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## Project Result 1

# WP1 – Analysis of agrivoltaics in Italy and Greece

**Description:** Comprehensive analysis of agrivoltaics in Italy and Greece, combining desk research, stakeholder interviews, and case study presentations

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**Authors:** Ioanna Liosi, Mauro Donnini

**Design/layout:** Ioanna Liosi

## AGRI4ENERGY partners

ASSISTAL Formazione e Servizi s.r.l.

Via Rubicone 9 | 00198 Rome (Italy)



EUDITI – Energy and Environmental Design LTD

Odos Therianou 11 | 11473 Athina (Greece)



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**Description:** The first activity focuses on the identification of the contents on which the training pills will focus. The aim is to identify and explore all the relevant aspects of the use of this technology that should be known by both installed of photovoltaics and agricultural entrepreneurs.



## Executive Summary

This executive summary presents the results of Work Package 1 (WP1) of the AGRI4ENERGY project, which examined the current state of agrivoltaics (agri-PV) in Italy and Greece. The aim of WP1 was to define the content areas that will form the basis of the project's training pills, which will be produced in subsequent activities and made available to photovoltaic installers and agricultural entrepreneurs. To achieve this aim, the activity combined three approaches: desk research on existing scientific literature, structured interviews with a wide variety of stakeholders in the field, and the analysis of case studies.

Agrivoltaics is an emerging technology that enables the dual use of land for both energy production through photovoltaic (PV) panels and agricultural activity. This approach has attracted considerable interest across Europe as a way to balance renewable energy targets with food security and sustainable land management. In Mediterranean countries such as Italy and Greece, where agricultural land is both economically and culturally important, the potential of agrivoltaics is particularly significant. At the same time, challenges remain in terms of legislation, financing, technological adaptation, and farmer acceptance.

This study is enriched with interviews from Italian and Greek stakeholders, such as EF Solare, GSE, ENEA for Italy and HELAPCO, National Agricultural University from Greece, to allow for a more complete picture of both national contexts. The findings provide the foundation for the design of training pills that are directly responsive to the needs of the target groups.

In terms of legislative context, at the European Union level, agrivoltaics are consistent with the broader goals of the **European Green Deal**, which aims for climate neutrality by 2050, and the **EU Climate Law**, which enshrines these targets in legislation. The **Renewable Energy Directive (RED II)** sets binding targets for renewable energy deployment, and the **Common Agricultural Policy (CAP)** emphasizes the integration of sustainability, biodiversity protection, and innovation in farming.

In **Greece**, the legislative framework for agrivoltaics remains incomplete. Laws such as **4414/2016** and **5087/2024** establish general guidelines for renewable energy projects, but do not yet provide a clear definition of agrivoltaics, nor do they set technical standards or specific adoption targets. This regulatory gap creates significant uncertainty for farmers and investors. The National Energy and Climate Plan (NECP) recognizes the potential role of agrivoltaics, but concrete measures are still lacking. Stakeholders interviewed in Greece stressed that this absence of a legal framework makes it difficult for the sector to grow beyond experimental or small-scale projects.

In **Italy**, by contrast, agrivoltaics has been integrated more clearly into both national and regional policy. The "**Decreto Agrivoltaico**" (2024) established incentives for **advanced agrivoltaic systems**, defined as systems that elevate panels and allow for mechanization and agricultural continuity. The "**Decreto Legge Agricoltura**" confirmed that conventional ground-mounted PV on agricultural land is banned, but that advanced agrivoltaics are explicitly allowed and supported. In addition, the **National Recovery and Resilience Plan (PNRR)** allocates more than **€1 billion** to the installation of over **1 GW** of advanced agrivoltaics. Regional authorities in areas such as Puglia and Sicily have also developed their own programs, creating a relatively predictable environment for investment and deployment.

Regarding financing of agrivoltaics, the high capital costs associated with the technology mean that financing methods and incentives play a crucial role in determining adoption. Both countries can draw on European instruments such as CAP funding, RRF/PNRR allocations, and Rural Development Programs. These schemes provide grants and subsidies that can be directed towards agrivoltaics projects.

In **Greece**, subsidies can cover 30–60% of eligible costs, and there are additional fiscal measures such as reduced VAT and accelerated depreciation. Some banks offer “green loans”. However, stakeholders emphasized that the implementation of these schemes is often **bureaucratically complex**, making it difficult for small and medium-sized farmers to use this technology. Moreover, the lack of a clear national strategy for agrivoltaics reduces confidence among both investors and farmers.

In **Italy**, the situation is more structured. The PNRR and related programs provide targeted resources for advanced agri-PV, while fiscal incentives and regional schemes complement national support. Italian stakeholders highlighted the importance of **predictability and stability** in financial support. EF Solare, for example, noted that medium-term price signals, streamlined permitting, and clear eligibility criteria are essential for bankability. Despite these advantages, Italy still faces bottlenecks, particularly in relation to **permitting procedures and grid connection queues**, which slow down project implementation.

Both in Greece and Italy, stakeholders noted that **social acceptance** can be a financial risk factor. Local resistance to large-scale projects can delay or block development, reinforcing the need for early community engagement and transparent communication about agricultural co-benefits.

From a technological point of view, agrivoltaic systems can be deployed in several different forms, each with strengths and limitations.

