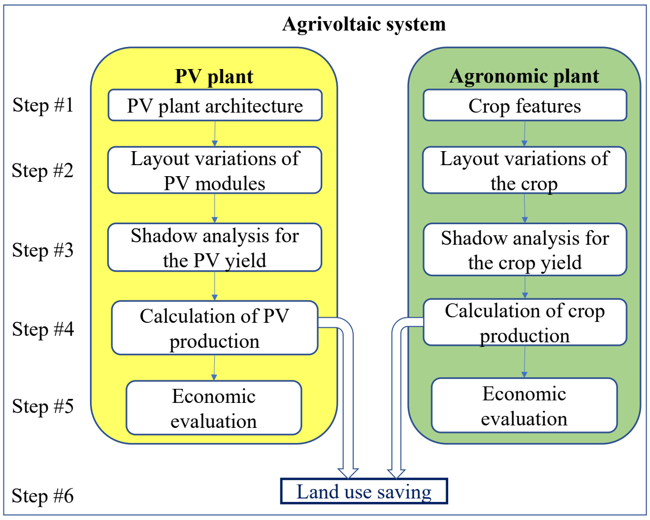

Fig. 1. Procedure for the design of an agrivoltaic plant.

A. Modelling of PV Production

The modelling, sizing, and data analysis of the PV part of the plant has been performed using a commercial software. This software permits the plant productivity calculation with the related shadow analysis throughout a user-friendly interface. The use of the software is organized as follows. Creating a new project starts with the definition of the site location and the download of its meteorological data. Different databases are available, such as PVGIS [6]. The software uses models proposed by [7] and [8] to create hourly profiles of irradiance and temperature. After the download of meteorological data, the architecture of the systems is chosen by importing the datasheets of PV modules and inverters. The software helps the user in the correct coupling of modules and DC/AC converters, obtaining the number of modules per string and the strings per array. The calculation checks the limits in voltage and current that are a function of irradiance and temperature of the selected installation site. The losses such as thermal loss parameters, ohmic losses, and auxiliaries energy needs are defined inserting in the program other information about the plants, such as the lengths and sizes of the cables (the software also supports the sizing of the cables to keep the losses low). The 3D model of the plant is created to calculate the effect of shadows on PV production. For the sake of simplicity, in the present work, a "linear shadowing" has been considered: thus, the losses are proportional to the area of the PV modules affected by shadows.

After analyzing the shadows, the energy production is calculated, simulating with the hourly time step, the conversion of solar radiation into electricity. It can be done by using an equivalent electrical circuit of a PV generator [9]. Actually, the knowledge of the parameters for an equivalent model is required to deeply study and simulate the operation of a PV module in any condition of irradiance and temperature. Indeed, they can permit to determine the current-voltage (*I*-*V*) curve of the PV generators under variable weather conditions. Moreover, these parameters can be fundamental in applications like mismatch studies in complex grid-connected PV systems [10], performance investigation of Maximum Power Point Trackers (MPPTs) under variable weather conditions [11], or reliability studies to reduce the maintenance activities in PV plants [12]. In this context, the most common equivalent circuit is the Single Diode Model (SDM) because it guarantees an optimal compromise between simplicity and high accuracy. This model is described by five parameters [13] that can be determined experimentally. Another common model is the Double Diode Model (DDM), which is preferred in case of partial shading [14]. The parameters of the SDM are the following [15]: the photogenerated current I_{ph}, the saturation current I_0, the diode ideality factor n, the series resistance R_{s} and the shunt resistance R_{sh}. The first term is the current generation of the solar cell, while the second current is a source of thermal losses. The parameter R_{s} quantifies the effects due to the front electrical contacts of the cell: an optimal compromise between efficient electrical contacts and high surface area available for sunlight conversion needs to be reached for PV generators. The leakage currents flowing through the lateral surfaces of the solar cell are estimated by the last term (R_{sh}): it needs to be maximized to ensure the best lateral insulation. The relevant equation of the SDM is the following:

$$I = I_{ph} - I_j - (V + R_s \cdot I)/R_{sh} =$$

$$= I_{ph} - I_0 \cdot \left(e^{\frac{q \cdot (V + R_S \cdot I)}{n \cdot k \cdot T_c}} - 1\right) - (V + R_s \cdot I)/R_{sh} \qquad (1)$$

where q is the charge of the electron ($1.602 \cdot 10^{-19}$ C), k is the Boltzmann constant ($1.38 \cdot 10^{-23}$ J/K), and T_{c} is the cell temperature. The electrical circuit representing the SDM, which is also used in the simulation software, is presented in Fig. 2.

