MACQUARIE University
SYDNEY·AUSTRALIA

TRANSFORMING ENERGY MARKETS RESEARCH CENTRE

Agrivoltaics in NSW Workshop Report:

Investigating legal, policy, market & technological barriers

Hosted by the Transforming Energy Markets Research Centre

Acknowledgements

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This workshop does not reflect direct quotations attributed to workshop participants nor does it present a holistic account of all views expressed. More detailed findings stemming from the workshop recommendations and outcomes will be produced in further scholarly research outputs.

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The 'Agrivoltaics in NSW: Investigating legal, policy and market barriers' workshop received Ethics Approval by the Macquarie University Ethics Secretariat on 30th May 2024 Project ID: 17328

The Transforming Energy Markets Agrivoltaics in NSW Workshop: Investigating legal, policy & market barriers Workshop

1. Executive Summary

On the 13th June 2024, The Transforming Energy Markets Agrivoltaics Research Team held an expert invite-only workshop to investigate the challenges and opportunities of implementing agrivoltaics with expert participants drawn from landholder, regulator, industry, engineering and academia sectors. The aim of the workshop was to initiate the development of a responsive, collaborative approach to agrivoltaics by unpacking existing legal, policy, market and technological barriers. The workshop provided a background for an ongoing programme of agrivoltaics research at Macquarie University to create best practice research-led guidance for the development of a thriving Australian agrivoltaics sector. A number of outcomes and recommendations from the workshop emerged including the need to foster further multidisciplinary research, agrivoltaics specific guidance, and ongoing collaboration between the solar energy and agricultural sectors.

The aims of the workshop were to:

- understand the need for agrivoltaics;
- determine the best legal/policy/economic mechanisms to facilitate the up-take of agrivoltaics;
- develop recommendations for reform; and
- address the knowledge gaps detrimental to planning and implementing agrivoltaics.

These aims responded to the barriers have largely resulted from Australia's slow adoption of agrivoltaic co-location as a feasible land use, in contrast to its ready acceptance and available regulatory guidance in international jurisdictions such as Japan, Germany and America.

Participants recognised the overall benefits of agrivoltaics, yet, determined that the extent of the benefits are dependent upon how the agrivoltaics project is integrated at the initial planning for a proposal in collaboration with the landholder and energy company.

Unresolved issues requiring clarification included:

1. the need to develop a legal definition of agrivoltaics;
2. create regulatory/policy/market incentives to invest in agrivoltaics;
3. identify the roles and responsibilities in establishing agrivoltaics (e.g., insurance risk sharing); and
4. develop best practice standards to guide, manage and monitor agrivoltaic developments.

An additional question to be confirmed was whether future regulatory and policy frameworks used for agrivoltaics in Australia need to distinguish between grazing and livestock agricultural activities, to that of cropping and horticulture agricultural activities. The workshop confirmed more research and regulatory guidance is needed to support the implementation of agrivoltaics in NSW to activate the benefits of this multifunctional land use for landholders and industry proponents.

2. Introduction

The Agrivoltaics in NSW Workshop provided a platform to solidify the purported benefits of agrivoltaics. These benefits include, but are not limited to: increased agricultural productivity (e.g., lamb survival, wool quality and crop resilience to droughts); diversified income streams for landholders; and provision of a social licence to industry proponents through enhanced community engagement.

17 expert workshop participants (i.e., 13 in-person and 4 online) representing 6 sectors were represented and were allocated one of four groups, including a blended online remote participant group. The workshop was structured in four sections; (1) Planning Policy Frameworks, (2) Legal Requirements, (3) Market and Economic Incentives, (4) The Future of Agrivoltaics: A Reformist Agenda. Each participant was invited to identify and comment on the most important issues to establishing agrivoltaics in NSW in relation to their sector(s) throughout each workshop section.

This workshop report summarises the discussions and recommendations of our workshop and is structured in nine sections. Section 3 attempts to define agrivoltaics from the landholder, legal, industry and academic perspectives of workshop participants. Section 4 analyses the policy requirements necessary to aid the implementation of agrivoltaics. Section 5 questions the effectiveness of using either a licence or lease agreement between landholders and industry proponents to establish and maintain agrivoltaics for the duration of the project. Section 6 details the (in)availability of market incentives, whilst Section 7 questions technological barriers and opportunities. Section 8 shares the core unresolved issues and recommended steps to safeguard NSW's future application of agrivoltaics identified by workshop participants. Section 9 concludes with recommendations for future regulatory and policy reform to facilitate the establishment of agrivoltaics in NSW.

