Agrivoltaics Handbook

A guide for solar developers and landholders

Acknowledgements

The following companies and individuals provided generous assistance with the development of these guidelines. Thank you for sharing your time and experience to help this important work.

Tom Warren – farmer

Gayle Lee – farmer

Spark Renewables

Dan Moloney – Fontenoy Project Group

Ben Wynn – Wynergy

Peter Hamill – farm manager

Tony Inder – farmer

Sabine Tausz-Posch – University of Melbourne

Wade Ryan – Wagga Tree Consultancy

Libby Skipworth – farmer, Cygnus Ag

Stephen Todd – Volt Farmer

Ian Askell – Essential Energy

Marteena McKenzie – BayWa

Tyler Lloyd – Midwestern Agrivoltaic Systems

Ryan McGoldrick – Solar Farming Solutions

Jess Gray – Lambscaping

Proudly funded by the NSW Government

NSW GOVERNMENT

EnergyCo

Authors

Andrew Bomm – Progressive Agriculture

Karin Stark – Farm Renewables Consulting

PROGRESSIVE AGRICULTURE

Farm Renewables CONSULTING

This publication is based on the knowledge and understanding available at the time of writing (2025). However, as advancements continue, readers should ensure they are referencing the most current information.

Individuals considering agrivoltaics are strongly encouraged to seek independent expert advice.

Contents

Contents

Introduction

Agrivoltaics (also referred to as 'agrisolar') refers to co-locating agricultural production systems with solar development. Integrating solar systems with agriculture provides a dual-use solution that helps meet the country's rising demand for renewable energy while preserving farmland.

For farmers, a secondary income earned from leasing land to solar developers builds financial resilience. From a production perspective, panel shading brings multiple benefits for stock welfare and fodder growth, while providing protection from heat and hail in horticulture systems. For developers, solar grazing reduces vegetation management costs and increases social acceptance if the land is kept in production. It can also help offset the loss of agricultural production, which should be assessed during the planning process, as part of any Environmental Impact Statement.

This Handbook is the first comprehensive resource to provide guidance on the planning, design and implementation of Australian agrivoltaics projects. It is best utilised to plan for integrating agricultural activities during the design phase of large-scale solar farms and to guide the thinking around integrating solar panels with horticultural crops. This ensures specialist expertise – such as graziers, agronomists or landowners - can support developers to create optimal conditions for the site's continued agricultural use. It is important for landowners and graziers to be involved during the early design phase of a solar farm, where possible, to ensure their input and specialist knowledge informs the design of the solar farm.

While developed for NSW, the principles in this document can be applied across the country, with context drawn from local, national and international case studies and experiences.

While this handbook has a stronger focus on information for solar developers, it is equally important for landholders to understand this content. Landholders encounter a variety of additional considerations when hosting renewable infrastructure. For further guidance, please refer to the NSW Renewable Energy and Transmission Landholder Guide, developed by NSW Farmers with support from the Queensland Farmers' Federation and funding from EnergyCo.

Photo courtesy of EDF Renewables

This Agrivoltaics Handbook covers three distinct topics.

1 Sheep grazing under solar

This section serves as a manual on how to successfully incorporate sheep grazing within a solar farm. These large-scale solar farms need a strategy to manage on site vegetation over the life of the project but have previously lacked a resource to guide the planning, design and implementation of an effective vegetation management plan.

In Australia, sheep grazing is the most cost-effective way to manage vegetation within a solar farm and ensure that these developments maintain agricultural use and provide further benefits to farmers and community.

These industry guidelines are for both solar developers and landholders. The goal is to offer a practical resource and actionable framework for integrating sheep grazing into solar farm operations, ensuring both operational efficiency and agricultural productivity.


Photo courtesy of Gayle Lee

2 Horticulture and crops under solar

This section provides guidance for solar developers and farmers interested in exploring small to mid-scale agrivoltaic systems for growing crops and horticulture under solar panels.

While this form of agrivoltaics holds significant potential, the practice is still evolving. As such, this section is not intended to be a definitive guide but rather a resource to raise awareness and help farmers and developers think through some of the issues, risks, and opportunities, and how it relates to their own circumstances.

By drawing on international research and case studies, this section highlights practical insights and lessons learned from existing agrivoltaic projects. The goal is to provide a foundation for informed decision-making and spark thoughtful reflection.


Photo courtesy of Solargik

3 Cattle under solar

This section provides a short summary of existing projects where cattle are grazed under solar panels, both in Australia and internationally.

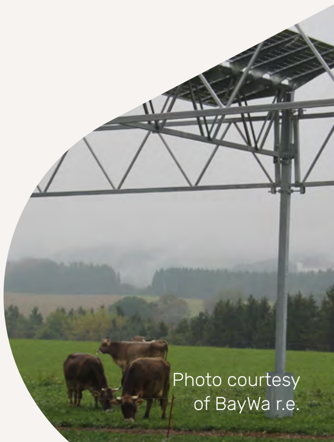


Photo courtesy of BayWa r.e.

Sheep grazing under solar

Solar grazing operation in Glenrowan, Victoria.
Photo courtesy of Gayle Lee.

Solar industry and grazier guidelines

Large-scale solar farms need a strategy to manage on-site vegetation over the life of the project but have previously lacked a resource to guide the planning, design and implementation of an effective vegetation management plan.

Some form of active vegetation management is required on every large-scale solar site. It is not feasible to apply a residual herbicide to remove all vegetation from the landscape. This will create land degradation from erosion, weed problems, dust on panels, and neighbour conflict.

In Australia, sheep grazing is the most cost-effective way to manage vegetation within a solar farm and ensure that these developments maintain agricultural use and associated benefits for farmers and community.

These industry guidelines have been developed to provide a practical resource to solar developers/owners, solar farm operators, and graziers on how to best achieve mutually beneficial outcomes on large-scale solar generation sites.

Developers intending to include agrivoltaics in their projects should include reference to this intent and information about implementation methods in the project's Environmental Impact Statement, which is considered by the Department of Planning Housing and Infrastructure (or the relevant consenting authority) as part of the NSW Government planning approvals process. An approved land management plan will likely be required for most projects as a condition of consent, which will cover much of the technical information outlined in this section.

Photo courtesy of ABC and Tom Warren

Solar industry guidelines

Solar grazing benefits

When implemented effectively, solar grazing has multiple complementary benefits for solar operators, graziers and local communities. However, it is important for developers, operators and graziers to understand that knowledge about grazing sheep within solar farms is in its infancy, long-term studies have not yet been undertaken, and successful implementation requires careful management.

This section primarily provides guidance to solar farm developers, however, much of this information will help graziers and landowners understand how they can provide advice to optimise agrivoltaic operations (e.g. design and layout of grazing infrastructure).

Input from graziers and livestock specialists in the early design phase is necessary, and will lead to optimal outcomes for developers and graziers during the operational phase of the project.

Advantages for sheep grazing from panel shading

Solar panels provide several complementary benefits for a sheep grazing enterprise. Sheep enjoy the shelter and shade provided by the panels, protecting them from extreme heat, wind, and blowing dust. Importantly, shade from panels also provides a beneficial microclimate for supporting improved pasture quality. Green grass within the panel arrays remains available for longer across the growing season, compared with pastures in open grazing country that dries off in late spring and early summer. Solar panels also concentrate water runoff into semi-irrigated strips, providing better feed availability during dry periods.

Lightsource bp has seen promising results from the second round of wool testing at its Wellington solar farm in New South Wales, Australia. Through comparisons of two small study groups of merino sheep – one group grazed in a regular paddock and the other at the Wellington solar farm – the findings suggest that the co-location of solar farming with sheep grazing could have a positive impact on wool production. While further long-term studies are required with larger sample sizes, these results are promising.

Inexpensive vegetation management

Managing vegetation height via a well-executed sheep grazing strategy is significantly less expensive than employing mechanical grass slashing services, which range from $100 to $250 per hectare (based on 2025 cost estimates), depending on machine trafficability, biomass density, and availability of service providers.

Social licence via retained agricultural use

In many communities, there has been resistance to modifying the landscape of their district - from traditional agricultural uses to large-scale industrial energy production. The retention of agricultural production on the same footprint as large-scale solar development is a critical aspect of delivering community benefit and gaining community acceptance for the energy transition to renewables.

Risk mitigation

Sheep cause less damage and present less worker health and safety risk than slashing. Grazing avoids the damage associated with rocks being propelled onto solar panels, the risk of ignition from slashing during fire danger periods, or contractors causing damage or being injured while manoeuvring slashing equipment around solar panels.

Case study
Tom Warren, Dubbo grazier

Tom Warren is a Dubbo-based farmer who leases part of his land to a solar farm and runs about 250 merino ewes and wethers on 54 hectares among the panels.

Since commencing his solar grazing operation in 2019, he has observed an increase in wool quality and quantity among his sheep within the panels, which he attributes to the protection the panels give from the heat, dust, and air-borne contaminants such as burrs.

While varying his stocking rate based on seasonal conditions, Tom reports carrying 25% more sheep overall, compared to land without panels, due to increased soil moisture retention and the concentration of moisture in green pasture strips during dry periods.

Photo courtesy of Tom Warren

Common mistakes to avoid

Despite the benefits of sheep grazing, the solar industry has not always capitalised effectively on this opportunity. The reasons for this are generally related to an underestimation of the logistical challenges and cost of vegetation management, a poor understanding of how agricultural enterprises operate, and a failure to adequately plan for grazing.

To assist with future development planning and design, here is a list of issues that have been observed from previous large-scale solar farms.

- ✗ Underestimating key grazing requirements and inadequate site specific development planning - leading to inaccessible mustering, inability to target graze, excessive stock handling, and reliance on mechanical slashing.
- ✗ Not having an Australian-based planning capability that understands local land management and planning requirements.
- ✗ Setting up competing objectives between developer and site operator, creating misalignment about sheep infrastructure investments and cost savings from avoided slashing.
- ✗ Having operations and maintenance contracts that haven't budgeted for vegetation management, and operations and management teams with little experience of land management.
- ✗ Creating unsuitable paddock sizes to control grass height and weed outbreaks.
- ✗ Designing an unsuitable structure that limits access for mustering or creates a threat to animal and farm worker safety.
- ✗ Failing to engage local agronomic and livestock expertise.
- ✗ Lack of land management and preparation prior to construction, causing later management issues.
- ✗ Having lack of access to adjacent pasture to enable: a) animal health treatments, b) increasing and decreasing stocking rates during wet or dry seasonal conditions, and c) removal of stock for herbicide withholding periods.
- ✗ Approaching grazing agreements incorrectly. That is, seeking to treat agreements like an agistment agreement farmers pay for, rather than a grass cutting service provided by graziers for minimal cost; attempting to force graziers to make investments on site to enable their grazing activities; and imposing unreasonable liability for damage from sheep.
- ✗ Poor communication with graziers, lack of co-ordination of activities, and lack of clarity about protocols.

Checklist of decisions

To best prepare for vegetation management post-construction of large-scale solar, a series of key decisions are required during the planning and design phase, and when later entering into a grazing agreement.

The technical information included later in these guidelines will assist solar developers to make informed decisions, but any decisions relating to managing vegetation should be made with assistance from local agricultural advisers.

Key decisions will need to be made at the following stages of solar farm development and operations:

- Pre-construction planning and design
- Post-construction grazing contracting

1. Planning for grazing

- Will the solar company be responsible for a landholding prior to construction? What is the plan for managing vegetation during that period?
- Are incentives between the developer and the operator aligned? Who receives the benefit of reduced slashing costs?
- Is the scale of the development sufficient to attract a grazing operation? What are the potential savings from avoided mechanical slashing?
- Do the design team have input from an agricultural expert about how to incorporate grazing into the development?
- What is the most suitable panel structure that meets both energy production requirements and enables grazing and mustering activities?
- How are fenced paddocks going to be integrated into the solar footprint? What should their size and configuration be?
- Where will gates, watering points, handling yards, and other infrastructure be located?
- Are there existing pastures that can be retained or will use and location-specific grasses need to be sown prior to construction? Is pre-sowing improved pasture feasible? How will damage to existing pastures be mitigated during construction?
- What are the stocking rate requirements of the site to maintain 100mm grass height insurance requirements under different seasonal conditions?
- How will sheep be held outside the solar farm footprint when grass cover is affected by dry conditions, in circumstances when animals require health treatments, or when weed spraying needs to occur?
- How will operations managers be trained to monitor grazing operations effectively?

2. Contracting a grazier

- Is the asset owner or the operator contracting with the grazier?
- Is the original landholder willing to graze the site and would they be suitable to host on an operational solar farm?
- Is the original landholder experienced in running sheep, or was the land use previously cropping or another different enterprise?
- If seeking another party to enter into a grazing commitment, how is this to occur? Does this require consent from the host landholder?
- What are the grazier's location or personality characteristics that best fit the circumstances?
- Would a non-adjacent grazier need to transport stock on and off when seasonal conditions dictate? Or is there adjacent land that can allow 'flex' of stocking rates on site?
- Is the grazier able to be relied upon to attend the site without solar operator staff present?
- Does the grazier understand the restrictions they'll need to adhere to, regarding site access, health and safety procedures, communications protocols, and vehicle movements?

Technical information

The following section outlines summaries of the key technical principles that need to be considered to undertake a successful grazing operation within a large-scale solar farm.

It is important to recognise that managing agricultural activities is very dependent on circumstances and location. While this document can provide useful guidance about the issues that need to be considered and some general guidance, expert advice from the grazier, livestock advisor and/or agronomist should be sought.

Landowners and graziers should use this information to inform their discussions with solar developers during the design phase.

These technical guidelines are broken into three key project phases:

Pre-grazing planning/design and site preparation

1. Paddock layout and grazing infrastructure
2. Site trafficability
3. Pasture establishment

Grazing implementation

4. Sheep stocking rates
5. Pasture management

Contracting arrangements

6. Sheep grazing agreement
7. Communications protocol
8. Checklist of professional advice

A reference to agrivoltaics should be included in project Environmental Impact Statement, which is considered by the Department of Planning Housing and Infrastructure or the relevant consenting authority as part of the NSW Government planning approvals process. An approved land management plan will likely be required for most projects as a condition of consent, which will cover much of the technical information outlined in this section.

Shade and wind protection from solar panels maintains green feed well into warmer months (photo taken in November, NSW Riverina)

1. Paddock layout and grazing infrastructure

Early planning and collaboration between developers and graziers/livestock specialists on infrastructure design will meet an important economic objective – reducing the cost of vegetation management, while also ensuring adequate infrastructure is in place to support the welfare of sheep on site. Planning needs to be devoted to creating the right paddock dimensions for effective grazing, and providing the supporting infrastructure needed to host sheep.

Vegetation management will be easier and more cost effective if internal fencing is designed to provide optimal paddock sizes. This will ensure that:

- Specific areas can be targeted for vegetation management.
- Sheep can be removed when pasture and ground cover is low, which will help protect soil from degradation.
- Sheep can be moved away from areas having herbicide applied.