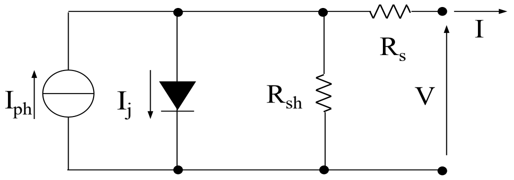

Fig. 2. Equivalent circuit of a PV cell according to SDM.

The main results of the simulation are the calculation of the PV generation, and the productivity (or the number of equivalent hours). The productivity is the ratio between the whole yearly generation and the nominal power of the plant (kWh/kW), being the equivalent number of hours per year in which the plant works at its nominal power. In addition, to define the main sources of losses and, eventually, try to mitigate them, it is useful to have an overview of the conversion process. The most important losses for a PV plant equipped with sun trackers are the following. Due to shadowing from a tracking system to the next one, 4.7% of energy is lost. Another important loss is due to dirt [16] and a loss of 3% can be assumed. In this work, plants with bifacial modules will be analyzed: the knowledge of the albedo and the rear side view factor are required to calculate the production from the rear side of the modules. However, the rear production is much lower, with a contribution of about 10% of the overall production (front and rear sides). At the array level, the *I-V* mismatch effect [17] reduces the power by about 2%. Approximately another 3% is lost due to inverter operation, joule losses and LV/MV transformers [18].

B. Calculation of crop yield in case of shadowing

In order to calculate crop production, the model in [19] is used. The crop production is proportional to the solar ratio R_{GR}, which is the ratio between the irradiance occurring in the agrivoltaic plant and the reference irradiance on the crops without PV modules:

$$\frac{Y_C(AV)}{Y_C(OF)} = m \times R_{GR} + (1 - m) \qquad (2)$$

- $Y_c(AV)$ is the crop yield in the AV plant,
- $Y_c(OF)$ is the On Field (OF) yield for a traditional crop,
- m is a parameter linked to the sensitivity of the crop to the shade; its value is in the range [0 − 1] (when *m* is close to 0, the shadow effects on the crops are negligible).

In the present work, the analysis of the shadow effects on crop production is performed for Arbequina plants, which produce olives and olive oil. This variety of olives, native from Spain, are suitable for intensive and super-intensive cultivation. Moreover, the Arbequina exhibits resistance to both drought and temperatures below zero. The growth of these plants goes from the first two years, when the plant does not produce fruits, to the 6th year, when the complete production is reached. The production rises from 3rd to the 6th year; then, it is constant for all the life of the tree. The sizes of the tree are 2.5÷3.5 m in width, and ≈6 m in height (not pruned) [20]. For the application described in this analysis, the tree would be pruned at 2÷2.5 m, avoiding any shadows on the PV modules since the modules are 3 m above the ground. During the harvesting phase, the machine moves between the strings passing on the olive trees through the brushes located in the lower part of the vehicle, as shown in Fig. 3.

Fig. 3. Example of harvesting machine [21].

III. FINANCIAL ANALYSIS OF AN AGRIVOLTAIC SYSTEM

The financial analysis of an agrivoltaic system can be divided into the analysis of the costs and revenues of the PV plant, and of the agriculture activity. The common cost is only related to the purchase or lease of land. In the following subparagraphs, the costs are presented and discussed.

A. Cost analysis of the PV plant

Regarding the investment in the PV plant, Table I shows that the costs for a single-axis PV tracking system (structure and motors/actuators) is in the range 130÷150 k€/MW. The costs in Table I refers to a nominal power of several MW: the cost of the PV modules (200÷300 k€/MW) is less than half the cost of the whole system; it refers to monocrystalline silicon modules with bifacial technology and efficiency ≈22%. Considering the other main costs, the total investment for the PV system is in the range 450÷615 k€/MW. During the operation of the plant, an overall maintenance cost of about 15 k€/MW is considered for the PV system. This cost includes different maintenance operations: e.g., the repairing of the inverters [22], the repairing of the tracking systems, and the check and cleaning of the modules [23].