Figure 1: Group photo of workshop participants and facilitators.
In person (L-R): Ben Wynn, Jonathan Prendergast, Nischala McDonnell, Dr Sara Deilami, Julian Kasby, Mark Callanan, Dr Madeline Taylor, A/Prof Peter Davies, Laurie Wallis, Kevin Nixon, Ian Thomas, Charlie Prell, Nathan Hart and Andrew Bomm. Online: Anne Dansey, Lilian Parker and Bridget Ryan.

3. Defining the co-location of solar generation and agricultural production

The NSW large-scale solar regulatory framework lacks an accepted and consistent definition on the co-location of solar generation and agricultural production activities.[i] This co-location of solar energy and agricultural activities is known as agrivoltaics and/or agrisolar.[ii] Both terms were used interchangeably throughout the workshop, with many participants expressing a preference for the agrisolar term. This preference reflects a shared sentiment that the agrisolar term provides more clarity to a general audience on this type of multifunctional land use. Agrisolar has been used in the Australian context to classify sheep grazing activities onsite solar development footprints (i.e., also known as solar grazing).[iii] It is unknown whether the agrisolar term will be broad enough to capture co-located horticulture activities onsite and/or adjacent to the solar development footprint in contrast to the agrivoltaics term. In contrast, agrivoltaics appears to be the preferred term in academic literature and leading international jurisdictions stemming from the original conceptualisation of solar photovoltaics and agricultural activities attributed to Goetzberger and Zastrow.[iv]

An additional consideration voiced by workshop participants concerning the definition of agrivoltaics vs agrisolar is to ensure the use of a broad(er) definition does not facilitate perverse outcomes, nor enable co-location to be merely applied as a weed management measure. In response to this concern, participants recommended the development of a tiered approach to identify the degree agricultural and solar production co-exist. The suggestion of developing and using a sliding scale system in which higher co-location of agriculture to solar percentages could be rewarded and incentivised. For example, solar developments where >50% agricultural activities occur onsite and/or bordering footprint could be considered as legitimate co-location. Incentives could be in the form of monetary returns, shared equity ownership and/or social licence benefits through the 'halo effect' of large-scale solar generation and distribution.[v] Determining whether solar developers, agricultural landholders, or both stakeholders should receive this incentivisation was inconclusive in this section, yet, most workshop participants indicated there is a higher need to incentivise developers to adopt alternative land use practices than encourage agricultural landholders to increase agrivoltaic uptake.

Irrespective of whether agrivoltaics or agrisolar is used as the broad classification for the co-location of solar and agricultural production, workshop participants confirmed that both terms indicate the need to further clarify the parameters of productivity.

From an energy development perspective, workshop participants suggested that solar productivity be measured and reported against a baseline minimum generation capacity (e.g., 1MW). The measurement of agricultural productivity was uncertain with measures either needing to relate to the proportion of land that is being used for production, value of production ($/ha), or the quality of agricultural land.[vi]

Participants also discussed whether agrivoltaics should be framed from the perspective of the dominant use of land. This is either:

- The existing productive agricultural land hosting a new enterprise (i.e., solar developments) and how they integrate; or

- The energy enterprise becoming the primary purpose of the land in which agriculture is then integrated onto or bordered development footprint.

The first perspective prioritises agricultural land as the primary industry, while the second perspective emphasizes large-scale solar energy as the primary industry. Although the workshop did not reach a conclusion on whether the first or second perspective should be harnessed to conceptualise agrivoltaics, participants recognised it will likely be dependent upon the future development of policy and regulatory guidance in NSW.

Key takeaways identified by workshop participants;

- **Barriers**: The definition of agrivoltaics dependent on how land is zoned, the parameters of energy and agricultural productivity and what is considered the primary purpose. Different tax implications for each land use classification.

- **Opportunities:** Incentivise and reward agrivoltaics adoption (e.g., be rewarded if have >50% agricultural production onsite solar farm). Encourage social licence and shared equity ownership between industry and landholder(s).

