Agrivoltaics checklist

Who is this checklist for?

This checklist is primarily for European farmers and their advisors who have an interest in generating energy through the use of agrivoltaics on their farms.

What is the best way to use this checklist?

This checklist specifically focuses on agrivoltaics and generating energy using solar panels on farmland in combination with arable and horticultural crops. The focus is on integration. It aims to get you thinking about all the aspects you need to consider.

Work through the sections that are relevant for your farm. You could also look at the Renewable Energy checklist, bringing together general considerations for producing renewable energy on farm, and the Biogas checklist which considers the production of biogas (mainly from crop residues). These form part of a Transition Tool which will help you consider all the factors around generating renewable energy on farm.

What it is not: This checklist is not a replacement for a professional feasibility study, it will not tell you if generating renewable energy on your farm is financially viable or possible, but it will help you to consider your options and think about whether it could work on your farm. Having made the decision to progress further you will need to explore all of these items in more depth, for example through a feasibility study for your farm or working with a renewable energy company.

What do we mean by the term agrivoltaics?

Agrivoltaics is the combining of solar panels to generate electricity with agriculture – arable, horticulture or livestock. Agrivoltaic systems are designed and built to enable farming and producing food to occur simultaneously with energy production. These systems differ from conventional solar farms in which electricity is usually the sole output.



In the checklist we look at:

- What – aspects need to be considered?

- Why – do they need be considered?
- Where – you can find information or advice

There are links to resources, organisations and projects where you could get support and more in-depth information, you could also take the free online course *Integrating food and energy production on farmland* for more about integrated farming systems and renewable energy. Other information and websites are available from Value4Farm partners, national governments, European Union or European Commission, EU funded projects, research projects or commercial companies.

Please note: Links are provided for information purposes and are not a recommendation for any companies or products linked to. Links to companies who are not Value4Farm partners are marked with "**".

- Links may be to information, services, tools etc. that may be free to access and use, require payment or require a subscription, wherever possible we have tried to make sure resources and information sources are open access / freely available.
- Information linked to may be general, or country or EU specific. For information specific to your own country or region you may need to do more searching.

You will find crossovers between the checklist sections, for example, the crops you grow will impact on the type of panels you may wish to use and how they are installed. The types of panels and their configuration in an orchard will be different to the configuration with arable crops or livestock to support access and maximise both yields and light capture by panels.

The checklist is divided into five main sections of factors to consider:

- Economic – Costs; Grants; Incomes; Partnerships; Risks
- Environmental – Crops; Location; Risks; Siting
- Governance – Certification; Regulations
- Social – Planning; Societal
- Technical – Energy; Installation; Panels

Economic:

What	Why	Where
Costs	**Costs of evaluating, installing and maintaining the technology**	
	Depending on how planning and construction is financed and if you are working in a partnership, you might need to consider the cost of: • Feasibility studies and input from advisors • Installation and building • Maintenance and upgrading or updating technology • Time needed for labour to run, service and maintain the technology • Connecting to national networks if energy is used off-farm	Partial budgeting tool and summary of possible costs on the *Value4Farm DST webpage* General farm budgeting - *Forecasting or budgeting farm finances* *InSPIRE Financial Calculator (USA)*
Grants	**Grants, subsidies and other types of funding could be available from a range of sources to support installing and running agrivoltaic systems**	
	Funding for agrivoltaics can be variable and location or project specific: • Grants may be available for e.g.: Feasibility studies, construction, producing renewable energy • Funding could be available from local, regional, and national governments, and organisations such as the EU or FAO depending on your proposal or location • Grants could be dependent on the size of the proposed agrivoltaics system, location (e.g. close to protected areas) and region or country. • Agrivoltaics (as opposed to solar farms or parks) could mean agricultural support payments could still be claimed. Land use rules and regulations for your location would need to be explored.	*European Commission Climate Action Innovation Fund* *European Commission Climate Action Modernisation Fund* *European Commission - Finance and the Green Deal*