TABLE I. INVESTMENT COST OF THE PV TRACKING SYSTEM

PV modules	200÷300	k€/MW
AC/DC converter	30÷50	
Installation of the plant	10÷15	
Tracking systems	130÷150	
Masonry work	80÷100	
Total cost	450÷615	

B. Feed-in tariffs and selling price for the PV production

The Italian law 04/07/2019 [24] divides the renewable energy plants that can access the feed-in tariffs into categories based on the technology, the renewable source and the type of investment (e.g., new installation or repowering). The incentives are paid for the electricity produced and injected into the grid regarding the newly built PV plants. In case of storage systems, incentive is calculated as the lowest value between the net production (equal to the gross production reduced by the consumption of auxiliary services, line and transformation losses), and the electricity actually injected into the network, measured with the exchange meter.

There are two different feed-in tariff mechanisms, depending on the nominal power of the system. Plants with rated power ≤250 kW can access an all-inclusive tariff (in Italian, "*tariffa omnicomprensiva*") paid by the Italian Energy Services Manager [25][26]. Plants with rated power >250 kW can access only a feed-in tariff calculated as a function of the local electricity price and the results of auctions in which the various producers participate [27]. In such a condition, the sale of electricity is up to 20 €/MWh in Northern and Central Italy, while in Southern Italy and the islands, it is about 13 €/MWh. In both cases, the value of the feed-in tariffs is constant, and their duration is 20 years.

Regarding the electricity selling price, an average value of about 50 €/MWh can be considered [28].

C. Cost analysis and revenues from the agricultural activity

The agronomic activity is based on the cultivation of the olive tree Arbequina, whose features have been discussed in the previous paragraph. The financial analysis of this activity is calculated by considering the following cost contributions: soil preparation, basic fertilization, trees planting, irrigation system, labor and implementation, and plants costs. The overall cost per hectare is in the range of 4÷5 k€/ha/year. It is possible to produce olives and oil from Arbequina trees. The production costs for each fully developed tree are 1.5÷2.5 €/tree for olive production and 3.5÷4.5 €/tree in case of oil production.

TABLE II. YEARLY REVENUE FOR EACH TREE

Year	III	IV	V	VI
Olive [€/tree]	2.8÷4.6	3.2÷5.6	4.3÷6.5	5.5÷7.8
Oil [€/tree]	3.8÷5.8	6.3÷8.3	7.6÷9.6	8.7÷10.7

The revenues for the crop are calculated on the basis of the commercial prices for olives and oil, which are respectively ≈0.5 €/kg and 5.5 €/liter. The revenue analysis is shown in Table II from the third to the sixth year, which is the time required by the tree to reach the full production (in the first two years of life, the plants are not productive).

IV. CASE STUDY

The agrivoltaic plant presented in this analysis is located in Southern Italy. The AV system for the photovoltaic part is equipped with North-South axis sun trackers with a height β=3 m above ground. Fig. 4 shows a scheme of the arrangement for PV tracking system and trees in alternating rows. In these structures, the modules in horizontal position have a height from the ground of 3 m. At their maximum inclination, the distance of the lower edge from the ground is about 2 m, because the length α of the modules is about 2.5 m. The distance from a tracker to the next one δ depends on the system configuration, and it will be discussed in the next subparagraphs. As previously mentioned, the crop chosen for this application is the olive tree variety *Arbequina*, which is adequate for intensive cultivation. These trees need a pruner to cut the branches and keep their size γ lower than 2 m (Fig. 4). The height plant control allows easy work of the harvesting machine and makes shadows on the PV system negligible.

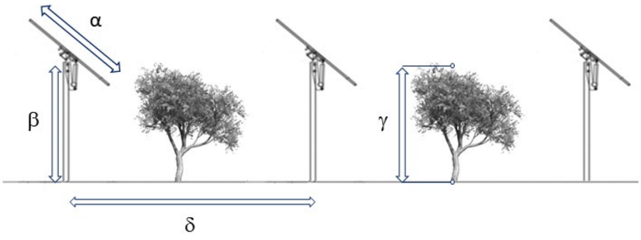

Fig. 4. Distances between trees and PV tracking systems.

A. Description of the PV plant

In this work, an area of 10 hectares is considered for the installation of an agrivoltaic system. Two different configurations are compared: each configuration includes a multimegawatt PV plant and olive trees, where the only difference is the distance δ between two trackers. In configuration #A (CONF#A), the distance δ is 6 m, while in CONF#B, the distance δ is 7.5 m. These numbers are calculated to guarantee the minimum safe distance required by the harvesting machine to work on the tree lines. As a result of the different distances, the nominal power of the plants is 7.13 MW and 5.68 MW, respectively. Both configurations use centralized inverters with a skid system, including the MV switchgear, transformers, and low voltage cabinets to collect power from the inverters.