- **Unresolved Issues:** Preference for co-location terminology and future agrivoltaics definitions must address how to determine the proportionality of energy compared to agricultural production to define land use as agrivoltaics.

Figure 2: A/Prof Peter Davies facilitating planning policy discussion.

4. Policy Barriers and Opportunities

The NSW Large-scale Solar Energy Guideline comprises the primary policy guidance on co-location of agriculture and solar enterprises.[vii] Agrivoltaics is not expressly cited within the NSW Guideline. Rather, agrivoltaics is read into the use of the co-location term in the Guideline.

Currently, the co-location of agriculture and energy activities are largely considered as a mitigation measure only against land use conflicts between agricultural and energy production. However, legal standards to guide consistent and best practice applications of agrivoltaics are absent in NSW.

The workshop participants discussed the value of creating a new specific agrivoltaic policy. Key areas of consideration included: how this would function; and whether it would be optimal in aiding the implementation of agrivoltaics throughout NSW.

Workshop participants noted that many largescale solar projects were designed and installed without consideration to integrating agricultural enterprises and then retrospectively added grazing as a weed reduction strategy. Discussion focused on the value of placing greater emphasis at the strategic planning stage, including how the site will be managed in the future. This forward planning emphasis should be included within the development proposal (planning application). In this policy session, workshop participants warned against the current NSW agrivoltaic trend where industry proponents wait until development consent has been granted before facilitating sheep grazing as a cheaper weed and grass height management measure (as opposed to annual and/or biannual slashing and mowing). Left unaddressed, this trend could perpetuate solar development greenwashing and co-location tokensim.

The workshop participants were divided in their responses on the (dis)advantages of a new agrivoltaics policy.

Advantages:

- Some participants argued NSW **required** a new policy to provide clarity and direction for industry proponents and landholders throughout the development assessment procedure. Participants highlighted that a new agrivoltaic policy could guide regulators, local government authorities, industry proponents and landholders to make informed decisions on how to accommodate co-location in alignment with NSW's large-scale solar regulatory framework. Policy measures could offer certainty to developers, facilitate investment, and increase establishment of demonstrate sites/pilot projects to quantify the benefits of utilising agrivoltaics.

- In doing so, participants outlined that future agrivoltaic policy could facilitate transparency throughout the design, construction, operation and decommission of solar developments to protect and promote agricultural activities and avoid greenwashing. This could be inclusive of community consultation conditions throughout project lifecycle(s) to achieve best practices. For example, participants suggested that a new agrivoltaics specific policy could require proof of co-location through detailed plans on how grazing and/or horticulture agrivoltaics will function onsite irrespective of the land classification. Social licence claims could then be grounded in evidence that the implementation of agrivoltaics is informed by landholder decision-makers in equal partnership with industry proponents.

- Workshop participants warned against amending existing policy to accommodate agrivoltaics since such interpretations would only superficially consider co-located use of agricultural land and instead, have the outcome of pigeonholing agrivoltaics to be valued only as a cheaper weed management measure.

- This apprehension was reflected in workshop participants voicing a preference for legal standards to be more effective than flexible guidelines in encouraging

developers to adopt agrivoltaics and prioritise holistic co-location over profit motives. The workshop participants also forecasted that future agrivoltaic policy could inherently become de facto best practice through functioning as standardised land use requirements. This certainty would then aid investors and banks authorise co-location, and assist in identifying the bearer of additional risk(s) is required contracts associated with agrivoltaics.

Disadvantages:

- Other participants argued against a new agrivoltaic-specific policy. Participants outlined that NSW should use and/or amend existing framework to avoid increased regulatory burden in the development assessment process and the potential stalling of NSW's renewable energy transition. The creation of a new bespoke agrivoltaics policy was seen by some participants as contributing to additional delay and costs for developers. Several workshop participants projected agrivoltaic conditions could be interpreted within existing environmental impact statement requirements.

- Workshop participants also voiced the concern that a new policy would unlikely have the capacity to enable continuity of agricultural production in terms of responsiveness to different environmental pressures onsite development footprints. This scepticism is grounded in NSW's existing large-scale regulatory framework and the renewable energy sector not reflecting this interrelationship between agricultural productivity and environmental safeguards.