Paddocks divided within the solar farm can ensure that less slashing is needed by more intensely grazing selected paddocks and focusing mowing attention on others.

Retrofitting the internal layout of a solar farm for grazing is either very challenging (for example due to the dangers of buried electrical cabling) or not possible, so good planning needs to occur before problems are baked into the lifetime of the project.

Drainage and water capture

Pre-existing farm dam infrastructure and water drainage systems adjacent to topographical low points should be retained and accommodated within the solar farm.

There have been instances of solar developers removing critical farm water infrastructure, which have created long-term problems for the operation of agrivoltaics within the solar farm. This includes filling in dams, removing water drainage systems, and creating artificial water courses where prior streams existed.

Vegetation management will be easier and more cost effective if internal fencing is designed to provide optimal paddock sizes.

Paddock layouts

A rule of thumb for optimal paddock sizes is:

1. High rainfall (600mm-1000mm/year) -> 20-40 ha
2. Moderate rainfall (400-600mm/year) -> 40-60 ha
3. Low rainfall (under 400mm per year) -> subject to pasture type

Average annual rainfall 1991-2020
Australian Bureau of Meteorology

Besides rainfall, several other factors should be considered when determining paddock layout, including stock movement, landscape, and specific grazing management objectives (stocking rate density and sheep type).

Existing solar farms are likely to have paddock sizes substantially above these recommendations. If paddocks on the solar site are larger than these recommended sizes, then watering points should be increased to better spread the areas that sheep occupy, which prevents inconsistent stock grazing.

There needs to be space within one of the paddocks to set up stock handling yards adjacent to transportation access.

Having adjacent grazing land is also very helpful to manage the requirement to move stock on and off flexibly, and without the need to incur transport costs to shift stock to an alternative location.

It is not possible to run a solar grazing operation with only one paddock, as this will prevent the use of herbicides for weed control (see more on this on the next page).

Case study
New solar farm in Northern Victoria

There is a newly constructed solar farm across a 40ha site in Northern Victoria, and the solar company is planning to graze sheep for vegetation management. The location of the solar farm, next to a 32ha paddock on the same landholding, is a positive feature that makes it viable for sheep grazing.

There is no grazier neighbour with a shared boundary that could have moved stock on and off the site without incurring transport costs and logistics. Without this adjacent paddock, and given the small size of the grazing area, it would have been an unappealing proposition for graziers to enter into an agreement.

This adjacent paddock provides flexibility for varying stock numbers to target vegetation management, a location for stock handling infrastructure, and a holding paddock when herbicide applications are occurring within the development footprint.

This site will likely require at least one spring vegetation mow each year, but the flexibility of the adjacent paddock will help to concentrate sheep grazing activity within the solar footprint when higher levels of vegetation management is required.

Grazing infrastructure

Infrastructure requirements to host sheep grazing include:

- Internal fencing and gates
- Water points
- Stock handling yards and loading facilities
- Exclusion fencing (if required)

Prices listed below are intended only to provide developers and operators with an indicative guide to expected costs. They are accurate as of 2025, and are subject to change over time.

Internal fencing and gates

The solar farm needs to be designed to allow for internal fencing that is not in conflict with the location and direction of solar generation infrastructure. This can be done without undermining electricity generation capacity, but needs to be accounted for during the project's planning and design phase.

Retrofitting internal fences to reduce paddock size is sometimes possible, but options may be limited, depending on the solar layout. Impeding infrastructure and underground electrical cabling will create challenges to modify paddock layouts post construction. Extreme caution should be taken when installing new fencing to ensure that electrical cabling is in fact located as per design maps, and is avoided when digging holes for fence posts.

Internal fencing for sheep containment will cost between $15 and $30 per metre (based on 2025 cost estimate) to construct, including materials and installation. Temporary electric fencing has been used in Australian solar grazing operations, but has been widely reported to be unreliable as a permanent barrier to stock movement across paddocks.

Retrofitted internal fencing and access grid

Internal gate access between paddocks needs to enable easy internal travel for operators and the grazier, but prevent unwanted stock movement. Access grids will cost between $7,000-10,000 each (see image) based on 2025 cost estimate.

Case study
Bomen Solar Farm

Grazing infrastructure

The Bomen Solar Farm has a footprint of approximately 250ha, across two similarly sized blocks divided by a road.

The developer, Spark Renewables, always planned to graze sheep on the site and, post construction, it invested in critical farm infrastructure to make sheep grazing viable on the site.

The southern block has been split into two paddocks with an internal fence, watering points and access gates, and planning is underway for an internal fence to divide the large northern block. This will reduce mowing costs by enabling high intensity grazing in selected paddocks to maintain groundcover, while reducing mowing requirements in areas with more challenging vegetation.

Perimeter gates

Gate locations and types need to be planned to provide sufficient access for large transportation vehicles. Things to consider include:

- Do large vehicles have enough turning and reversing space?
- Where should loading ramps be located for easy vehicle access?
- Can ramps be attached to stock yards to make loading efficient and easy?

Perimeter gates also need to provide southern and eastern escape options in the event of an aggressive grass fire.

Water points

Each paddock requires a watering trough for stock, via a piped water system. As described above, paddocks substantially larger than those recommended in this guide will require additional watering points.

Consideration needs to be given to water supply and delivery across the site before construction. Trucking water on site will be expensive, so access to other sources of stock water (usually groundwater or surface stock and domestic water) needs to be investigated.

It is generally much more difficult to provide water delivery infrastructure post-construction, than including it in pre-construction planning. An important factor is integrating pipes and associated trenching requirements into the build design, as this exercise will be considerably more difficult after cabling and other generation infrastructure is in place. Again, caution should be taken when installing water piping to ensure that electrical cabling is in fact located as per design maps.

There may be existing water extraction and delivery infrastructure that can be utilised. Even if new infrastructure is required, it is not a major expense relative to alternative management options.

Watering points should be located away from gates to ensure that stock traverse paddocks and graze as consistently as possible. Stock water troughs cost approximately $3,000-5,000 each (including installation and connection), and water pipe costs $5-10 per metre installed (based on 2025 cost estimate).

Stock handling yards

Graziers require stock handling yards to undertake necessary animal health treatments and transport stock on and off the property. This infrastructure should be proportional in scale to the number of sheep intended to be grazed.

These yards should be assembled on site as the solar installation is finalised, and before sheep are introduced to manage vegetation height.

A transport loading ramp will also be required to enable stock delivery and removal, and consideration needs to be given to the accessibility of stock transport vehicles.

Semi-permanent stock yards for 500 sheep will cost approximately $20,000 (based on 2025 cost estimate).

Exclusion fencing

Exclusion fencing may be required in areas where sheep grazing is typically unviable due to predators, e.g. wild dogs. This requirement may be a significant upfront cost and could make the economics of sheep grazing less desirable. However, most large-scale solar farms in NSW occur where sheep grazing is being undertaken without exclusion fencing.

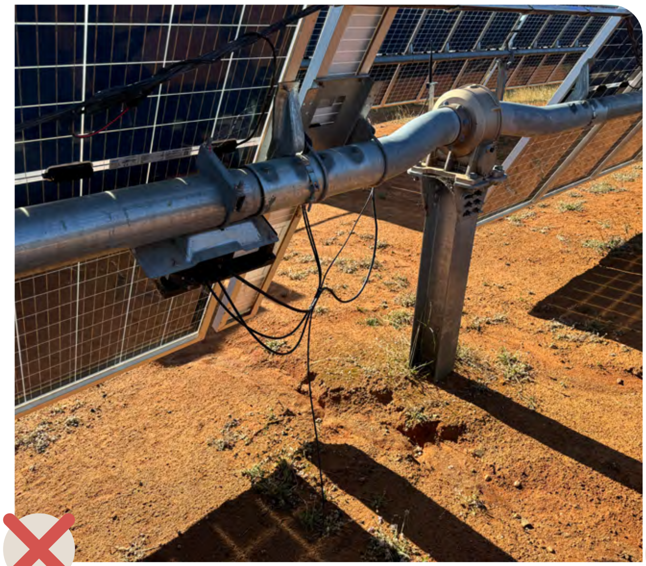
Solar infrastructure protection

To avoid damage to key generation infrastructure, large-scale solar farm designs should ensure that mechanical equipment is set away from potential contact with sheep. Getting these design elements right at the early planning stage is greatly beneficial for preventing later unplanned costs and/or damage.

Cabling, motors, and stop buttons should be placed away from sheep access or, if necessary, retrofitted with container boxes to protect them.

Exposed equipment accessible to sheep

Protective guard to prevent sheep damage



Snagging hazard

Wires inaccessible to sheep

Although potentially more efficient, bifacial surfaces on solar panels are easily damaged and may be unsuitable to a working environment, either from grazing or slashing. When slashing occurs, rocks and other debris thrown up will damage the panels.

Mitigating risk of damage by sheep can be achieved by:

- Limiting sheep breeds to those least likely to cause damage.
- Limiting the periods in which sheep fleece is long enough to present a 'snagging' hazard.
- Maintaining good animal health to prevent scratching urges, e.g. keeping sheep free from lice.

Summary

- ✓ Optimal paddock sizes help maximise the efficacy of sheep grazing
- ✓ Adjacent grazing land is invaluable to be able to move stock flexibly
- ✓ Additional watering points can avoid inconsistent stock grazing patterns in large paddocks
- ✓ Consult with the host landowner and/or local advisers on infrastructure requirements
- ✓ Payback period for investing in grazing infrastructure is short
- ✓ Measures should be taken to mitigate the risk of sheep damaging generation infrastructure

2. Site trafficability

Solar developers need to provide an efficient electricity generation facility, while ensuring that operations and maintenance teams, and graziers, can traffic the site effectively.

Whether sheep or lawnmowers are used, improved trafficability will generate significant cost savings over the life of the project. Design during the planning phase needs to ensure trafficability for sheep mustering, grass cutting, weed spraying, and fire control.

The following principles should be followed to enable both graziers and mechanical grass slashers to safely and efficiently move around generation infrastructure.

Solar layout

Spacing: Solar rows should be spaced at least 5m apart for vehicle access, and trafficability is improved with spacing up to 7m.

Height: The mounting height of panels should be at least 2m (with minimum panel clearance of at least 50cm at full tilt) to mitigate against sheep damage, maximise visibility for mustering activities, and allow mechanical slashing.

Traversing rows: All rows should be free of perpendicular drive shafts and any other impediments to trafficking the full length of rows.

Impediment (foreground) to slashing equipment

Another example of panel tracking equipment as a barrier to trafficability

Grass cutting equipment, vehicles for mustering, and firefighting equipment need to be able to move through the site without traverse impediments. Access to the ignition point of a fire and ability to move quickly around the panels to suppress a fire is essential.

There will be periods where seasonal conditions instigate pasture growth that is too rapid for stock to maintain at required heights (to meet insurance policy thresholds), and mechanical slashing will be required. The layout of panels and other generation infrastructure will determine the size of machinery that can mow vegetation, and the trafficability of those machines.

Economically, larger machines (small tractors pulling a slasher) with good trafficability will be less costly than commercial mowing machines that cut grass at a slower pace and need to cover more ground because of impeded trafficability. The existence of traversing drivelines will be a determining factor for tractor access, as they require machines to turn around mid-row and approach from the other end.

Graziers will use a range of methods to muster sheep around the site as required. Typically, mustering will involve a person on a vehicle (ute, all-terrain vehicle or motorbike) and a working farm dog. It is generally easier to muster sheep during the middle of the day, when tracking panels are flat (horizontal) and visibility and sheep movement are at their best.

Safety risk for mowing contractors

Some farmers have circumvented issues with mustering through a solar farm by using drones, which can be used to both locate and muster stock.

Mustering visibility is best during the middle of the day when panels are at their highest clearance

Summary

- Poor trafficability for grazing and grass cutting will be expensive over time and reduce the ability to fight fires.
- The critical mistake to avoid is electricity generation infrastructure that intersects rows.
- Ease of mustering will be important for attracting willing graziers who will alter stock numbers when required and maintain animal health treatments.

3. Pasture establishment

If feasible, vegetation grown within the solar footprint should be deliberately selected and established for the dual-purpose use of the site – energy production and sheep grazing. This requires pasture types that achieve the following:

- Are suited to the climate and soils.
- Are palatable to sheep and will be grazed down to height limits.
- Provide groundcover to suppress competing weeds and dust.
- Are not too fast growing and difficult to control – minimising the need for slashing.

Every location has unique vegetation growing conditions, derived from rainfall patterns, temperature variation across seasons, soil types, and topography. This means that the selection, establishment and maintenance of site vegetation needs to be carefully considered. If this is not done, the site will be overrun with grass types/weeds that are difficult to manage and unappealing to a grazing operator. It should also be recognised that the sustainability of the pasture may be compromised by the energy generation land use, which will require early consideration on how pastures will be maintained and, where necessary, re-established throughout the lifecycle of the solar farm. Reference should be made to the NSW Department of Primary Industries and Regional Developments guide to Maintaining groundcover to reduce erosion and sustain production.

Before planning for post-construction pastures, solar developers should consult a local agronomist or adviser for information about the suitability of the pasture varieties for the site.

Preparing a vegetation management plan

A plan is required to manage the land from the time ownership or a leasing arrangement commences, which includes what pasture species are to be promoted and how they are to be managed.

This needs to be in place prior to any land management transition, as vegetation without active management can deteriorate quickly and lead to significant remediation costs later on.

A vegetation management plan should be developed in conjunction with an experienced agricultural adviser prior to responsibility for land management occurring. It should include pre-construction, construction period, and post construction management strategies. These plans and the engagement of an adviser will not be costly and will avoid continuing higher operational costs later on.

If the solar company is leasing the land from the continuing landholders, the terms of the vegetation management plan need to be outlined and included in any lease agreement.

Pasture species selection

The information on species/varieties included here is only a guide, and site-specific information from a professional advisor will be required.

Most large-scale solar farms in NSW will be suited to temperate pasture varieties that produce most of their feed during winter and spring, and can tolerate cold and frost. They may be annual varieties, which grow only during certain periods of the year and rely on regenerating from seed each year, or year-round growing perennial varieties.

Examples of suitable temperate varieties include:

- Annual ryegrass, which is a very common grass species used for grazing operations in NSW. Grows in winter-spring and suits a wide range of soil types. Very palatable to sheep. Will grow tall if left ungrazed during spring. Sown in autumn but will be prevalent without sowing. Minimum rainfall: 400mm.
  Ryegrass – Annual
- Annual clover species that grow and set seed each year, ensuring they survive in areas with long hot summers and low rainfall. There are a wide range of species available including aerial and subterranean seeding types which are adapted to different locations, soil types and uses. They have the benefit of not being a tall species (150mm max). Sown in autumn. Minimum rainfall: 375mm
  Subterranean clover
- Perennial lucerne, which mainly grows in spring, summer and autumn when moisture is available. It suits a wide range of well-drained soils and is drought tolerant. Lucerne needs to be rotationally grazed or cut for good persistence, and has the benefit of not growing to the height of annual grasses. Usually sown in autumn or spring (irrigated) when the soil temperature is warm and there is sufficient moisture for establishment. Minimum rainfall: 375mm.
  Lucerne
- Perennial cocksfoot is a variety of grass that will persist in a dry summer environment and is suited to low fertility soils. Sow in autumn or spring. Minimum rainfall: 450mm.
  Cocksfoot

Pastures within lower rainfall zones will often be pre-existing native pastures, e.g. where solar is installed on western NSW pastoral country. These native pastures should be retained and managed according to local agronomic advice.