In CONF#A, the nominal power of the generator is 7.13 MW. The number of modules is 11688, and each string includes 24 series-connected modules, with a nominal voltage of 43 V per module (total nominal voltage of 1032 V). There are 301 strings in parallel connected to an inverter with a rated power of 4200 kW, and 186 strings in parallel for the second one with rated power of 2500 kW. In CONF#B the nominal power of the generator is 5.68 MW. There are 9312 modules, each string has 24 modules, and there are 194 strings for both the two converters (each one with nominal power of 2750 kW). The PV field modelled in CONF#A produces 13.7 GWh/year, while the production in CONF#B is 11.2 GWh/year. On a yearly basis, the performance ratio for the two configurations is 0.896 and 0.904, respectively.

B. *Analysis of the crop production*

The trees used in this AV application are arranged in lines, side by side with the PV strings. In a hectare, there are 83 rows of plants of different lengths; each olive tree is 1.2 m far from the following one, and the trunks are at least 2.5 m from the edges of the PV modules.

Fig. 5. Picture of an Arbequina field [29]

The model described in Subsection II.B was applied to the olive and oil production from Arbequina trees (Fig.5): the crop production has been evaluated considering two different shading conditions, depending on distances among PV rows. The 6 m layout (CONF#A) takes into account the inclination of the trackers to let the harvester go across the lines, forcing the plant to a day of low electricity production. On the other hand, the 7.5 m layout (CONF#B) allows the harvesting without forcing any PV tracker movement. Obviously, keeping longer distances leads to an overall lower installed PV nominal power and related energy production. Table III shows the olive and olive oil production per unit of hectare as a function of the configuration and of the shadowing sensitivity.

TABLE III. OLIVE AND OLIVE OIL PRODUCTION PER UNIT OF HECTARE AS A FUNCTION OF CONFIGURATION AND SHADOWING SENSITIVITY

	Configuration	m=0	m=0.5	m=1
Olive tons (tons)	CONF#A	92	68	44
	CONF#B	92	72	52
Oil (liters)	CONF#A	15000	10000	7000
	CONF#B	15000	11000	9000

When the shading sensitivity m is zero, there are no shadows; thus, the production is the same in both configurations. The analyzed cases are the following: m=0 (no sensitivity to shadowing), m=0.5 (average sensitivity to shadowing), and m=1 (maximum sensitivity to shadowing). Both CONF#A and CONF#B exhibit a linearly decreasing trend for olive production. The reference production at m=0 is about 92 tons for each configuration; it is the same in both configurations, because the shadows from PV modules on the trees lead to a negligible effect on the crop. With m=0.5, the olive production in CONF#A decreases by 26%; if m=1, production is halved with respect to the case without shadowing (m=0). With a longer distance among rows (CONF#B) and m=0.5, the production is slightly higher (relative difference is ≈6%) with respect to CONF#A. Finally, with m=1, CONF#B production is 18% higher (relative difference). In the case of oil production (for the sake of clarity, it is not represented in Fig. 6), the shadowing has a slightly non-linear effect. In CONF#A, an intermediate shadowing sensitivity m=0.5 leads to a relative lower production (-9%) with respect to CONF#B. Finally, with m=1, CONF#B production is 29% higher.

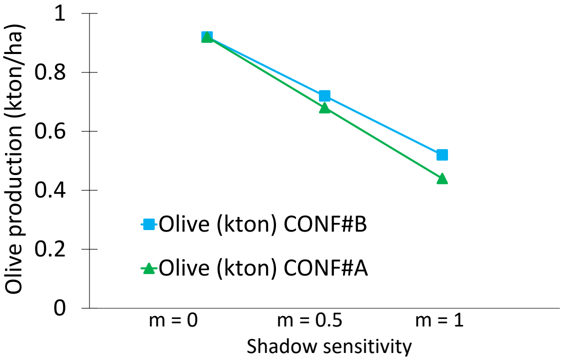

Fig. 6. Effect of shadows on olive production.