If a new agrivoltaics policy is formulated to assist future development applications, workshop participants emphasised the need to identify trigger points to activating regulation. Questions on responsibility and land use conditions were perceived to differ according to the co-location use; i.e., should policy be subcategorised into grazing agrivoltaics and horticulture agrivoltaics requirements. Workshop participants were undecided on whether agrivoltaic policy should be subcategorised according to dominant land use, as observed in session 1 of the workshop (i.e., defining agrivoltaics). Despite this, there was a general consensus amongst workshop participants that a new policy would be valuable in generating and disseminating more information on agrivoltaics in NSW.

Key takeaways identified by workshop participants;

- **Barriers:** Creation of new planning policy to add to assessment timeframes, regulatory burden and slow down large-scale solar development as part of NSW's renewable energy transition is needed.

- **Opportunities:** Upfront inclusion in siting and design of development footprint should focus on fencing, water trough, machine access etc considerations help make informed decisions for industry and landholders.

- **Unresolved Issue:** Whether new and/or reform of existing agrivoltaics policy should differentiate between grazing and horticulture activities.

5. Legal Barriers and Opportunities

Grazing and horticulture agrivoltaics were found by workshop participants to share similar legal risks. However, such legal risks were acknowledged as holding different scales depending on which is the dominant land use co-located with solar generation. For example, Table 1 lists the shared risks arising from insurance requirements. The need to allocate responsibility for the legal risks and rewards of using agrivoltaics was identified as a key theme in this workshop session.

Another overriding theme concerned the implications of different land use zoning for legal risk and tax requirements. This discussion is closely related to the need to formulate a legal agrivoltaics definition that identifies dominant land use purposes in relation to land quality and co-location feasibility discussed in session 1 of the workshop.

Participants noted the absence of best practice demonstration sites in NSW. In this absence, some participants discussed the feasibility of agrivoltaics based upon their experiences in onshore large-scale wind development. These participants reaffirmed the need to equalise the power dynamics between industry and landholder parties in land use discussions and contracts. Increasing community consultation and landholder power in negotiations (e.g., through public advocacy) could then facilitate mutual trust between all stakeholders involved in the proposed agrivoltaic development and assist landholders to navigate the legal process.

Table 1: Similarities and differences between legal risks for grazing and horticulture agrivoltaics

Risk Categories	Shared Risks raised by participants	Differences raised by participants
Fire	Landholders will unlikely have the means to pay insurance if there is a bushfire. Both grazing and horticulture agrivoltaics also impose fire risks upon neighbouring landholders. Risk mitigation includes: designing and maintaining access tracks within and outside development footprint; access to water onsite; dry vegetation mass maintained especially during summer seasons. These land use measures can be organised through both types of agrivoltaics.	Grazing activities can lower fire risk by managing vegetation height and mass. This might be accepted as a land use mitigation in the insurance. Horticulture agrivoltaics have a higher fire risk due to their characteristic of growing vegetation and crops underneath and/or between solar arrays. Would crop production underneath and/or between solar arrays be managed by the landholder or industry? How would fire mitigation duties be shared if crop is owned by a third-party (i.e., owner is not the landholder)?
Groundcover	Conflict in vegetation biomass underneath and between panels vs strict insurance requirements. Who bears responsibility to effectively manage groundcover in an agrivoltaic land use agreement in a way that is sensitive to	Practicalities of keeping grass to certain height not possible to do with grazing unless managed either by mosaic or cell grazing. Lawnmowing is considered a default option. Overgrazing is another key issue causing bare ground (i.e. leads to increased panel soiling, and