Incomes	**Incomes, and changes to farm incomes and costs also need to be considered**	
	Agrivoltaics could lead to increases and decreases in incomes, for example: • Income from energy exporting / selling energy • Income from leasing land if you form a partnership with a renewable energy company • Reduction in on-farm energy costs There could also be changes in income from crop yields, e.g. increased or decreased yields from the impact of solar panel shading or sheltering, or different crops (e.g. to better fit with solar panels) affecting yield income.	Partial budgeting tool on the *Value4Farm DST webpage* *InSPIRE Financial Calculator (USA)* Summary of possible incomes on the *Value4Farm Decision Support Tool webpage* Agrivoltaics and crop selection on the *Value4Farm DST webpage*
Partnerships	**Partnerships with, for example, renewable energy companies or neighbouring farms could support building and maintaining the technology**	
	Partnerships could take a range of forms: • Leasing land to a company who will install, manage and maintain the agrivoltaic systems while you use the land to grow crops. • Partnership with a renewable energy company to build and maintain technology which you own. • Partnerships and co-operatives with other local farms to share technology or farm equipment A partnership that works well for your farm and farm business could depend on: • Type and size of installation • The time and money you can invest	*Profitability & business models in the agrivoltaics sector - Fraunhofer ISE* *What Europe needs to scale renewable energy in agriculture - Climate KIC* *Agricultural Knowledge and Innovation Systems (AKIS) EU CAP Network* Renewable energy companies: • *Rem Tec (Italy)* • **Next2Sun (Germany)* • **H2arvester (Netherlands)* • **Statkraft* Energy co-operatives and communities: • *Energy4All* • *Community energy toolkit - Welsh Government*

Risks	**Potential financial risks to the farm business**	
	• Fluctuating energy prices impacting on prices paid for renewable energy • Changing policies relating to green energy tariff or payments • Risks to any partner companies / groups / organisations • Upfront costs of construction	*Power Purchase Agreements (PPAs)* *EU Renewable energy – directive, targets and rules*

Environmental:

What	Why	Where
Crops	**What will be grown alongside or underneath the solar panels? Agrivoltaics can impact on, for example, crop shading, soil moisture and shelter from wind or snow. This could affect the crops grown, and the type, siting and configuration of panels**	
	Will you be combining solar panels with: • Arable crops • Arable crops and livestock • Vegetables • Fruit or vines • Livestock This will impact on the type and set-up of panels and accessibility for agricultural equipment.	Example agrivoltaic configurations: • *HyPErFarm project agrivoltaic installations* • Agrivoltaics case studies and example photovoltaic systems on the *Value4Farm DST webpage* • *Solar panels in a UK free-range egg farm*
	How might agrivoltaics impact on: shading, sheltering, soil moisture? • For example, "hedge style" panels could increase shelter and reduce wind speeds but have high shading. • Stilt mounted panels could produce less shading. Are there crops (you currently grow, or could grow) that would benefit from the shade and shelter provided?	*Value4Farm agrivoltaics demonstration site (Aarhus University)* ** *Fungi natur - mushrooms and solar panels* Agrivoltaics and crop selection on the *Value4Farm DST webpage* *ADAPT2CLIMA DST - adaptation planning in agriculture*
	Different crop rotations could benefit soil and support nitrogen retention. Rotations including cover or catch crops could provide biomass for biogas production if you were interested in combining agrivoltaics and biogas production. What is your current rotation? • Duration	Crop rotation resources: • *Rotations for Field Vegetables - Technical Guide (Agricology)* • *DiverIMPACTS project* and *DiverIMPACTS - Extending crop rotations resource*

	• Food crops • Cover / catch crops • Nitrogen fixing opportunities	• *Legume Hub* • *Decision support system for intercropping (Leguminose)* • *Crop rotation and its ability to suppress perennial weeds* • *Organic Farm Knowledge Toolbox*
	Encouraging pollinators, soil fauna and pest control species with biodiversity strips adjacent to and underneath panels where equipment cannot access could benefit your crops and soils. You might also find practices such as minimum tillage, cover cropping or other regenerative farming techniques beneficial	• *SPIES (Solar Park Impacts on Ecosystem Services) Project and App* • *FiBL Institutes of organic research information and resources*, including *Perennial flower strips – a tool for improving pest control in fruit orchards* • *CoolFarm tool - Measure Carbon Footprint, Water & Biodiversity* • *Six Simple Steps to Regenerative Agriculture (Agricology)* • *Regenerative agriculture (WWF)*
Location	**The geographical location of your farm will impact on a range of factors, from climatic to policy**	
	You may need to consider factors around climate and location such as: • Average and seasonal variations in temperatures • Solar radiation levels and annual patterns • Precipitation - amount, patterns and type (e.g. rain or snow) • Future likelihood of more extreme weather events, such as flooding and storms which could damage panels • Soil types on your farm – for example are they prone to compaction? Policies and regulations affecting agrivoltaics could also be location dependent, including grants and subsidies, planning rules, land use rules, and the impact of nearby conservation or preservation areas.	*Climate ADAPT - European Climate Data Explorer for Agriculture* *The Weather Year Round Anywhere on Earth - Weather Spark* *ESDAC - European Soil Data Centre* *PVGIS user manual - solar radiation and photovoltaic system energy production* *European Nature Information System - species, habitat types and protected sites*