C. *Analysis of energy production*

The results of the simulations show that the system can produce a yearly energy of 13.7 GWh in CONF#A, and 11.2 GWh in CONF#B. The details of the production and losses in CONF#A are shown in Fig. 7. An estimation of the expected efficiency for the PV plant can be given by the performance ratio (PR), calculated as described in [30]:

$$PR = \frac{E_{AC}}{H_g \cdot S_{PV} \cdot \eta_{STC}} \qquad (3)$$

where E_{AC} is the electricity production (kWh) in the period under analysis (i.e., one year), H_g is the irradiation on the plane of array in the same period (kWh/m^2), S_{PV} is the total surface of the PV generator, and η_{STC} is the nominal efficiency of the modules at Standard Test Condition [31]. As shown in Table IV, the yearly PR for CONF#A and #B is 0.896 and 0.904, respectively.

TABLE IV. COMPARISON OF MONTHLY ENERGY PRODUCTIONS AND PR VALUES IN CONF#A AND CONF#B

	CONF#A		CONF#B	
	E_{AC} (GWh)	*PR*	E_{AC} (GWh)	*PR*
January	0.567	0.921	0.466	0.933
February	0.798	0.927	0.660	0.935
March	0.935	0.927	0.767	0.937
April	1.402	0.911	1.147	0.918
May	1.656	0.898	1.349	0.906
June	1.735	0.879	1.412	0.887
July	1.786	0.872	1.457	0.880
August	1.511	0.872	1.240	0.879
September	1.278	0.890	1.048	0.898
October	0.854	0.905	0.701	0.916
November	0.642	0.907	0.532	0.916
December	0.564	0.912	0.469	0.923
Year	**13.73**	**0.896**	**11.25**	**0.904**

Obviously, the energy production follows the usual trend with the highest values in summer. The differences in energy values are due to the different rated capacity of the plants.

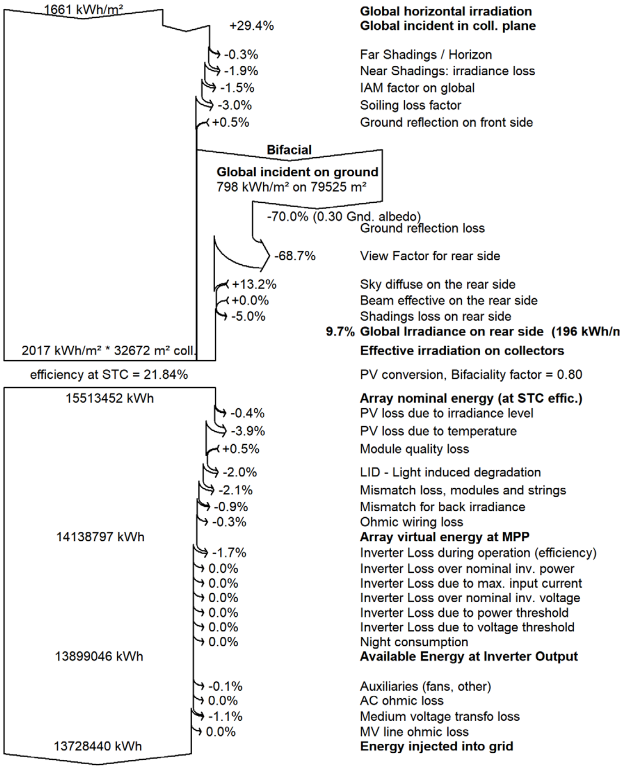

Fig. 7. Calculation of production and losses for CONF#A.

D. Financial analysis

For these two configurations, a cash flow analysis for both the PV energy and crop productions has been performed. The Net Present Value (*NPV*) for CONF#A is about 10.4 M€, and about 5.4 M€ for CONF#B after 20 years. The payback time is similar for both configurations: the investment is repaid in 5.3 years for CONF#A and 6.2 years for CONF#B. The Return On Investment (*ROI*) is 276.5% and the Internal Rate of Return (*IRR*) is ≈21% for CONF#A, while for CONF#B the *ROI* is 168.7% and the *IRR* is ≈15%. The Levelized Cost of Electricity (*LCOE*) is estimated 0.012 €/kWh for CONF#A and 0.017 €/kWh for CONF#B.