Tropical species are most productive during the warmer months. In the areas of NSW where large-scale solar development is occurring, their profitable use is limited by relatively lower summer rainfall, low temperatures, and frost. They are generally confined to the coastal districts, and the NSW northern central inland areas of the lower slopes and plains.

More detailed information including on more suitable grasses for subtropical climates can be found in the NSW DPI's publication Pasture varieties used in New South Wales 2012-13.

Establishing pastures

Solar developers should plan for preparing optimal vegetation ground cover prior to construction where it is feasible to do so. Post-construction pasture sowing is approximately 3-5 times the cost of sowing paddocks before the solar panels are in place.

If the land is being converted from cropping to grazing use, this requires sowing during the appropriate seasonal window prior to construction, to allow for pasture establishment and control of unwanted vegetation species that make post construction operations and management more difficult.

Planning needs to start early to enable weed clean-up and paddock preparation prior to sowing. A local agronomist and sowing contractor will be required to advise on how and when to sow pastures into the site, and any soil preparation that will be required to best enable pasture establishment. Depending on the topography of the site, it may be feasible to broadcast seed and achieve successful establishment.

If construction occurs when ground conditions are wet, this can ruin the establishment of pre-sown pastures, and re-sowing may be required. Care should also be taken to minimise heavy traffic and soil disturbance across sown areas, as this will hinder the viability of new pastures.

Where the development site has previously been used for grazing, planning for construction methods that best maintain existing pastures may be sufficient.

If a solar company is dealing with a site that has not planned for appropriate pasture establishment, there are management options available to eradicate unwanted species and encourage those that will benefit ease of management. These are included later in this guidance when outlining weed control options.

Another option for retrospectively modifying vegetation types is to re-sow preferred pasture species between panel rows. Due to the emergence of solar grazing on sites where adequate planning had not occurred, there are now service providers equipped to undertake this task using specialised seeding equipment designed for trafficking large-scale solar farms.

Although sowing pastures requires financial outlay, the benefits of avoided vegetation management costs will outweigh the investment made in optimal pasture species establishment.

Summary

- ✓ The best pasture option is location specific, and a local expert should be engaged
- ✓ A pasture mix that retains year-round groundcover, but limits grass height is best
- ✓ Previous cropping country will require a complete pasture seeding
- ✓ It is possible to re-sow preferable vegetation between rows after construction (using specialised seeding equipment)

4. Stocking rates (sheep per hectare)

When choosing the number of sheep to occupy the site, the objective of the solar operator should be to have an adequate number of sheep to minimise the requirement for mechanical slashing, but not so many that they need to be frequently removed to avoid the degradation of pastures and related dust and weed control issues.

The number of sheep (site carrying capacity) that can be sustained over long periods within a solar farm will be determined by local climate, prevailing seasonal conditions, and the nature and quality of pasture. Again, expert livestock advice should be sought to match local conditions and inform the development a sheep grazing management plan.

Good solar grazing plans will vary onsite sheep numbers under three scenarios:

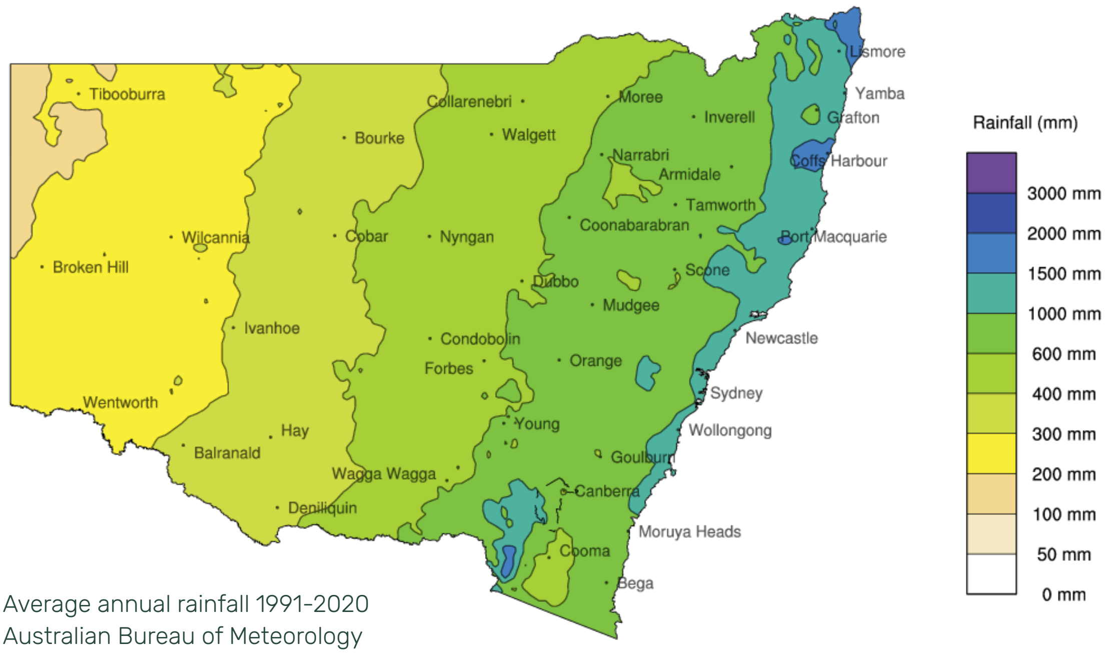
1. A default stocking rate to provide year-round vegetation management.
2. An increased stocking rate to manage vegetation during high growth seasonal conditions.
3. A drought stock removal to maintain groundcover when rainfall is insufficient to promote any growth.

For more information on sheep management, please see the Department of Primary Industries and Regional Development's advice: Animals and livestock – sheep.

Default stocking rate (for conventional grazing operations)

A rule of thumb for selecting optimal sheep numbers is:

1. High rainfall (600mm-1000mm/year) -> 4-6 sheep/ha
2. Moderate rainfall (400-600mm/year) -> 2-3 sheep/ha
3. Low rainfall (under 400mm per year) -> 1 sheep/ha



Average annual rainfall 1991-2020
Australian Bureau of Meteorology

This assumes that the sheep type that is grazing is a wether sheep – other sheep breed options will consume pastures at different rates, and stocking can be adjusted accordingly. (Dry Sheep Equivalent is the standardised unit of measurement to determine suitable stocking rates based on the feed requirements of different animals. Livestock advisers will often provide seasonal advice on stocking rates using this approach.)

Merino or merino cross wethers, dry ewes or weaner lambs are most suitable to occupy a solar farm. Other breeds (e.g. dorpers) present greater risk to the solar operator's infrastructure, and animal health may be compromised if lambing is attempted within the array, due to restrictions on constant supervision.

These stocking rates are a good rule of thumb to guide solar operators when initially engaging with graziers about vegetation management objectives and the terms of an agreement. Grazier suggestions for a default rate much higher than this risks pasture degradation, and a much lower stocking rate risks being ineffective to minimise mechanical slashing. However, operators should always consult with and heed advice from the grazier and an independent livestock specialist.

The site layout and access to adjacent pastures are also major factors in determining the appropriate stocking rate. Large-scale solar sites with more, smaller sized paddocks can potentially carry more stock, as the ability to graze at higher densities at key times provides more targeted grazing, which helps manage vegetation height with more precision and lessens the burden on stressed pastures.

These guidelines also assume that the grazier doesn't have the flexibility to muster sheep to an adjacent farm, without the need for transportation, which incurs a cost to be borne by either the solar company or the grazier. Where the flexibility of adjacent access to grazing pastures exists, the default set stocking rate can be increased to more intensively manage rapid vegetation growth.

Increasing stock rates

When default stocking rates aren't sufficient to suppress vegetation growth during peak growth period, additional measures will be required. These are either more sheep, supplementary mechanical slashing, or both.

Solar operators will be required under insurance policies to control grass heights to an agreed height, which is often stated as a 100mm threshold. In meeting this objective, there are variables that complicate decision making about when additional sheep or slashing will be required to comply. For instance:

- Is the height assessed as an average height across the site, or a maximum height at any location?
- Does the height limit only apply during nominated fire danger periods?
- What will be the effect of early slashing or intensive grazing on the capacity for favoured annual grass species to regenerate next year?
- Is bringing additional sheep onto the property feasible for the grazier and/or required under the agreement?
- Is the cost of bringing additional sheep less or more than the cost of slashing?
- Will slashing be required during peak growth regardless of sheep grazing effects?

Sheep grazing will at times not be enough to maintain vegetation to required heights due to favourable conditions for grass growth. Slashing options need to be available to solar operators, but even when required, sheep consumption will reduce overall vegetation biomass and limit overall slashing costs.

Sheep grazing is a far more cost-effective vegetation management option than mechanical slashing. Solar operators should be prepared to cover the transportation cost of bringing additional sheep onto the site. Graziers will often be unwilling to meet this cost as favourable seasonal conditions are providing good grazing opportunities elsewhere, without the associated transport costs.

A rule of thumb would be to increase sheep numbers by 2-3 times the default rate during periods of rapid growth, and remove them when grass heights have been addressed. For logistical or commercial reasons, this may not always be feasible for the operator. Contracts will need to specify any grazier obligation for increasing stock rates, or whether this is optional.

Solar operators should be aware that additional sheep may only be sustainable for as little as 4-6 weeks, and factor in the cost of transporting sheep to and from the site within this time period.

Case study
Bomen Solar Farm

Changing stock rates

In early 2024, stock numbers grazing the site were approximately 500 across the 250ha solar footprint. This was increased to 1500 in September to cater for spring vegetation growth as temperatures warmed up and rainfall events contributed to strong grass growth.

The grazier runs several thousand head of sheep at their home property, and having received very little spring rain there, was relying on costly supplementary feeding to sustain the flock. He benefitted from the availability of pastures under panels at Bomen, and had a grazing operation of sufficient scale to be able to increase numbers as requested by the solar farm operator.

A contribution to transportation costs was made in recognition of the benefits of having short-term access to an increase in sheep numbers.

Although a spring mow on the solar farm was still required, the vegetation management option provided by sheep grazing saved significant costs by avoiding extra slashing.

A lesson learned from this experience would be to have confidence to stock even more intensively in periods of strong vegetation growth, leveraging off the flexibility provided by a grazier with access to large numbers of stock who can increase and decrease stock numbers in a timely way to match vegetation management needs. This approach avoids overgrazing and undergrazing and reduces vegetation management costs.

Drought provision

During dry seasonal conditions it will be necessary to de-stock the site to maintain groundcover when rainfall is insufficient to promote any pasture growth. This is necessary for animal health and avoiding degradation of pastures, and related dust and weed control issues.

Solar operators and graziers need to have a mutual understanding of the trigger for removing stock from the site, and seek input from an independent agronomist. A useful rule of thumb is to de-stock when groundcover is reduced to 70%.

The solar operator should cover the transport cost associated with stock removal triggered by dry seasonal conditions.

Summary

- ✓ Favour more paddocks of smaller size in the design phase
- ✓ Access to grazing paddocks adjacent to the solar site is optimal
- ✓ Understand the sheep carrying capacity of the site
- ✓ Seasonal conditions will dictate appropriate stocking density
- ✓ Grazing agreements should cover the full range of vegetation management needs
- ✓ Solar operators may need to meet the cost of stock number variations

5. Pasture management

With pasture management, the overall objective of solar operators is to:

1. Limit pasture height to agreed insurance threshold levels for managing fire risk.
2. Maintain groundcover to prevent land degradation and dust issues that affect electricity generation.
3. Ensure that pastures are suitable to attract graziers delivering cost saving vegetation management services.

The quality and type of existing pastures, variable seasonal conditions, and weed outbreaks will necessitate continuing management decisions, whether sheep are used, mechanical slashing, or a combination of both.

These decisions should be based on a vegetation management plan developed with the grazier and an independent expert adviser. This management plan needs to be flexible and adaptable, recognising that long-term pasture management in solar farms has not been tested, and the compositions of pastures may alter over time.

Example of a paddock with suitable groundcover within height limits and good weed control

Erosion issues from poor groundcover

Vegetation management plan

Pasture management requires specialist expertise or the pasture and land within the solar project footprint will deteriorate quickly. Solar farm operators will require advice from local agricultural advisers about vegetation management and maintaining suitable grazing pastures.

A clear vegetation management plan is usually required by the project's planning consent. It will help improve or maintain the vegetation on site and reduce soil degradation, guide budget allocation, ensure timely management decisions, and mitigate cost shifting between site owners and operations and maintenance providers. It should be updated annually and provide scope for dynamic decision making as seasonal conditions require. This plan will include:

- What pastures are to be retained, established, or promoted.
- Indicative stocking rates at various times of year, based on dry, wet or average climatic scenarios.
- An outline of trigger points for engaging slashing contractors, increasing stock numbers, or de-stocking the site.
- Month-by-month weed monitoring and control measures, including specific weed types for the location at various times of year and herbicide options.
- The timing of any required infrastructure upgrade or maintenance.

It is considered best practice to maintain groundcover to at least 70% coverage to prevent land degradation from erosion, weed problems, dust on panels, and neighbor conflict.

During the planning phase of a solar farm, an assessment of the state of vegetation on the site will likely be undertaken to inform an Environmental Impact Assessment. This information will provide a baseline of data that will help developers and graziers evaluate the success of their vegetation management against the objectives set out in the vegetation management plan.

Weed control

In areas of NSW where sheep will be suitable for grazing on large-scale solar farms, maintaining good pasture groundcover across the site is essential to the effective management of the site. Resources and expertise will be required to promote beneficial pastures and manage unwanted vegetation - predominantly broadleaf weeds such as thistles, stinging nettles, and capeweed. Solar companies should engage a professional adviser to identify and address weed incursions.

Preventing the spread of weeds is important for several reasons:

1. They are unpalatable to sheep and can affect wool quality, so will limit the capacity to run a viable grazing enterprise on site.
2. They will eventually overwhelm more desirable groundcover species, creating potential dust and land degradation issues.
3. Certain fast growing weed types will interfere with machinery on site and create an additional cost burden to keep below threshold vegetation height limits.
4. Managing weeds on site is necessary to prevent detrimental effects on neighbouring farms.
5. It may be a requirement under the company's environmental management plan.