Risks	**There could be risks to the local environment**	
	Although the energy produced is renewable and can be beneficial to the environment, the placement of the technology or how it is applied can have an impact. An Environmental Impact Assessment (EIA) could be required.	*Environmental Impact Assessments for Solar and Wind*
Siting	**Where will the AV panels be located on your farm? And how could panel siting impact on electricity generation?**	
	Have you considered the scale of implementation. Can you start small and scale up over time? What will the distance of the panels be to: • National electricity network • Access points and roads This will affect the costs of grid connections if exporting electricity and the ease of installing panels. You will also need to consider the type and configuration of panels – see the "Panels" section of the checklist.	*Agrivoltaics simulation tool* *InSPIRE Financial Calculator (USA)*
	This distance between rows of panels could impact on specialist equipment needed for harvest or planting, you might need to consider: • Modifying equipment • Purchasing new equipment • Sharing equipment across a farming co-operative • Setting up panels to accommodate current equipment • Precision farming technology	Harvesting with agrivoltaics: • *REM Tec rice harvest (YouTube)* • *REM Tec barley harvest (YouTube)* • *Hyperfarm potato harvest (YouTube)*
	What will the impact be on landscape and views? This could have an impact on planning regulations and relationships with neighbouring stakeholders.	*Agrisolar Policy Map (SolarPower Europe)*

Governance:

What	Why	Where
Certification	**If you are producing renewable energy on your farm you might want to consider green energy certification**	
	If you are intending to sell the energy you produce on your farm, certifying it is from a renewable source could mean a guaranteed or higher price for it. Certificates or certification could have a variety of names, such as Green Energy Certificates; Renewable Energy Certificates (RECS); Guarantees of Origin (GoOs); Renewable Energy Guarantees of Origin (REGOs). Emissions Trading Schemes may also be of interest	*Voluntary certification schemes in the EU* *Renewable Energy Guarantees of Origin (REGO)* *EU Emissions Trading System (ETS)*
Regulatory	**What planning permissions do you need and what legislation or regulations do you need to adhere to?**	
	Regulations you need to follow will depend on a range of factors, including the type of technology being used, the size of the installation and the country or region where your farm is located. Regulations could focus on: • Solar panel location and placement • Environmental risk assessments • Planning permissions • Changes in land use • Certification of renewable / green energy • Crop production and yields	Examples of policy and regulations: • *Agrisolar policy map* • *Planning for solar farms - UK parliament* The following organisations could offer support and information: • *SolarPower Europe* • *EUROSOLAR - The European Association for Renewable Energy* • *Solar Energy UK* • *Global Solar Council* Consultancy and advisory services, farm clusters: • *European Commission - Farm advisory services*

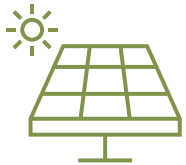
		• *Agricultural Knowledge and Innovation Systems (AKIS) EU CAP Network* • *AEICA - European Association of Independent Agricultural Consultants* Environment and conservation: • *Managing and protecting Natura 2000 sites* • *EUNIS - European Nature Information System, species, habitat types and protected sites across Europe*

Social:

What	Why	Where
Environment	**What impact could agrivoltaics have on the local environment?**	
	Have you considered the possible: • Impact on the landscape, e.g. historical features and views • Impact on nature and biodiversity • Impact on local roads and other infrastructure • Impact of the construction process Have you explained the benefits of the technology? Education can support positive public opinion, you could share: • Environmental benefits of the technology – local, national and global • How it supports energy security for the farm and wider society • Economic benefits, such as mitigating fluctuating energy prices	*REPowerEU* *Renewable energy – powering a safer future (United Nations)* Setting up meetings: • *Organising a public meeting (Resource Centre)* • *Organising Successful Meetings (Seeds for Change)*
Planning	**How might the views of local citizens and neighbouring farmers on agrivoltaics impact on the planning process?**	
	What will be the impact of agrivoltaics on the local landscape and communities? How could the views of locals affect e.g. planning permission? If locals are strongly against, could permission be refused? Have you spoken with the local community and residents about the benefits of the technology on a local and national scale? Many of the resources listed in this checklist could be useful for your local community.	*Agrivoltaic Designs and Configurations* *Introduction to the Concept of Combining Agriculture and Solar Energy (InSPIRE)* *Getting Started - Groundwork (InSPIRE)*

Technical:

What	Why	Where
Energy	**What type of energy is used on farm**	
	Audit the energy use on your farm, what is used, where is it used and when is it used. This could support your decisions about what agrivoltaic technologies to use, their configuration, and whether you are using energy generated on farm or exporting it.	• *The Farm Carbon Calculator* • *SustainFARM sustainability assessment for farms* • *Why and how to do an energy audit (Farm Advisory Service Scotland)* • *Farm Energy Audits* • *Energy Auditing In Agriculture (Teagasc, Ireland)*
	With agrivoltaics you might need to consider: • If you will be using the energy on-farm, exporting it or a combination of the two • Energy storage (e.g. Battery Energy Storage Systems, BESS) • Ease of connection to national energy network if exporting electricity	*Solar Integration: Solar Energy and Storage Basics (Department of Energy)* ** *Farming the Future: BESS & Agrivoltaics (Eco Green Energy)*
Installation	**During the installing of solar panels, what might need particular consideration and planning for?**	
	Soil compaction can be an issue during installation of solar panels, and also with equipment and machinery having to take a set route between panels during planting and harvest Is there suitable access to the site for installation equipment? Is the land suitable? Can it take the weight of the installation equipment and the solar panels? During construction and maintenance there could be risks to workers	Short films showing the installation of agrivoltaic systems: • *RemTec agrivoltaics installation* • *HyperFarm agrivoltaics installation at German pilot site* • *University of Illinois Agrivoltaics Farm Installation Timelapse* *Renewable Energy Systems EU certification*

Panels	**What type and configuration of panels in your agrivoltaic system would fit best with your farm and crops?**	
	There are a wide range of types of panel available and variety of ways to set them up, what works best for your farm could depend on: • Farm location, and average days sunlight • Planned location of solar panels on the farm, taking into account landscapes, topography, sunlight and site access • Costs – balance between cost of panels and installation and income generated, size of installation (i.e. number of panels and wattage) • Crops grown, which crops might benefit from shade or shelter? • Equipment used for e.g. planting and harvest, can they fit between panel rows? • Size of the installation – number of panels and area covered	Example agrivoltaics systems on the *Value4Farm Decision Support Tool webpage* *Agrivoltaic Designs and Configurations* *Agrivoltaics Simulation Tool (KU Leuven)* *PVGIS user manual - calculations of solar radiation and photovoltaic system energy production*
	Panel types could include: • Semi-transparent (e.g. on greenhouses) • Static • Tracking – track the sun on one or two axes (mono or bi-axial) • Fold away – can be retracted to increase light levels to crops or in case of extreme weather events	*RemTEC - agrivoltaic technologies* **Next2Sun - Vertical Bifacial Photovoltaics* ***Insolight agrivoltaics*
	Configuration: • On stilts above the ground to improve access for equipment • Ground mounted, angled towards the sun or in a “hedge” type configuration • Orientation, e.g. North-South or East-West – panel rows can be orientated or angled to capture more light or reduce shading to crops	*Agrivoltaic Designs and Configurations* *HyPErFarm pilot agrivoltaic set-ups*

Next steps

Now you have had a look through the checklist of considerations for agrivoltaics on your farm, what next?

This checklist is part of a Decision Support Tool (DST) developed by the Value4Farm project, to support farmers interested in generating renewable energy on their farm and integrating the production of crops and energy.

The DST contains:

- An Open Access Online Course – Integrating Food and Energy Production on Farmland – which looks at the benefits and challenges of renewable energy generation on farmland
- An Audit Tool to evaluate the farm to support farmers and their advisors in deciding which path to follow in order to produce renewable energy via biogas or agrivoltaics
- A Transition Tool (of which this checklist is a part) to help you take the next steps if agrivoltaics or biogas could be useful on your farm. The Transition Tool also has checklists for biogas and renewable energy, case studies of agrivoltaics and biogas and an introductory budget tool to help you consider the economic impacts of these technologies on your farm

If you haven't already explored these resources, you may find them useful in thinking about your next steps. All are free to use and are available on the Value4Farm website - *https://value4farm.eu/*

You might consider speaking to an Agricultural Advisor who specialises in renewable energy and renewable energy technologies or explore the possibility of having a professional feasibility study undertaken. The following links could be useful:

- *European Commission Farm advisory services*
- *AKIS (Agricultural Knowledge Exchange Systems) EU CAP Network*
- *AEICA - Association of Independent Agricultural Consultants*

Solar power associations may also be a useful source of information, for example:

- *SolarPower Europe*

- *EUROSOLAR - The European Association for Renewable Energy*
- *Solar Energy UK*
- *Global Solar Council*

Your first starting point could be as simple as an action plan, an action plan outline is available on the *Value4Farm Decision Support Tool webpage*

This project has received funding from the European Union's Horizon Europe Research and Innovation programme under Grant Agreement No. 101116076.