For the agronomic part of the plant, the yearly incomes have been considered on three levels of sensitivity to shadowing. As the shadowing sensitivity increases, the agronomic output decreases. The economic output is calculated both for olive and oil selling, considering the financial data described in the previous paragraphs. When the sensitivity parameter is set to 0, the global revenue is 29 k€/year for olives and 50 k€/year for olive oil. These revenues are the same in the two configurations since shadows have no effect on the crops. If an average sensitivity is set, the profit is 12 k€/year for the olives and 29 k€/year for the oil in CONF#B, while for CONF#A the values are almost the same for the olives and about 2% less than CONF#B for the oil. When the sensitivity is maximum, the effect of shadowing on the profit is high: the incomes for CONF#B are less than 1 k€/year for the olives and 8 k€/year for olive oil. In CONF#A with maximum shadow sensitivity, the incomes are 65% less than in CONF#B for the olives and 13% less for the oil. The *ROI* values after 20 years are presented in Table V.

TABLE V. COMPARISON OF ROI VALUES IN CONF#A AND CONF#B

	Olive production		Oil production	
	CONF#A	CONF#B	CONF#A	CONF#B
$m = 0$	1168%	1168%	2028%	2028%
$m = 0.5$	497%	590%	1153%	1319%
$m = 1$	12%	197%	277%	611%

E. Land use saving due to agrivoltaic concept

The agrivoltaic technology allows to better exploit the available land, providing the possibility to doubly harvest from the sun. The land saving has been evaluated: as indicated in [32], the Land Equivalent Ratio (*LER*) can be computed. It is a dimensionless parameter used in literature to evaluate the performance of AV farms:

$$LER = \frac{Y_{el}(AV)}{Y_{el}(PV)} + \frac{Y_c(AV)}{Y_c(OF)} \tag{4}$$

where $Y_{el}(AV)$ is the estimated annual electricity production per hectare (GWh/year/ha) from the simulated agrivoltaic system, and $Y_{el}(PV)$ is the estimated annual electricity production from a traditional PV plant (GWh/year/ha). $Y_c(AV)$ is the estimated crop production in the AV system, while $Y_c(OF)$ is the estimated crop production in a traditional field.

In the present work, the traditional PV generator used as reference has the same tracking structure as the AV systems, but the rows are installed with a minimal distance of 5 m. Its annual production is 1.6 GWh/year/ha; regarding crop production, a traditional field produces 17 ton/ha of olive oil from intensive cultivation of about 1700 trees. Thus, in the case of CONF#A and the production of olive oil, the calculations are shown in (4), and the resulting $LER_{\mathrm{CONF\#A,olive}}=1.341$. Thus, the saved land is 0.341 ha per hectare of the agrivoltaic system.

$$LER_{\ CONF\#A,olive} = \frac{1.3\ GWh/year/ha}{1.6\ GWh/year/ha} + \frac{9\ ton/ha}{17\ ton/ha}$$

$$LER_{\ CONF\#A,olive} = 0.813 + 0.529 = 1.341 \tag{5}$$

The results for the olive and electricity production are finally shown in Table VI.

TABLE VI. LAND SAVING CALCULATION FOR AGRIVOLTAIC PLANT WITH OLIVE PRODUCTION

	Olive production			
	Only PV	Only Crop	Agrivoltaic	
			CONF#A	CONF#B
Energy [GWh/year]	1.6	-	1.3	1.0
Crop [tons]	-	17	9	9
LER	-	-	1.34	1.2
Land Saving			0.34	0.2

The land saving is dimensionless because it is the number of hectares of land saved for each hectare used for the agrivoltaic plant. In conclusion, in olive production (CONF#A), the whole extension of the simulated and analyzed agrivoltaic plant is 10 ha, and the whole land saving is estimated ≈3.4 hectares. In case of olive oil production, the land saving is about the same.

V. CONCLUSIONS

This paper presents the simulation and analysis of the production of an agrivoltaic plant in Southern Italy to generate PV energy and implement an intensive olive cultivation. The goal of this kind of plant is land saving: thus, it may meet the needs of countries with high energy demand and low available areas (e.g., Italy). For both energy and crop production, the models have taken into account the effect of shadows. By changing the mutual distance among crops and PV systems, different plant configurations were created, and a sensitivity analysis was carried out, with the comparison on the productions. An economic analysis has been performed on both AV energy and crop productions to evaluate the economic effectiveness of the system in the different configurations. Finally, land use savings have been estimated with respect to conventional PV plants and plantation. The simulations show that the combined PV energy and crop production is possible, with a noticeable land saving. Indeed, in this case study, for each hectare of terrain used for the agrivoltaic plant, 0.34 ha is saved. In conclusion, this work demonstrates that there are cases in which agrivoltaic technology works well: crop production is not omitted, the cost-effectiveness of investment is preserved, and a considerable amount of land can be saved for other purposes.

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