This publication from the NSW Department of Primary Industries is a useful resource: Weed control for cropping and pastures in central west NSW

Invasive and noxious weed management may also be required from time to time. Weed types that graziers and solar companies need to work together to monitor, report and take action to eradicate are outlined by the NSW Department of Primary Industries here:

High risk weeds

Silverleaf nightshade requiring eradication

Weed control will require the application of chemical herbicides as part of a well-considered herbicide spray program. This may involve a broadly applied (via boom spray) selective herbicide targeted at controlling particular weeds that doesn't affect beneficial species, or specific weed spot spraying to control invasive weeds with glyphosate or other knock down herbicide. These measures will be best achieved after rain events when plants are actively growing and not suffering from moisture stress.

Weed control will be particularly important after summer rainfall events when annual pastures are dormant.

Solar operators will need to consult with landholders/graziers, agronomists and spray contractors about the appropriate herbicide application for specific weed types being targeted.

Solar operators should be aware of withholding periods applying to chemical use, which prevent sheep grazing on affected areas for a set period. The intended use of herbicides should be clearly communicated to graziers in advance of these activities.

Where solar farms have been established in areas of pre-existing grazing on native pastures (i.e. western NSW), weed control measures will be much less onerous.

Managing biosecurity risks

An important responsibility for solar developers and operators is to be well prepared for managing biosecurity threats. This requires understanding the risks (and responses) before land falls under their control, and understanding whether the farm has a biosecurity plan in place. The basic principle of 'come clean, go clean' should be at the core of biosecurity risk management plans.

A biosecurity risk management plan should be in place to address the introduction, presence or spread of plant pests or diseases, weeds and pest animals. Such a plan considers all potential biosecurity risks and identifies appropriate strategies to prevent, eliminate or minimise those risks, including measures such as plant and machinery inspections and vehicle decontamination before site entry.

Grazing agreements should include provisions for landowners, site managers, and graziers to communicate incursions immediately, so early action can be taken. Solar companies and their contracted asset managers should defer to graziers (and any lessor) about the need for taking necessary mitigation measures.

In NSW, the guiding legislation for land managers is the NSW Biosecurity Act 2015.

Further guidance on how to manage biosecurity risks can be found on the Department of Primary Industries and Regional Development website.

Biosecurity Management Plan

Managing biosecurity risks in land use planning and development guide

NSW Local Land Services: On Farm Biosecurity Planning Tips

Fire risk

Insurance companies will specify grass height limits to manage fire risk as per their policy terms. These policies often specify that grass heights should be maintained at or below a height of 100mm, which is subject to audit. Solar company policy holders (with landholders and/or graziers) should seek clarification about these requirements and how grass height is to be assessed. For instance:

- Will the limit be relaxed if the vegetation is still green and doesn't present a fire risk?
- Is the 100mm limit based on average height across the site?

Solar companies should seek to ensure that insurance company mandated limits reflect fire risk at any given time, and aren't applied before the fire season commences. Also, it will be impractical to limit the occurrence of isolated plants exceeding a 100mm limit at any given time, and average height assessments should apply.

Operators need to carefully consider how they manage the risk of weed and animal disease incursions on site.

Having a comprehensive vegetation management plan will help negotiate workable policy terms with insurers.

Operators should always consult with local fire authorities about appropriate risk management. The Country Fire Authority of Victoria has prepared a useful guide: CFA DGMR Renewable Energy Facilities v4

A key risk management strategy will be to control vegetation via the use of knock down or residual herbicides in the following targeted locations:

- Around inverters, transformers and substations to protect them from fire incursion.
- Along the strip underneath solar transmission infrastructure, to prevent ignition from electrical faults from connectors, fuse holders, cables, combiner boxes, etc.

Within grazing contract terms, graziers should be required to take reasonable measures to mitigate fire risks associated with their management activities. Mainly, this will involve restricting vehicle use across pastures during total fire ban days, where there may be opportunity for igniting vegetation.

Successful strip spraying within an array

Mechanical slashing

Vegetation management with sheep is preferable to mechanical slashing for several reasons:

1. Mechanical slashing is more expensive.
2. Residual cuttings can create fire risk and affect solar panel efficiency.
3. Slashing presents a higher risk of damage to infrastructure, either from operator error or projectiles.

However, there will be vegetation growth rates in excess of the capacity of a sheep grazing operation to maintain grass heights to threshold levels (typically 100mm). In the NSW temperate zone, this requirement will be most prevalent in spring, as warmer seasonal conditions and rainfall provide ideal conditions for vegetative growth. This circumstance will be highly variable; there may be 5-10 times the number of stock required to maintain grass heights to target levels in a wet spring than during a dry year. This will often not be practicable to implement, and a minimum of one spring mow will generally be required in most seasons.

Equipment should be used that has a mowing width that corresponds with the width of solar panel rows to ensure efficient coverage by minimising passes.

The timing of mechanical slashing should be guided by both grass height and pasture management requirements. There may be trade-offs between the need to control grass height and good pasture management that maintains the right pasture types in future years. If possible, mechanically slashing annual winter grass species during spring growth periods should account for grass seed set and regeneration, which will maintain beneficial vegetation species and limit the influence of unwanted weeds.

For the perennial lucerne option, consideration should be given to the detrimental effect of continuing slashing on plant viability. If lucerne is cut too low you can damage the crown and kill the plant, therefore reducing plant density and allowing weeds to take over. Some slashing gear that is used in general slashing operations is designed to cut too low for lucerne to recover properly.

Where solar farms have been established in areas of pre-existing grazing on native pastures (i.e. western NSW), care should be taken to avoid mechanical slashing that will jeopardise sustained regeneration of these species.

The section above on site trafficability outlined the issues that determine what grass slashing equipment can be used. For large solar paddocks, which require high use hours and navigating tougher vegetation than typical lawn mowing scenarios, a tractor with slasher is preferable. However, solar designs that limit trafficability may rule out this equipment as an option, and mowing equipment will be required.

Where mowers are required, there are trade-offs between the different commercial grade options. Flail mowers will be more durable than rotary blade mowers, which aren't designed for large scale areas and challenging vegetation. However, they can also generate additional debris, and the risk of panel damage.

Operators should consult with local advisers and contractors about the most suitable equipment for their own circumstances.

Annual grasses requiring mechanical slashing just prior to fire danger period

Combined vegetation management services

The best arrangement for reducing overall vegetation management costs involves a single provider delivering complete vegetation management services for a fixed fee, and they manage the mix of both grazing and slashing according to vegetation management targets. This includes grazing, mowing, herbicide applications, and associated labour costs.

In this scenario, the provider will be financially incentivised to utilise sheep grazing as much as possible and limit the more expensive requirement for mechanical slashing. This will reduce the cost otherwise incurred by contracting grazing and slashing separately, where incentives to mow are present where cheaper grazing options exist.

This arrangement may not always be feasible, particularly where the optimal grazier doesn't intend to provide slashing services.

Further information about the best service provision arrangements is included in the section below.

Re-sowing

If there is poor post construction pasture, sustained pasture degradation, or the widespread incursion of unwanted species, re-sowing preferred pasture species may be warranted. Solar operators should also be aware that sown pastures will have a finite life span of between 5-20 years, depending on species, management and climate conditions.

See the above section on pasture establishment for information about site preparation, pasture choice and establishment.

Re-sowing among solar panels will require specialist service providers with equipment that can prepare ground and re-sow pastures within the physical constraints of a solar farm. Smaller equipment is generally used that can be easily manoeuvred between rows.

Soil treatment

There may be a requirement to apply soil nutrition (fertiliser) and/or lime to address soil health issues - and ensure the viability of beneficial vegetation - before construction occurs. This will be determined by soil testing as part of ordinary due diligence and EIS requirements prior to development approval. An agricultural adviser (agronomist) should be engaged to assess soil test results and appropriate soil applications.

Post-construction – there are several issues that need to be considered by operators when deciding whether to agree to a grazier's request to apply fertiliser to pastures within a solar farm:

1. The nutritional benefits of fertiliser application can help sustain pasture groundcover over time.
2. Fertiliser applications are intended to stimulate more plant biomass, which may exacerbate grass height issues.
3. Synthetic fertilisers are often avoided by solar companies, as they may have a corrosive effect on poles supporting the array.
4. The best fertiliser option may be a liquid organic product.

These represent complex tradeoffs that will be balanced according to local conditions (climate and pastures) and site-specific requirements of operators and graziers. Advice should be taken from a qualified agronomist about fertiliser application options.

An agronomist should be engaged to assess soil test results and appropriate soil applications.

Carbon sequestration

Solar companies may seek to enter into carbon sequestration projects to meet Environmental, Social, Governance (ESG) requirements.

While there are carbon sequestration opportunities available where land use changes from cropping to pastures, these agreements should be undertaken only following extensive research and due diligence. Solar companies seeking to generate carbon credits from land management techniques should be satisfied that their carbon-based obligations are consistent with vegetation management objectives.

These opportunities are best suited to solar developments in locations with pre-existing native grasses, taking into account any conflict with vegetation height targets. In modified pastures, independent expertise should be sought to advise on proposed management changes to meet carbon objectives.

Summary

- ✓ Have a binding vegetation management plan
- ✓ Engage an independent agronomist, and base vegetation management decisions on their advice
- ✓ Fire risk should be managed by both operator and grazier adopting sensible risk management strategies
- ✓ Re-sowing may be required if pastures deteriorate
- ✓ Carbon sequestration projects add complexity to vegetation management
- ✓ Engaging sheep grazing and mechanical slashing from the one provider can help reduce costs

6. Sheep grazing agreement structure

There needs to be a clear and well-understood agreement between the responsible solar facility manager and graziers. The agreement should clearly outline the roles and responsibilities of the solar business responsible for vegetation management, and the grazier supplying sheep for site grazing.

Solar companies should understand that while a contractual agreement is important, the relationship with a grazier will only work with effective communication and an understanding of the requirements of agricultural production.

Key agreement principles

Contracting with a grazier should be based on these key principles:

1. Graziers are providing an important cost saving management tool.
2. Graziers won't place sheep on solar farms if it involves cost or inconvenience.
3. Site access for the grazier needs to be on a 24-hour per day basis.
4. Grazing infrastructure costs need to be met by the solar owner/developer and/or site operator.
5. Larger projects will be more appealing to graziers because their fixed costs can be spread across higher production revenue.
6. Liability for damage caused by sheep should not be imposed on graziers.
7. Operators should respect the knowledge and advice of graziers about vegetation management.
8. Companies and operators (if different entities) should align their budget allocation and economic incentives to ensure sheep grazing can be successfully implemented.

Grazing contracts should be drafted by qualified legal practitioners. The information contained in the section below provides a useful framework for ensuring key substantive issues are addressed within a standard legal contract.

Solar companies contracting with graziers should also provide a short-form, easy-to-read, version outlining key roles and responsibilities contained in the contract.

Service delivery models

There are several contractual models that may achieve lower cost vegetation management incorporating sheep grazing:

Three options require a separate grass slashing contract:

1. An agreement with the landowner to graze sheep on the site.
2. A neighbouring grazier with access to adjacent grazing areas.
3. A remote grazier with associated transport costs.

Two options integrate grazing and grass slashing by a single provider:

4. The grazier also undertakes slashing, and charges a per hectare rate for supplementary slashing services.
5. The grazier charges a fixed vegetation management cost, and manages a mix of grazing and slashing according to vegetation management targets.

The relationship with a grazier will only work with effective communication and an understanding of the requirements of agricultural production.

Terms of a grazing agreement – key provisions and recommendations

Note: a grazing agreement is a separate legal agreement from any leasing entered into by the solar facility owner (lessee), and the landholder (lessor).

General provisions:

Term (length) of the agreement.

Licence v. agistment agreements.

Payment terms – including contribution to grazier to meet transport costs from any increase or de-stocking request.

Liability for damage – normal sheep activity v. damage from negligence/omission of grazier and their contractors/employees.

Changes to the agreement.

Termination of agreement terms.

Requirement to operate in good faith as issues arise.

Prescribed contact details for site manager and grazier.

Grazier responsibilities:

Stocking rates in three scenarios: 1. Base level stocking rates 2. Increasing stock provisions during high grass growth. 3. De-stocking provisions during dry seasonal conditions.

Allowable sheep breeds and age, e.g. placid and low maintenance sheep breeds, no lambing, rams, etc.

Animal health requirements (crutching, drenching, shearing), removal of dead sheep within certain periods, etc.

Site access terms, notice of attendance, and following directions of site manager.

Organising transport of stock on and off site.

Allowable vehicle types to be used to muster sheep through the solar panels.

Removal of sheep to permit spraying and observe withholding periods.

Observing agreed communications protocols about site attendance, mustering activities, and sheep entry/exit.

Notify the company of invasive or harmful weed incursions.

Notify the company of any damage to infrastructure, whether from human or animal causes.

Liability for negligent activity causing asset damage and/or unsafe practices causing human harm.

Hold public liability insurance for $20 million (typically) and relevant workers compensation insurance.

Observing site rules about closing gates and cleaning up rubbish and debris.

Managing fire risk by not using vehicles on site during a total fire ban and complying with other fire safety requirements.

Equipment disposal at end of term.

Solar company/operator responsibilities:

Allowing reasonable access to undertake grazing management activities.

Responsibility for provision and upkeep of grazing infrastructure, including fences, water points, gates, handling yards, etc.

Observing agreed communications protocols about prior notice for stocking rate changes, necessary sheep movements to and from certain paddocks, impending weed spraying activities, hazardous events, sheep welfare issues.

Weed control.

Provision of dead animal disposal facility.

7. Example communications protocol

Format of communications	
Text message and email	
Prescribed contacts for required communication	
On-site operations manager	(Phone and email)
Grazier/landowner	(Phone and email)
Operator notification responsibilities	
De-stocking request	14 days (following consultation)
Request to increase stock	Subject to negotiation
Impending weed spraying	7 days
Observed sheep welfare issues	24 hours
Grazier notification/action responsibilities	
Site attendance	Notification prior to entry
Mustering between paddocks, sheep entry/exit	48 hours
Observed invasive or harmful weed incursions	24 hours
Damage to infrastructure from grazing activities	Immediate notification
Removal of dead sheep	24 hours
Attending to sick animals	48 hours
Scheduled meetings	
Annual vegetation management planning	August
Pasture management updates	Monthly

8. Checklist of professional advice

Action	Source of information and consultation
Vegetation management plan	Agronomist/landowner
Infrastructure layout	Livestock adviser/landowner
Pasture variety selection	Agronomist/landowner
Pasture sowing	Agronomist/sowing contractor
Biosecurity plan	Agronomist/landowner/grazier
Weed control	Agronomist/spray contractor/grazier
Fertiliser application	Agronomist/grazier
Grass cutting	Vegetation contractor/grazier
Carbon projects	Carbon specialists/landowner

Landholder/grazier guidelines

Benefits

1. Free grazing to complement other parts of the sheep enterprise.
2. Quality pasture access under panels, where there is reduced heat and wind.
3. Animal shelter and health benefits.