1. **Stilt-mounted arrays** raise solar panels above the ground to allow the continuation of crop cultivation and mechanization beneath.
2. **Greenhouse-integrated PV systems** make use of semi-transparent or organic PV materials, providing controlled microclimates alongside energy generation.
3. **Ground-mounted inter-row systems** position panels between rows of crops, a less costly approach but one that restricts mechanization and crop diversity.
4. **Dynamic or tracking systems** allow panels to move in response to solar and crop requirements, optimizing shading and light exposure but adding cost and maintenance requirements.

Design factors such as shading, spacing, orientation, and irrigation integration are central to system performance. Evidence from Mediterranean contexts suggests that **moderate shading can be beneficial**, reducing irrigation demand, protecting crops from excessive heat, and in some cases improving product quality. However, excessive shading reduces yields, particularly for light-demanding crops.

The Italian interviews enriched this picture. **ENEA** highlighted the role of advanced monitoring and control systems, including AI, IoT, and PAR-aware trackers, in balancing agricultural and energy outcomes. **EF Solare** emphasized the need for co-design with farmers, the use of digital modeling tools to optimize shading and spatial layouts, and the monitoring of both agronomic and electrical performance to continuously refine system operation. In Greece, **Brite Solar** stressed the potential of semi-transparent panels for both greenhouses and open fields, but warned that tracking systems may prioritize solar output at the expense of crop needs if not carefully configured.

Another important factor relating with agrivoltaics is crop suitability and the agricultural impact. Specifically, not all crops are equally suited to agrivoltaics. The data indicate a range:

- **Shade-benefiting crops**, such as lettuce, leafy greens, and berries, often perform better under partial shading, especially in hot and dry conditions.

- **Shade-tolerant crops**, including grapes and olives, can adapt with only moderate yield reduction and may experience improved quality and reduced water stress.
- **Shade-sensitive crops**, particularly cereals, are less compatible due to their high light requirements.

Professor **Stefano Amaducci** from the University of Piacenza highlighted that water availability and summer heat strongly influence crop responses. Even crops typically considered light-demanding may benefit from shading under Mediterranean summer conditions with limited irrigation. He also emphasized the importance of mechanization and harvest logistics in determining crop suitability.

Beyond crops, livestock integration is another promising avenue. Grazing sheep beneath solar panels has been shown to reduce vegetation management costs, maintain agricultural use of the land, and improve animal welfare through shading. The large-scale Pezouliotika project in Greece demonstrates the practical viability of this approach.

The interviews conducted in Italy and Greece provided valuable insights beyond those found in the literature.

- **Researchers** stressed that maintaining agricultural productivity must remain the top priority. They emphasized the importance of crop-specific design and the need for training and pilot projects.
- **Industry representatives**, such as EF Solare, Brite Solar, and Geothermiki, demonstrated technological innovations but highlighted cost and regulatory challenges.
- **Farmers**, such as the Oreines Fyteies Gkosi cooperative, reported tangible benefits from agri-PV systems in terms of reduced costs and improved product quality, but pointed to financing and regulatory clarity as prerequisites for wider adoption.
- **Institutional actors**, including GSE in Italy and HELAPCO in Greece, highlighted the regulatory context, with Italy moving ahead with concrete frameworks and Greece still lacking a comprehensive legal foundation.

These perspectives confirm that while technological potential is clear, adoption is highly dependent on financial, regulatory, and social conditions.

The analysis of available case studies also provided knowledge and information that was not found in the literature alone. Several case studies illustrate the practical application of agrivoltaics:

1. The **Tsantali Vineyard** in Greece integrated semi-transparent panels that reduced grape heat stress, conserved water, and generated renewable energy, highlighting the potential of agri-PV in viticulture.
2. The **Pezouliotika Solar Plant** combined a 50 MW PV installation with sheep grazing, demonstrating large-scale dual land use.
3. The **Thermi Autonomous Greenhouse** used organic PV to create the world's first fully energy-autonomous greenhouse, with trials reporting yield increases of up to 30% in hydroponic tomato cultivation.
4. In **Italy**, pilot projects in vineyards and orchards demonstrated scalability and integration into regional and national policy frameworks, showing that large-scale deployment is possible without compromising crop yields when systems are carefully designed.

The comparison between Greece and Italy highlights different stages of development.

In **Greece**, agrivoltaics remain at an early stage. Pilot projects demonstrate strong potential, but adoption is hindered by fragmented legislation, small farm sizes, and complex administrative procedures. While subsidies and financing tools exist, their impact is reduced by bureaucratic hurdles and uncertainty. Stakeholders express enthusiasm but remain cautious without clearer rules and incentives.

In **Italy**, agrivoltaics are more advanced. National and regional policies provide explicit support, including incentives and funding for advanced systems. Large-scale demonstration projects are underway, supported by a relatively mature regulatory framework. Nonetheless, challenges remain in terms of permitting, grid connection, and social acceptance.

To conclude, agrivoltaics offer a **triple benefit**: renewable energy generation, improved agricultural resilience, and additional income opportunities for farmers. However, the implementation of such projects requires targeted actions at both national and European levels.

Some recommendations include:

- Establishing clear definitions, technical standards, and adoption targets for agrivoltaics.
- Strengthening financial incentives, ensuring predictability, and simplifying administrative procedures.
- Expanding pilot projects and demonstration farms adapted to regional contexts.
- Providing training for farmers, installers, and policymakers.
- Encouraging co-design approaches to ensure that agricultural productivity remains central.
- Enhancing community engagement to address concerns around landscape and land use.

Italy demonstrates how structured policies and targeted funding can accelerate adoption, while Greece shows the barriers that persist in the absence of regulatory clarity and effective incentives.