Common mistakes to avoid

1. Entering into an agreement with a solar developer that won't consult with agricultural experts during solar grazing design and implementation phases. Input from graziers and livestock experts is necessary for good vegetation management and animal health outcomes.
2. Not understanding the strict procedures and processes associated with accessing and working on a solar farm.
3. Having no plan increase or decrease stock as seasonal conditions arise.
4. Not properly assessing the trafficability and mustering options around the solar footprint.
5. Committing to a solar grazing agreement too far from the main property.
6. Stocking rate requirements that are unprofitable for transport cost, commodity price or other reasons.
7. Importing lice, footrot, or other biosecurity incursions.
8. Not understanding the solar farm's vegetation management agreements or budgetary constraints from the developer/owner.

Checklist of decisions

- [ ] If a host landholder, have you had input into the way the site has been developed to accommodate a sheep enterprise?
- [ ] If not the landowner, is the site suitable for a sheep enterprise? Considerations include paddock sizes, watering points, handling yards, pasture quality, consideration of the appropriate breed/sex of sheep for the solar farm etc.
- [ ] Can sheep be effectively mustered around the site? Are the vehicles you need to muster stock allowed on site?
- [ ] Are site access rights sufficient to attend to the flock as needed, at any time of day or night?
- [ ] Is it logistically and financially feasible? Will the stocking rate requirements in the agreement incur transport costs to get sheep on and off site? Can stock numbers be altered up or down when required?
- [ ] Will stock increase requirements require uncommercial stock purchasing decisions?
- [ ] Are you liable for damage outside your control?
- [ ] Are you able to work with the site operator/s?
- [ ] What are the arrangements in place for weed control and slashing when grass heights can't be managed by sheep?
- [ ] What are my Livestock Production Assurance declaration and risk assessment obligations when grazing sheep under solar panels?

*These suggestions are separate to leasing agreements between a lessor landholder and lessee solar company.

A landholder leasing part or all of their property to a solar company should be seeking legal advice on the terms of any leasing agreement before entering into any contract.

This should include a pre- and post-construction vegetation management plan binding on the solar company lessee.

A useful guide for farmers entering into a solar development agreement is here: www.aeic.gov.au/publications/considerations-landholders-entering-commercial-agreements

Entering into a grazing contract

Suggestions from Tom Warren, grazier

- Grazing is a service provided to solar companies, and sheep access should be free or paid for by the solar operator.
- Graziers should accept that solar operators don't want certain sheep breeds that increase risk of equipment damage.
- Check that proper farm infrastructure is in place to sustain sheep (water, fencing, gates, yards), or there is a commitment from the operator to install them.
- Grazier liability for damage should only be where negligent conduct has occurred, not from sheep damage.
- Make sure that the site doesn't have exposed infrastructure (cables and other machinery) that will cause problems.
- Discuss strategies for the timing of stock number increases, weed control, use of fertiliser and chemicals, and biosecurity measures before entering into an agreement.
- Confirm communication/notification requirements of both parties about chemical and fertiliser use, animal health issues, and infrastructure damage.

For more information about grazing contract terms and communications protocols, see sections 6 and 7 in the industry guidelines above.

Horticulture and crops under solar

Photo courtesy of Fraunhofer ISE

Horticulture and solar – Guidance for considering opportunity and risk

Food security, renewable energy and decarbonisation are interconnected goals, however the concept of integrating solar panels over horticulture and cropping is still emerging in Australia. In contrast, many other countries have been growing crops beneath solar for decades.

In these agrivoltaics systems, food production is the primary purpose for the land and is complemented by solar, as opposed to energy generation being the primary land use as it is for solar grazing sites. One key reason is that stilted agrivoltaic systems typically require 20 to 40% more land to produce the same amount of energy as traditional ground-mounted solar systems.

This section of the Handbook provides guidance for solar developers and farmers interested in exploring small to mid-scale agrivoltaic systems for growing crops and horticulture under solar panels. Limited examples of solar over horticulture or crops exist in Australia, with more research required to progress the industry. While this form of agrivoltaics holds significant potential, the practice is still evolving, and as such, this section is not intended to be a definitive guide but rather a resource to raise awareness of some of the issues, risks and opportunities in agrivoltaics systems and how it relates to an individual's own circumstances.

Photo courtesy of BayWa r.e.

The opportunity in Australia

Australia holds considerable potential for agrivoltaics in horticultural regions, particularly with sub-5MW solar developments connected to the mid-voltage distribution network. These systems can provide behind-the-meter power to farm operations, while exporting excess energy at other times. Use of power produced by agrivoltaics behind-the-meter is particularly attractive when the network reliability around the farm is poor, adding to the business case for solar over crops.

While international experiences offer valuable insights, substantial research tailored to Australian conditions is still needed. The 2023 report, Pursuing an Agrivoltaic Future in Australia, outlines specific research needed for successful implementation.

Photo courtesy of SolarGik

Agrivoltaic benefits for crops and the energy transition*

Benefits for the energy transition

The successful deployment of agrivoltaics would help address the perception that Australia's energy transition will come at the expense of agricultural land.

Agrivoltaics creates secondary incomes for farmers exporting renewable energy to the grid, or used behind the meter, cutting expensive power bills for farming operations.

It can also create jobs in both sectors (however usually shorter term for solar), which supports local economies.

There is further opportunity for agrivoltaics to create localised food processing or manufacturing run on renewable energy, generated across farms nearby. This could support job creation, reduce the need for grid upgrades to carry power long distances, and set up regionally based decarbonisation hubs and circular economies.

Higher yields

International studies suggest enhanced crop yields in the case of certain produce that tolerate shade well, such as berries, fruit trees (apples, pears and soft fruits), asparagus, garlic, hops, lettuce and leafy greens. In Australia, however, excess shading in apple canopies can lead to a reduced level of bud fruitfulness, excess vegetative growth (which perpetuates the shading) and challenges with red colour development in fruit. Existing hail netting covers reduce PAR by 10-20% depending on colour and weave. This can cause problems in trees that already have significant shading due to their dense foliage. More research is required to understand which crops in Australia are best suited to agrivoltaics systems.

Plant protection

Solar panels can help safeguard fragile fruits, such as berries, against frost and hail damage.

Elevated solar systems can also be used as the supports for nets, if installed between panel rows, providing protection to crops against pests and disease.[1]

* Taken largely from international research.

[1] SPE Agri Solar Best Practice Guide https://api.solarpowereurope.org/uploads/SPE_Agrisolar_Best_Practices_Guidelines_cefc915769.pdf

Worker health and safety for farm employees

Agrivoltaics can improve working conditions for farm staff, providing shaded, cooler conditions for workers harvesting berries in summer.

Extended growing season

The presence of solar panels can create a more even growing environment (e.g. less fluctuations of temperature), allowing for extended harvest and growing periods.

Irrigation efficiency

Shaded areas may require less water for irrigation, which is particularly beneficial in arid regions with some studies recording reduced irrigation requirements by up to 20%.[2]

Microclimate improvement

Solar panels can provide temperature regulation through shade and protecting crops from excessive heat. Solar over vineyards in countries such as Italy[3] has demonstrated benefits to the sugar and alcohol content of grapes given the fruit's sensitivity to hot weather.

Soil preservation

Depending on the design, the presence of solar panels can help protect soil from erosion and degradation, particularly in windy, dry conditions.

Grid efficiency and increased locations for renewables

Agrivoltaics could enable better use of the distribution network allowing more landholders to contribute to the renewable energy transition. Smaller 1–5MW solar systems in horticultural areas increase the opportunities for siting renewables closer to load centres (cities or industry). The ability to export to the grid will depend on the location of the farm property and a study will be required to assess grid capacity in the area.

These systems also present an opportunity to be coupled with grid scale batteries in areas of grid instability which would support local network reliability.

[2] Y. Elamri, B. Cheviron, J.-M. Lopez, C. Dejean, and G. Belaud, Agricultural Water Management 208 (2018).
[3] www.vinetur.com/en/2024092181827/a-revolutionary-project-installs-solar-panels-on-vineyards.html

International experiences

Japan cultivates around 120 different crops in agrivoltaics systems, including rice, cereals, vegetables, mushrooms, fruit, tea, coffee, and ornamental flowers.

This practice is driven by land scarcity and is incentivised through feed-in premiums, which offer financial benefits to developers and farmers depending on the business model, underpinning the commitment to maintaining agricultural productivity alongside solar energy generation.

Japanese agrivoltaic systems must ensure at least 80% of agricultural yield is maintained post installation of solar assets, with panels required to be installed at a height of at least 2m, allowing sufficient light for crops beneath.[4]

Other countries such as Germany, France and Italy have established their own agrivoltaics standards to ensure certain outcomes for agriculture while the land is also used to produce energy.

Agrivoltaic incentives have been used in the US to encourage adoption, including in Massachusetts where higher feed-in tariffs (rates up to $0.06/kWh) are offered to projects incorporating elevated panels and farming.[5]

[4] www.sciencedirect.com/science/article/abs/pii/S0306261924016556
[5] www.sciencedirect.com/science/article/abs/pii/S0306261924016556

Business Models for Agrivoltaics

There are several business models for agrivoltaics although typically, farmers do not own or operate the solar systems. Instead, they earn payments for the electricity generated or lease their land to solar developers.

Typical characteristics of this include:

- All risks and costs related to energy generation and infrastructure are the responsibility of the solar developer.
- Costs and risks related to farming activity are the responsibility of the landholder/farmer.[6]

A beneficial scenario occurs when the farmer has significant on-site energy needs, such as those in wineries, dairies or food processing, and can procure energy through a Power Purchase Agreement (PPA) with the solar developer or use the power behind the meter before it is exported. Placing solar over crops is relevant here if shed rooftop space is limited or structurally unsuitable for multiple solar panels.

Solar Power Europe have a new AgriSolar Handbook, which covers a few of the more common business models being adopted, however these do not always translate to the Australian context.

[6] Agrisolar Handbook

Photo courtesy of Fraunhofer ISE

Overview of technologies

Different types

Elevated solar structures

Agrivoltaic systems in countries such as France and Japan, are often mounted on elevated supports usually 2–5m above the ground. While these systems can be more expensive, they enable tractors to move around below, cater to taller crops beneath, and allow more even light distribution reaching the plants beneath.

A site in France, developed by Sun'Agri, is trialling the effect of elevated solar panels over a 10-year-old Golden Delicious apple orchard. The tracker panel solar system built in 2019 has rows that are 4m apart and panels that are 4.5m high to allow machinery to pass through. The light interception of plants is 40% and the orientation of the tracker panels adjusts according to the apple orchard's needs.[7]

Results indicate that the apple trees experienced 63% less water stress than those on the control plot and cooler temperatures were maintained under the panels (ranging from 2°C to 4°C cooler).

[7] Sun'Agri, (2020) Arboriculture: La Pugere. https://sunagri.fr/en/project/the-la-pugere-experimental-station

Photo courtesy of AgRack - Midwest Agrivoltaic Systems

Ground mounted solar panels

Research in the US suggests kale, chard, broccoli[8], jalapenos and tomatoes[9] can be successfully grown under and around ground-mounted solar panels.[10] Generally, this form of agrivoltaics is where farming activity takes place between the rows of solar panels rather than under.

At the University of California, research evaluated how different levels of shade from ground-mounted solar tracker panels affect various leafy green vegetables. The study revealed that crops such as kale, chard, and tomatoes thrive well under moderate shade, achieving similar harvestable biomass when Photosynthetically Active Radiation (PAR) was 55% or higher. In contrast, broccoli, capsicum, and spinach demonstrated lower shade tolerance, needing at least 85% full sun exposure to perform optimally. Notably, broccoli showed improved results under 85% PAR compared with full sunlight.

In Australia, apples, pears and cherries would have similar PAR needs to maintain bud fruitfulness and produce quality fruit.

These findings highlight the importance of both the design of solar systems and the selection of crops in agrivoltaic systems. Choosing shade-tolerant crops that thrive in the local environment can significantly boost productivity.[11]

8 Hudelson, T (2020) Conference Crop Production in Partial Shade of Solar Photovoltaic Panels

9 Barron-Gafford et al. (2019) Agrivoltaics provide mutual benefits across the food-energy-water nexus in drylands

10 https://assets.cleanenergycouncil.org.au/documents/resources/reports/agrisolar-guide/Australian-guide-to-agrisolar-for-large-scale-solar.pdf

11 National Renewable Energy Laboratory, (2020) Capital Costs for Dual-Use Photovoltaic Installations: 2020 Benchmark for Ground-Mounted PV Systems with Pollinator-Friendly Vegetation, Grazing and Crops.
www.nrel.gov/docs/fy21osti/77811.pdf

Tracking Systems

Dual-axis tracking solar panels offer the flexibility to prioritise either the needs of the crops or to optimise energy generation. The more sophisticated tracking systems use light, soil moisture and cloud sensors to optimise energy production while also ensuring crops are receiving optimal light or protection.

One such system, the US based Solargik Agri PV Tracker, integrates crop models, tracker and inverter data with agricultural sensors to tilt panels to allow the plants below to receive the light needed.[12]

Some of these systems, however, come with higher costs and, when using large panels, may create excessive permanent shade underneath, making them less suitable for use over crops.[13]

[12] www.solargik.com/wp-content/uploads/2023/11/Agri-PV-Technical-Spec-2023-Ver2.pdf

[13] Agrivoltaics: Opportunities for Agriculture and the Energy Transition
A Guideline for Germany | February 2024 Fraunhofer ISE

Photo courtesy of SolarGik

"While tracking systems can produce 45% more power, there is a higher need for maintenance as moving parts create risks of failures. Farmers generally would prefer not to have solar operation employees on site to fix issues, so fixed bi-facial panels are a good alternative for agrivoltaics systems as they produce 30% more power than conventional panels, so you're only missing out on 15% by not using tracking systems."

Tyler Lloyd, Midwest Agrivoltaic Systems (MAS), US

Solar systems with a single-axis orientation can tilt their panels nearly vertically. This allows the panels to align either with the sun's rays or with the direction of rainfall. Alternatively, panels can be positioned parallel to the sun to create shade or shelter for the crops growing beneath them.[14]

Dual and single axis tracking systems are more sensitive to wind effects, so care should be taken in the design phase to ensure the structures can withstand heavy winds especially if used at height.

[14] SPE Agri Solar Best Practice Guide
https://api.solarpowereurope.org/uploads/SPE_Agrisolar_Best_Practices_Guidelines_cefc915769.pdf

Types of Photovoltaic Panels

In principle, all types of solar photovoltaic (PV) panels can be utilised in agrivoltaic systems.

Currently, wafer-based silicon solar cells dominate the global PV market, comprising around 95% of total installations. These panels typically feature a glass front and a white covering film on the back. Opaque solar cells are connected and laminated in series between these layers with a spacing of 2-3mm, and a metal frame is employed for mounting and stabilisation.[15]

Light Transmission and Panel Design

Solar panels with a transparent back cover, be it glass or film, allow light to pass through the spaces between the cells, thereby benefiting the crops below.

Commonly used solar panels have gaps between the cells that constitute about 4-5% of the surface area.

To enhance light transmission, these spaces can be widened and conventional frames can be replaced with clamp mountings. Panels designed with a higher ratio of transparent area will maximise available light for crops.[16] These panels may work with the next generation of narrow orchards in Australia, as many current orchards do not have sufficiently open canopies to make this work if retrofitted.

Semi-transparent solar panels. Photo courtesy of Fraunhofer ISE

15 Agrivoltaics: Opportunities for Agriculture and the Energy Transition A Guideline for Germany | February 2024 Fraunhofer ISE

16 Agrivoltaics: Opportunities for Agriculture and the Energy Transition A Guideline for Germany | February 2024 Fraunhofer ISE

Transparent solar panels

Panels that are transparent or semi-transparent are proving to be a strong solution for agrivoltaics systems. Field research conducted by Colorado State University has demonstrated that the vegetables jalapeño pepper, bell pepper, lettuce, Tasmanian chocolate tomatoes, and red racer tomatoes had equal or higher yields under transparent and semi-transparent panels, whereas the summer squash crop reduced yields under all of the panels tested.[17]

Companies like ClearVue have created solar glass with 90% transparency for use in greenhouses, on the vertical walls and rooftops. A high transparency would benefit cherry orchards, acting as a complete cover to help mitigate risk of rain cracking of fruit in the approach to harvest. However, transparent solar panels can have lower energy efficiency compared with traditional opaque solar panels.

Bifacial PV Panels

Bifacial PV panels are capable of utilising light that strikes their reverse side to generate additional electricity. These panels can boost electricity yields by as much as 25%.

Photo courtesy of AgRack – MAS – bifacial solar panels

[17] www.sciencedirect.com/science/article/pii/S2405844024120890#tbl1

Colour shifting technology

Red light is the most effective colour used for photosynthesis in plants. Plants contain two important pigments, chlorophyll a and chlorophyll b, which absorb light mainly in the blue and red parts of the spectrum.[18]

US company Soliculture uses LUMO technology, which combines transparent photovoltaic technology with luminescent red light for electricity generation and optimised plant growth.

Results from Soliculture's research on colour shifting technology include:

- Herbs: up to 50% higher yields.
- Lettuce: One week faster time to harvest.
- Chives: 20% higher yields.
- Cucumbers: Longer harvest times, greater disease resistance.
- Tomatoes: Equivalent yields.[19]

Photos courtesy of Soliculture

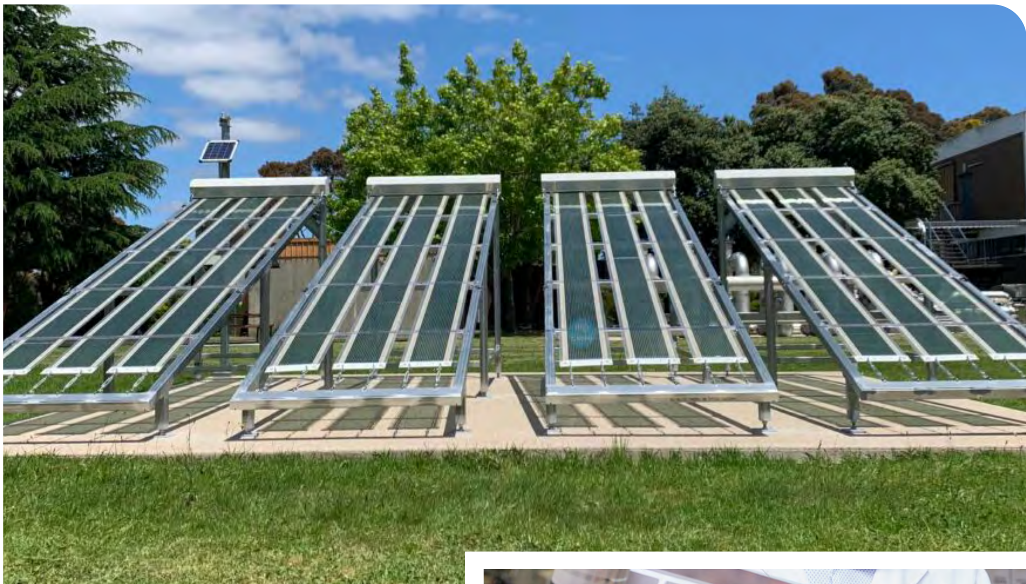
[18] www.soliculture.com/lumo-technology
[19] www.soliculture.com/plant-response

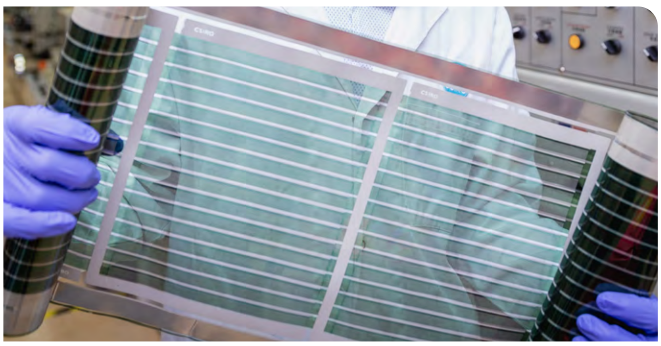
Future innovations

Thin-Film PV

Thin-film PV panels offer flexibility in installation and can be adapted to various structures, including cylindrical forms and polytunnels. While thin-film PV generally exhibits lower efficiency compared with traditional silicon panels, their versatility can make them suitable for specific agrivoltaic applications (see the protected cropping map link).[20]

Longevity of thin-film PV can be an issue, so it is worth checking on the lifespan when making decisions and considering disposal/waste issues. CSIRO have developed a thin-film solar cell that could be used on greenhouses or instead of poly tunnels, and research on the application is ongoing.





**Thin-film PV.
Photos courtesy of CSIRO**

[20] Agrivoltaics: Opportunities for Agriculture and the Energy Transition
A Guideline for Germany | February 2024 Fraunhofer ISE

Project considerations

The agrivoltaic industry in Australia is still in its early stages, with ongoing research, pilot projects and demonstration trials needed to pave the way forward. To drive progress, Australia needs innovative thinkers and greater knowledge sharing within the sector. However, it's crucial to start small e.g. begin by trialing agrivoltaic systems on limited areas of crops before scaling up.

Successful agrivoltaic systems also require meaningful conversations between farmers and solar developers. Understanding each other's objectives, then agreeing on joint goals, and aiming to meet the needs of all parties will result in better long-term outcomes.

Agrivoltaic systems in horticulture can either be installed in existing horticultural farms, or crops can be grown in greenfield developments, between ground-mounted rows of panels.

Semi-transparent solar panels.
Photo courtesy of Fraunhofer ISE

Retrofitting solar to existing horticultural farms

When adding solar to an existing horticultural farm, solar developers need to understand the current operations of the farm, growing seasons, harvesting, and maintenance equipment. Familiarity with the types of harvesting equipment needed, and how harvesting activity could impact the solar infrastructure, will help identify potential risks to mitigate.

Farmers, in turn, should be aware of the trade-offs involved, such as potential changes in agricultural production under solar panels, shifts in production costs, and modifications to on-farm practices. This understanding is crucial for evaluating the viability of agrivoltaics on their property. Additionally, factoring in lease payments and their financial benefits will provide a comprehensive view of the overall impact on the farm's bottom line.

Given the nascent nature of agrivoltaics in Australia, it would be wise to pilot smaller-scale systems on a portion of the crop first. This approach allows for the assessment of impacts on plant health, soil and the microclimate before committing to solar coverage across the entire farm.

Relevant University programs

Crop health assistance

Adelaide University

Grapevine physiology (including grape biochemistry and effects on wine making quality), plus to a limited degree, assessments of solar on the effects in other horticultural crops.

Contact: School of Agriculture, Food and Wine, Waite Campus
https://set.adelaide.edu.au/agriculture-food-wine

Melbourne University

Research can be undertaken on changes in crop performance and microclimates.

Contact: School of Agriculture, Food and Ecosystem Sciences (SAFES) | Faculty of Science
https://safes.unimelb.edu.au

Technical assistance

University of NSW

For Agri-PV technology, including technologies available or Agri-PV trials in other counties, contact the School for Photovoltaic and Renewable Energy Engineering (SPREE) at UNSW.

Contact: UNSW School of Photovoltaic & Renewable Energy Engineering

www.unsw.edu.au/engineering/our-schools/photovoltaic-and-renewable-energy-engineering

Greenfield solar developments

The rise in large-scale solar developments in regional Australia could also unlock the opportunity to increase the variety of food produced in different localities.

While climatic and soil data will help determine what crops are suited to the area, exploring what types of horticultural enterprises exist nearby and speaking to the landholder, local farming or Landcare group, will aid decision making.

Photo courtesy of Sunfarming

Understanding shade, solar and farming interactions

Impact of solar radiation on plant growth

Plant growth is maximised when adequate light availability and homogeneity is prioritised, which in turn is influenced by agrivoltaic system design, such as distance and orientation of solar panels.

Most plants will not use all the sunlight they receive on any given day and will reach light saturation where more light will not increase photosynthesis. In many crops, an upper leaf would be saturated at around 32,000 lux (lux being the measurement of the total amount of light seen on a surface at a set distance). However, because of shadowing of lower leaves, light levels of around 100,000 lux might be necessary for the whole plant to become light saturated.[21] Hence, partial shade from solar panels does not always negatively impact plant growth.

For light-sensitive crops, project developers and farmers should assess the light intensity - in some cases the degree of shading - and the light homogeneity of any solar system to understand possible impacts on crops. Further information for understanding light intensity can be found on the NSW Department of Primary Industries and Regional Development page.

Measuring light intensity can be done through measuring the PAR which is part of the light spectrum used for photosynthesis and plant growth. PAR sensors can be bought to assist with this.

Solar panel spacing

The spacing of solar panels is crucial in agrivoltaic systems to balance crop growth and energy production. Panels must be positioned to allow sufficient sunlight for crops, with the ideal distance varying by crop type, climate, and location. Too-close spacing can cause excessive shading, harming crops like tomatoes that need more sunlight, whereas some breeds of leafy greens that thrive in partial shade, benefit from closer spacing of the panels.[22]

[21] www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/119365/light-in-greenhouse.pdf

[22] Best Practices in Agrisolar, Agrisolar clearing house, 2025

Temperature effects

Soil temperatures are typically reduced in agrivoltaics systems, which can benefit root health and moisture retention. Air temperatures may also decrease slightly in hot climates.

Panels can also increase humidity and fungus growth in certain climates, so a thorough understanding of associated risks to plants and what is needed to counteract fungus is necessary.

Wind dynamics

Wind speed dynamics are contingent upon the orientation and design of the agrivoltaic system. Depending on these factors, wind speeds may either increase or decrease under the panels. It is essential to consider potential wind tunnel effects and their implications for plant growth during the planning and design phase.

Soil and air moisture

Shade from panels can help retain moisture in the soil, benefitting crop health particularly in dry climates. Additionally, the air moisture levels can increase beneath the panels, generally creating a more favourable environment for plant growth, however, as mentioned, could result in increases in fungus growth from higher humidity.

Depending on the crop (e.g. established perennial), measures should be taken to minimise soil disturbance during construction and decommissioning, focusing on reducing compaction and land movement. Constructing the solar system when the ground is dry can reduce damage.[23]

[23] SPE Agri Solar Best Practice Guide
https://api.solarpowereurope.org/uploads/SPE_Agrisolar_Best_Practices_Guidelines_cefc915769.pdf

Height

The height of the supports for the solar panels plays a critical role in the microclimate beneath the panels. Lower supports can lead to more extreme light and shade ratios and microclimatic changes which may affect plant growth.

Ideally solar panels are elevated 3–5m above the crop, depending on what is being grown and farm equipment used. This height produces a more even distribution of light for the plants growing under the solar panels but can be more expensive than lower supports.

Panel tilt

The best panel tilt will depend on the agricultural activity, the panel size, the typical weather conditions, and the windward side profiles of the project site. Being able to change panel tilt can add extra flexibility, bringing benefits for both agricultural and electricity generation activities, however, they increase operation complexity and installation costs.[24]

Row distance

The distance between rows will depend on the agricultural activity and should provide enough space for workers and farm machinery to easily and safely move around.

If developing on existing horticultural farms, the farm layout will determine the spacing of solar panel rows.

In new developments, it is important for farmers and developers to discuss the potential needs of the crops and consider the equipment used for sowing, harvest, and spraying as this will help decide the optimum distance between rows.

[24] SPE Agri Solar Best Practice Guide
https://api.solarpowereurope.org/uploads/SPE_Agrisolar_Best_Practices_Guidelines_cefc915769.pdf

Foundations and mounting structures

To preserve the soil structures and reduce disturbance, piled or screw foundations are preferable to concrete foundations for agrivoltaics anchoring systems.

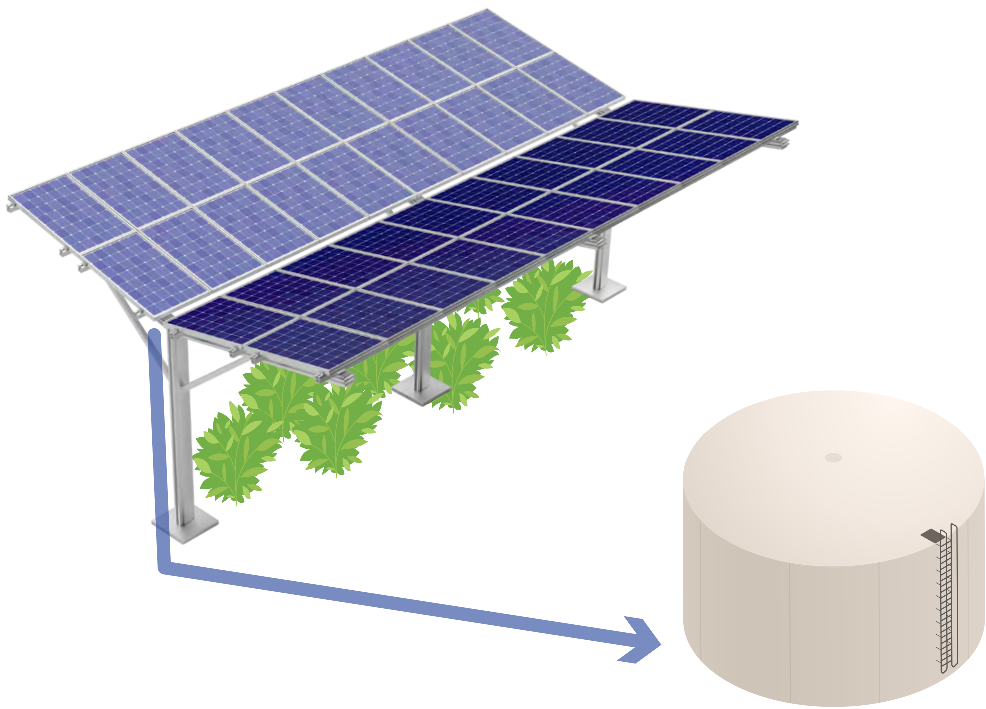
The AgRack system in the US uses extremely large piles, to avoid ground disturbance and the use of concrete, which can be difficult to remove at decommissioning.

Erosion and water

Ideally rainwater is distributed evenly to crops below. However, with fixed tilt panels, water running off the edges of large solar panels can create soil disturbance and erosion underneath. The use of narrow panels can reduce the volume of water collecting or running off panels.

Integrating a rainwater capture system beneath solar panels can enhance water independence and irrigation systems. This solution is especially beneficial in regions where establishing groundwater bores may be challenging or where crops demand significant irrigation.

Constructing fixed solar panels in a V shape can aid collection of rainwater if the right pipes and tanks are set up.



Considerations and checklists of decisions

Considerations for solar developers

Site selection

- Are any existing crops grown in the area suitable for partial shade? Crops found to be suitable for agrivoltaics include berries, some fruit trees (e.g. soft fruits), asparagus, garlic, hops, and leafy greens such as lettuce.

- Is the site on a part of the distribution network that has capacity for export? Are there export limits in the area? What is the capacity of the transformer on the farm and is augmentation required? Can power be used on the farm first (behind the meter) to cut costs for the farmer?

- If new overhead powerlines and power poles are needed, ensure pole placement and the height of the wires do not interfere with the ability to access the land with harvesting equipment and tractors.

- Check what regulations need to be adhered to with the local council. Local governments have planning schemes that dictate land use, with agrivoltaics falling under agricultural, industrial, or renewable energy zones, depending on the area. Check the specific zoning classifications and allowable uses as well as development application requirements.

Talking to the landholder to understand the farm

- What are the landholder's equipment heights?

- Discuss what the best solar panel height and spacing would be to optimise crop yield and energy generation. The rows should also provide sufficient space for workers and farm machinery to safely carry out their work.

- Check for any land tax/zoning implications or insurance changes due to the addition of energy generation to the farm.

- What is the current access to the site and are alternatives needed? How can additional access roads/points benefit the landholder?

- In certain situations, solar developers may need to have staff accompany the farm team while on-site, particularly at larger industrial locations. When drafting site access agreements, it's standard practice to define a minimum clearance distance to ensure that panels, junction boxes, disconnect boxes, wiring bundles, and inverters remain untouched.[25] The AgriSolar Clearinghouse 'Best Practices in Agrisolar' Guide includes recommendations of what should be considered in site access agreements. It covers training and education, personal protective equipment, communication and emergency preparedness.

Design and construction

- One of the key considerations in agrivoltaic systems is preventing mechanical damage to the solar panels or cables caused by farm machinery. Cables and cable tranches should be installed at a safe depth (of at least 1m) to avoid any damage caused by farming activities such as ploughing. It's good practice to reduce the number of cables in the ground. Instead, cables should be secured under panel roofs, alongside the mounting structure. In addition to protecting from mechanical damage, cables are away from direct rain or sun exposure, increasing the lifespan of the system.[26]

- Rainwater running off the edges of solar panels can lead to soil erosion, especially in areas where the soil is disturbed and bare. To mitigate this risk, implement erosion control methods such as temporary access matting, hay mulch, or similar materials. These measures will help protect the soil until ground cover/ crops are fully established, and should be included in any groundcover management plan.

- Encourage runoff to flow as sheet flow from the solar panels across vegetated areas. If concentrated flows are unavoidable, ensure proper design and construction of features like shallow channels, raised areas, and level spreaders, along with regular maintenance to manage water effectively.[27]

- Talk to the farmer to ascertain the best time of the year for construction, avoiding busy periods such as planting, pruning, and harvesting.
- If panels are elevated, what workplace health and safety measures are required to ensure workers maintaining the system are not put at unnecessary risk?
- Use construction techniques that minimise soil disturbance, such as directional drilling rather than excavating/trenching.[28]

Operations and maintenance

- Maintenance schedules and repair work need to be agreed ahead of time, in an operations and maintenance plan sent to the farmer and agreed to.
- Be aware that cleaning of panels to remove dust may be required more regularly due to the cultivation of soils, especially in drier climates.
- Discuss and agree with the farmer how farm operations will be integrated once the solar development has been installed, including how far in advance operational scheduling needs to be known/agreed.

Decommissioning

- Ensure a comprehensive decommissioning plan is agreed upon and provided to the farmer.

[25] Best Practice in Agrisolar, Agrisolar Clearing House 2025
[26] SPE Agri Solar Best Practice Guide https://api.solarpowereurope.org/uploads/SPE_Agrisolar_Best_Practices_Guidelines_cefc915769.pdf
[27] DACF solar guidelines www.maine.gov/dacf/ard/resources/docs/dacf-solar-guidance-182021.pdf
[28] DACF solar guidelines www.maine.gov/dacf/ard/resources/docs/dacf-solar-guidance-182021.pdf

Considerations for landholders

As agrivoltaic systems over horticulture and cropping in Australia are in their infancy, the design and build will be unique to each farm's circumstances, farming systems, region and position on the grid.

Don't be constrained by expected outcomes or traditional opportunities for what crops can be grown where. Cooler temperatures and higher soil moisture typical of agrivoltaic systems, can create favourable new environments for crops that previously didn't thrive in open field conditions. Seek advice from agronomists or the Department of Agriculture, research organisations, or groups such as Hort Innovation.

Include a risk-sharing component in any agreements or contracts. Outline expected outcomes for both parties, and establish clear processes for addressing situations where those expectations are not met. This ensures both sides are protected and have a clear path forward in case challenges arise.

The following checklist assumes the most common arrangement where the farmer does not own or operate the solar system but receives an income from leasing their land. The considerations apply to elevated solar panels or inter-row cropping rather than greenhouses with solar roofs.

Do your due diligence

Given the emerging nature of solar over horticultural crops in Australia, there may not be many developers with experience in this area. As solar over crops generally prioritise food production over energy generation, it's important to have clear discussions early on and ensure developers:

- either understand or are willing to understand farming practices.
- include a risk-sharing component in any agreements or contract.
- outline expected outcomes for both parties, and establish clear processes for addressing situations where those expectations are not met. This ensures both sides are protected and have a clear path forward in case challenges arise.

Farmers should undertake their own due diligence to understand the currently available research for your crop and the knowledge that still needs to be developed.

Leveraging external funding for the development will help to mitigate risks for both parties.

- [ ] Check for changes to insurance premiums and determine who is responsible. Are there any impacts on neighbouring property's insurance?
- [ ] It's important to let those who have an interest in your farm know your plans and consult with them regarding possible impacts. This may include your insurer, agronomist, neighbours, local farming system groups, government (such as NSW Department of Primary Industries and Regional Development, Local Land Services), local distribution network (if wanting to export power, although the developer would usually manage this) and local electricians (if wanting to use energy for farm operations behind the meter).
- [ ] Prior to beginning work, ensure boundary lines, harvest objectives, and post-construction conditions have been discussed and agreed to with the solar developer and any subcontractors.
- [ ] Walk the property with the solar developer, their subcontractors, and other relevant professionals (such as agronomists, engineers, council and state officials) to identify important features of the site, such as seasonally wet areas, steep slopes, invasive plants, irrigation equipment, and poorly drained soils.

  Farm workers or managers could also be included in the walk to ensure they are aware of changes and can provide insights into operational aspects of the farm.
- [ ] Discuss protocols for biosecurity measures, water crossings, roads, landings, and for protecting water bodies or drainage lines during construction and operation.
- [ ] Gather information on what formal studies may be required (depending on the size of the project) such as the Aboriginal Heritage Impact Permit (AHIP). The AHIP is sometimes required depending on the project. It is critical that farmers are involved in discussions and site visits when these are undertaken to ensure accuracy with findings.
- [ ] Document the soil profile of the land prior to any solar construction as this will be crucial for land restoration following the project's lifespan. Keeping this information up to date is beneficial, as landowner needs and interests may evolve over time, particularly with changes in ownership.[29]
- [ ] Seek advice from your accountant and understand whether income earnt (from leasing the land) will be considered off-farm and whether there are tax implications.
- [ ] Find out whether land classification or council rates change.

[29] DACF solar guidelines
www.maine.gov/dacf/ard/resources/docs/dacf-solar-guidance-182021.pdf

Integrating agrivoltaics with the farm

- Will the height of current farm equipment safely fit under the proposed height of the mounting system for the panels?
- What parts of the farm are easiest to access for solar contractors? Will new roads be required?
- What chemicals are sprayed on crops, and have they been approved for use near the solar panels?
- How large will the solar structures be? What space is required and how will it impact existing farm structures such as trellis or vineyards?
- Consider the microclimates created by agrivoltaics systems. For example, in multi-row cropping systems, one row may be exposed to direct sunlight in the morning, while other rows receive sunlight later in the day when temperatures exceed thermal optimum for plant growth. Planting shade tolerant or temperature-sensitive crops in rows that receive morning sunlight and heat resistant, sun loving plants in rows exposed to afternoon sun will create better outcomes.[30]

Photo courtesy of Fraunhofer ISE

Construction

- Ensure the solar company are responsible for removal and recycling of waste after and during construction.
- Consider the future needs and operations of the property. Where would roads be best placed? Is there fire suppression access?
- Consider the timing of construction and how it may interfere with current activities on the land. Will it impact crop production and harvest activities on adjacent land? Would it create limitations on access to other land or equipment?[31]

Maintenance and operations of the solar farm

- Review the operations and maintenance agreement with the solar developer to understand who is responsible for what activities during and after construction. Generally, the solar developer should be solely responsible for monitoring, remediation, and maintenance. However, if potential damage arises due to agricultural practices implemented by the farmer, responsibility may shift accordingly.[32]
- Ensure it is clear in any agreement that access for the farmer to their crops is 24 hours, 7 days a week.
- Be aware that solar infrastructure can also create challenges for farm workers, such as awareness of height if working underneath the panels, picking trellised produce where height changes, and working around electrical equipment.
- Will the solar company clean panels regularly and what detergents/chemicals are used? This can contaminate food and feed, so must be understood early on.

[30] Best Practice in Agrisolar, Agrisolar Clearing House 2025

[31] DACF solar guidelines
www.maine.gov/dacf/ard/resources/docs/dacf-solar-guidance-182021.pdf

[32] DACF solar guidelines
www.maine.gov/dacf/ard/resources/docs/dacf-solar-guidance-182021.pdf

Decommissioning

- Decommissioning arrangements need to be in accordance with EIS or DA approvals.
- Ask the solar developer for a decommissioning plan as part of any agreement. The plan should identify when a project is considered abandoned (the solar system is no longer operational) and a timeframe for completion of decommissioning. The plan should also identify that the solar developer is responsible for the costs of decommissioning and how this work will be funded (e.g. trusts, surety bonds, or letters of credit). The developer should inform the landowner before beginning any decommissioning activities or when an update to the decommissioning plan is required.[33] The plan should include:
  1. Above-ground structure removal and recycling/disposal.
  2. Removal and offsite disposal of any equipment buried at a depth of less than 120cms, including but not limited to underground utilities, concrete piers, footers, and electrical conduit.[34]
  3. If agreed, removal of access roads and restoring land back to original condition as much as possible.
  4. When decommissioning, if soil/dirt is required as fill, use excess topsoil stockpiled from the property or source clean topsoil free of weeds and foreign seeds.
  5. Repair surface or subsurface drainage structures.
  6. What restorative work is needed on adjacent lands that have been disturbed by the project's activities? E.g. Identify if culverts are still required.[35]

[33] DACF solar guidelines www.maine.gov/dacf/ard/resources/docs/dacf-solar-guidance-182021.pdf

[34] DACF solar guidelines www.maine.gov/dacf/ard/resources/docs/dacf-solar-guidance-182021.pdf

[35] DACF solar guidelines www.maine.gov/dacf/ard/resources/docs/dacf-solar-guidance-182021.pdf

Demonstration sites

- Victoria VitiVoltaics (ViViVo) – Agrivoltaic research being undertaken on solar over a vineyard project at University of Melbourne's School of Agriculture, Food and Ecosystem Sciences (SAFES), funded by Agrifutures Australia.

  Contact: School of Agriculture, Food and Ecosystem Sciences (SAFES), Faculty of Science

  The University of Melbourne, Dookie Campus, Victoria

- Adelaide University is conducting research on two modest-sized working agrivoltaic structures on grapevines - one on the Waite Campus vineyard, and one on the Paxton Wines vineyard in South Australia.

- Agriculture Victoria Research has the Tatura pear orchard under solar trial (see case study below).

Photo courtesy of Melbourne University, solar over a vineyard

Case study
AgVic's Tatura pear orchard under solar, Victoria

Tatura SmartFarm in Victoria established an experiment during the 2021–22 growing season, focusing on the integration of solar technology in a pear orchard (red-blush variety, known as 'ANP-0118' on BP1 rootstock (marketed as Lanya™). The rows are oriented north-south and utilise an open Tatura trellis system (V system) for tree training.[36]

Photos courtesy of AgVic

The study implemented two solar panel treatments positioned above each tree row in 1.05m wide strips, angled at 45° and 5° to the horizontal and facing west. A control group of trees without solar panel coverage served as a baseline for comparison. The energy produced by the solar arrays was systematically monitored, stored in batteries, and exported to the grid.

The trial included 120 solar panels, evenly split between the two orientations. Researchers recorded data, including crop yield, pear size, colour, quality, and energy output.

The implementation of agrivoltaic systems demonstrated improvements in water use efficiency. By measuring sap flow and analysing soil and air moisture levels beneath the panels, researchers found that these systems maximised water usage, leading to enhanced yield per unit of transpiration. This is important during droughts and for increasing water costs.

Pears grown under the solar panels exhibited reduced risk of sunburn—an important factor when temperatures exceed 30°C—which can adversely affect fruit quality. Additionally, the panels provided shelter from severe hailstorms, mitigating damage to the fruit.

Despite these benefits, the study revealed a notable decline in pear production under the solar panels. Specifically, there was a 37% reduction in yield for trees under the 45° panels and a 47% reduction for those under the 5° panels. A reduction in sunlight also impeded the development of the desired rosy blush in the pears, a key attribute for consumer appeal.[37]

As Australia faces increasing climatic challenges, these findings provide valuable insights into the dual benefits and limitations of integrating solar technology in agricultural practices.

[36] https://extensionaus.com.au/energysmartfarming/effects-of-pv-transpiration-and-energy
[37] www.pv-magazine-australia.com/2023/11/01/agrivoltaics-and-the-art-of-farming-under-cover

Cattle under solar

Photo courtesy of
Zimmermann PV-Steel Group

Cattle and solar

Grazing cattle under solar panels is an emerging agrivoltaic practice that generally involves elevated solar structures to reduce damage to panels from livestock and enable animals to graze underneath. This approach shares some similarities with growing horticultural crops, such as fruit trees, under solar panels. However, due to the added costs of elevated structures, these systems are currently most viable for smaller-scale solar developments, typically under 5MW. As innovations and economies of scale evolve, or as government incentives become available, larger systems may become more feasible.

The Queensland Government has undertaken some analysis on the grazing of cattle under solar which can be found here.

However, it should be noted that no independent assessments of these practices for Australian conditions are currently available and due diligence on the costs and viability of such operations should be explored.

Photo courtesy of BayWa r.e.

Australian case study
Cressbrook Station, Queensland

One small-scale system exists at 'Cressbrook Station' near Toogoolawah in Queensland. Caitlin McConnel and her family graze beef cattle under 100kW of solar panels, each with a concrete base of $1m^2$. The solar panels provide a diversified income for the property through the rebate received for exporting power to the grid. The family have been grazing cattle amongst the solar for 10 years.

Photo courtesy of Caitlin McConnel

Australian case study
Farrer Memorial Agricultural High School, NSW

Across the winter of 2021, WYNERGY Commercial Pty Ltd constructed a 60kW elevated 2P SAT solar system (2x 30kW FTC Voyager Trackers - engineered for a minimum panel height ground clearance at east and west tracking angle extremes of 2.4m) for Farrer Memorial Agricultural High School.

The trackers were constructed close to Farrer's farm workshop and mains power supply board for logistical purposes. However, placing the trackers in the home paddock close to the workshop necessitated infrastructure that could coexist with cattle, as the home paddock is used regularly to host the school's Illawarra Dairy Cow herd and the school's Angus stud bulls, typically aged between 1-2 years.

The system cost $240,000 to install ($4/W). This compared to 1P SAT trackers being built in solar farms at the time for $1.30/W. Much of the installation labour was supplied by the school's Year 10 industrial tech students. Wynergy's director indicated that the cost of installing the higher and more durable panels for cattle grazing was 300-400% higher than ground-mounted solar.

Photo courtesy of Wynergy

International research and technology

Research is being undertaken in the US, through Silicon Ranch, to determine appropriate spacing and height of solar that enables cattle grazing below and that is commercially scalable.[38] Over 39 months, a team of agrivoltaics experts, animal welfare scientists, regenerative farmers, and soil and ecosystem scientists will work together to develop, analyse and optimise cattle co-location and ecosystem dynamics on grasslands.

International examples of integrating cattle grazing with solar energy include US-based company Rute Foundations, which has developed mounting structures designed with high clearance. According to the company, their system requires no grading or use of H-piles, and instead utilises a pre-assembled rack. It also features raised cables, positioned 9ft above the ground, ensuring they are out of reach of livestock. The company reports that at a 4.5MW scale, the system's costs are comparable to traditional ground-mounted solar, at approximately US$2 per watt.[39]

[38] www.siliconranch.com/cattletracker
[39] www.rutefoundations.com/for-landowners

The company BayWa r.e. has several Cow-PV projects in development across France, Germany, and Austria. These agrivoltaic systems incorporate 1P and 2P-tracker technology, with row spacing designed to allow easy access for agricultural machinery, while offering multiple benefits to the cattle, including shading, cooler temperatures, and rain protection. Additionally, the systems help keep the farmer actively engaged on the project site, preserving the farmland's status.

The Cow-PV systems operate using rotational grazing, where multiple paddocks are designated for different purposes. Cows are moved between paddocks based on grass/hay management. In the cow paddock, the tracker angle is restricted to a horizontal position to prevent the cattle from reaching the panels. In the other paddocks the panels are sun-tracking and used for hay production. Paddocks rotate with the grazing cattle and change their panel tilt accordingly.

Depending on the specific technical and legal configuration of each project, the Levelised Cost of Energy (LCOE) for Cow-PV systems may range from 0% to +25% higher than that of traditional GM-PV systems.

Photo courtesy of Zimmermann PV-Steel Group

Next2Sun, a European business, uses bifacial panels to create vertical solar fences, where livestock can graze between rows rather than under elevated structures.[40]

The vertical orientation creates energy generation peaks in the morning and early evening (rather than in the middle of the day) helping reduce the over-supply of midday solar.

The business's largest vertical solar development is 17.4MWp at Frankfurt airport.

[40] https://next2sun.com/en

Midwest Agrivoltaic Systems (MAS) have created AgRack, an elevated ground mount racking system that seeks to optimise bifacial PV modules and enable cattle grazing below.

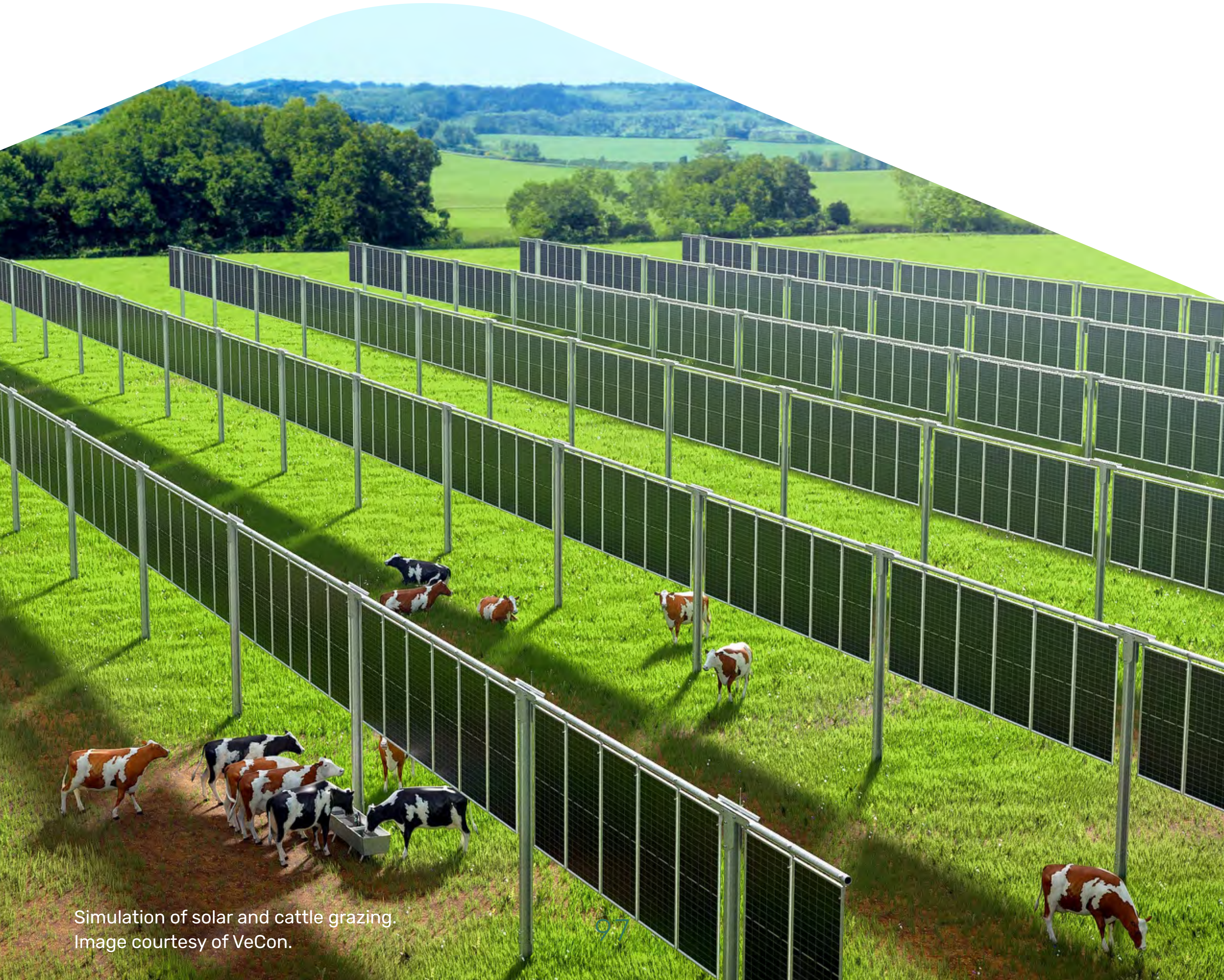
Tyler Lloyd from MAS talks about the crush resistance of structures being more important than the spacing of panels. The AgRack system can take 1,500–2,000 newtons of force. They use underground beams from support to support for the system's foundations.

Tyler also suggests that any cattle and solar projects need to plan the installation of scrapers, so that animals can scratch themselves instead of using the PV structures to do so.

Elevated AgRack system suitable for cattle.
Photo courtesy of AgRack.

German business VeCon have created a 'clothesline' style of vertical hanging solar panels that can be integrated with farming cattle and dairy cows, requiring minimal land. The 2.1m elevated system uses a support tube between the field pillars to enable panels to hang and swing reducing wind load on the system.[41]

[41] www.vecon.green/en



Simulation of solar and cattle grazing.
Image courtesy of VeCon.

Resources

Photo courtesy of JR Howard

Useful maps for solar over crops and horticulture

Protected cropping map for horticulture

https://experience.arcgis.com/experience/66ecdfd3f6be4e3b9dbcf73c40dcea16/page/Page

Network Opportunity Map

https://nationalmap.gov.au/#share=s-dMKvt5tfcrPHZ6KSXijVlXosjly

NSW distribution network based information

Essential Energy Network Coverage and Distribution Annual Planning Report

https://dapr.essentialenergy.com.au

Essential Energy Capacity Map (Distribution Substation)

Essential Energy (arcgis.com)

Essential Energy Detailed Asset Map (Locations, Type and Ratings)

https://essentialenergy.maps.arcgis.com/apps/webappviewer/index.html?id=947af3fb3749427e97a4824dcbd49980

Essential Energy Network Coverage

https://www.essentialenergy.com.au/about-us/our-network-area

Zone Substation Reports (Zone Substation Interval Data)

Zone Substation Reports

Ausgrid's Rosetta platform

https://dtapr.ausgrid.com.au for Ausgrid's network supply area:

- Locations of 33kV+ lines
- Locations of major substations
- Downloadable spreadsheets containing forecast data
- Information on current network constraints

NSW Regulations

www.planning.nsw.gov.au/sites/default/files/2023-03/lep-making-guideline.pdf

Further reading

Australian Energy Infrastructure Commissioner, Considerations for landholders entering into commercial agreements, January 2023:

www.aeic.gov.au/publications/considerations-landholders-entering-commercial-agreements

Clean Energy Council, Australian guide to agrisolar for large-scale solar, March 2021:

https://assets.cleanenergycouncil.org.au/documents/resources/reports/agrisolar-guide/Australian-guide-to-agrisolar-for-large-scale-solar.pdf

Lightsource bp, Wool quality and sustainability: Insights from Lightsource bp's Wellington solar farm, October 2024:

Wool quality and sustainability: Insights from Lightsource bp's Wellington solar farm | Lightsource bp

NSW Department of Primary Industries, Pasture varieties used in New South Wales, 2012:

Pasture varieties used in New South Wales 2012 – 13

NSW Department of Primary Industries, Weed control for cropping and pastures in central west NSW:

Weed control for cropping and pastures in central west NSW

Queensland Department of Agriculture and Fisheries, Agrivoltaic grazing systems in Queensland, February 2024:

https://era.daf.qld.gov.au/id/eprint/12988/1/Bowen_Agrivoltaic%20grazing%20systems%20in%20Qld_February%202024.pdf

Stark, K. and Bomm, A. Pursuing an agrivoltaics future in Australia, 2023:

www.farmrenewables.com.au/_files/ugd/484d75_825000a3311249f7bfaf0279a6c88a6a.pdf

Agrisolar CRC bid website

https://agrisolarau.com

Melbourne University agrivoltaics project (funded by Agrifutures)

https://energy.unimelb.edu.au/about-us/news/news-archive/using-sunshine-twice-is-agrivoltaics-a-win-win-for-australian-farmers

Macquarie Universities Legal Framework for Agrisolar report

https://researchers.mq.edu.au/en/publications/agrivoltaics-in-nsw-workshop-report-investigating-legal-policy-ma

Australian Protected Cropping Map Dashboard

https://experience.arcgis.com/experience/66ecdfd3f6be4e3b9dbcf73c40dcea16/page/Page/

NSW Department of Primary Industries distribution feeder capacity map

www.dpi.nsw.gov.au/dpi/climate/energy/clean-energy/electricity-supply-constraints-and-opportunities-for-intensive-industries

Data on major production areas for different horticultural industries

www.horticulture.com.au/growers/help-your-business-grow/research-reports-publications-fact-sheets-and-more/australian-horticulture-statistics-handbook

CFA Renewable Energy Guidelines for fire risk and emergency planning

www.cfa.vic.gov.au/plan-prepare/building-planning-regulations/renewable-energy-fire-safety

Renew Economy article "Solar shepherds" make big money grazing sheep among panels – and it benefits everyone involved

https://reneweconomy.com.au/solar-shepherds-make-big-money-grazing-sheep-on-solar-farms-and-it-benefits-everyone-involved

Tropical perennial grasses for northern inland NSW

www.dpi.nsw.gov.au/agriculture/pastures-and-rangelands/establishment-mgmt/tpg/book-tropical-perennial-grasses-for-northern-inland-nsw

International resources

AgriSolar Handbook (EU)

www.solarpowereurope.org/press-releases/new-agrisolar-handbook-reveals-benefits-for-the-farming-and-energy-sectors-including-up-to-60-crop-boost

Fraunhofer Institute's APV Guideline

www.ise.fraunhofer.de/content/dam/ise/en/documents/publications/studies/APV-Guideline.pdf

American Solar Grazing Association

https://solargrazing.org

AgriSolar Clearinghouse, Best Practices in Agrisolar 2025

www.agrisolarclearinghouse.org/best-practices-in-agrisolar

Sheep Empire podcast, US based

https://open.spotify.com/show/1bQeqYi6miWnn8GPVgh46G

France: Agrivoltaics working group- Accueil - France Agrivoltaisme (france-agrivoltaisme.org) & Agrivoltaism | The Green Platform (laplateformeverte.org)

India: National Solar Energy Federation of India (NSEFI) - Agrivoltaics in India | Agri-PV

Japan: Ministry of Agriculture, Forestry and Fisheries - Farming-type solar power generation: Ministry of Agriculture, Forestry and Fisheries (maff.go.jp)

Agriphotovoltaics Farm @Parbhani - SunSeed APV video

www.youtube.com/watch?v=XGh3K30x36s

Agrisolar Best Practice Guidelines

https://api.solarpowereurope.org/uploads/SPE_Agrisolar_Best_Practices_Guidelines_cefc915769.pdf

Acronyms

EIS	Environmental Impact Statement
ESG	Environmental Social and Governance
MW	Mega Watt
PAR	Photosynthetically Active Radiation
PPA	Power Purchase Agreement
PV	Photo Voltaic
GM-PV	Ground Mounted Photo Voltaic panels
kW	KiloWatt

NSW GOVERNMENT

EnergyCo

Farm Renewables CONSULTING

PROGRESSIVE AGRICULTURE