	bespoke site topography and land use condition(s)?	degradation of topsoil land and soil integrity). Who is responsible in managing grazing and preventing overgrazing: industry, landholder or subcontractor? How to manage crop productivity risks due to panel shading and microclimate differences underneath and between solar arrays. Also, it remains unknown how to measure risks to infrastructure arising from future replanting of vegetation if initial direct seeding fails and/or a new crop variety has to be sown. Replanting considerations should be included in design and operation management. Who bears the cost for failed crops and replanting?
Biosecurity, weeds and feral pests	Overall need to minimise biosecurity, weed and feral pest risks onsite and surrounding development was identified. This could be managed through site design and the operation management conditions agreed upon when granted development consent.	Emergence of animal diseases in Australia could affect solar grazing on site-by-site basis. Use of general herbicides and pesticides for groundcover management should take into consideration its impact upon onsite crop(s) and other horticultural activities. Use of targeted herbicides and/or pesticides and regenerative farming are recommended to avoid stripping soil nutrients.
Third-party obligations	How to determine responsibility for risks arising from sub-contractors managing onsite vegetation by mowing, slashing, and/or spraying. How would consequent impacts affect warranties held between industry and landholder(s).	Requirement for contractors to respect open/closed fences to manage sheep movement. Requirement for contractors to prevent the introduction of invasive species harmful to crop production.
Decommissioning	Responsibility to rehabilitate land to previous agricultural use lies with industry proponents. However, it is unknown how this decommissioning condition will affect the retention of assets used for continued agricultural activity (e.g., fences and access roads) post-solar development. Legal implications of recycling panels and associated solar infrastructure are also unknown in NSW, as NSW does not ban the disposal of solar panels in landfill nor does it hold any active incentivisation to recycle agrivoltaics solar panels.	Additional costs placed upon landholders to retain beneficial infrastructure might differ between fencing requirements for sheep grazing versus what is used in horticulture agrivoltaics.

Workshop participants were tasked with evaluating an agrivoltaics lease in contrast to licensing arrangements. The workshop participants were presented with draft agrivoltaics licensing clause examples in determining which stakeholder generates the benefit of the agrivoltaics cost saving, who bears the production risk, and how to share this risk between parties.

Discussions on the difference between a lease and licence included: how to value agrivoltaics when calculating security against a lease/licence; beneficiaries' contractual obligations to manage vegetation; flexibility to alter land use management according to site conditions and future emergence of improved co-location technology. Participants concluded a licence would retain the capacity to be flexible and ensure agrivoltaic developments accord with the latest best practice standards, as opposed to an agrivoltaics lease in which land use management would be inflexible for the duration of the solar development (i.e., 30 years). As a result, workshop participants expressed a majority preference for licence agreements to be used in adopting grazing and horticulture agrivoltaics in NSW.

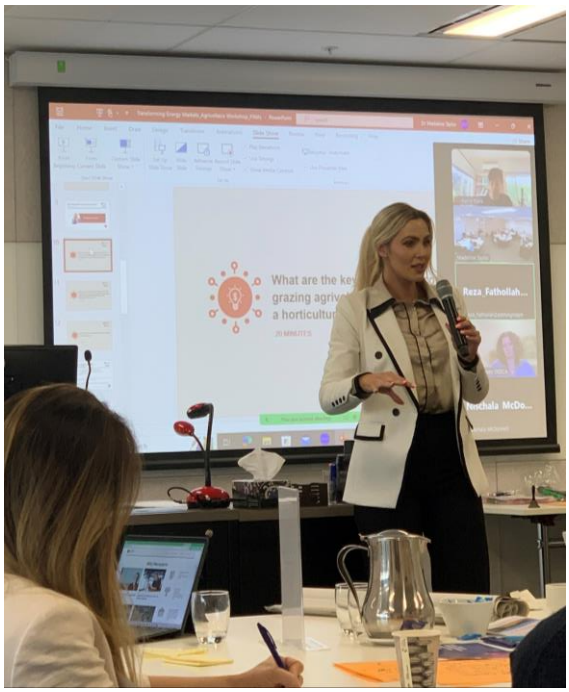


Figure 3: Dr Madeline Taylor leading the legal discussion on argivoltaics.

Key takeaways identified by workshop participants;

- **Barriers:** Increased risks (e.g., insurance compliance) and land maintenance, determining who will bear these risks and/or how they will be shared between landholders and industry.

- **Opportunities:** Licence offers flexibility to go beyond traditional agrivoltaics/agrisolar best practice by building biodiversity and holistic land use operation, construction and management conditions. Development of state level land use zoning to determine whether co-location is admissible.

- **Unresolved Issues:** What are minimum overgrazing levels, how to manage overgrazing, and what penalties should be used if land is mismanaged for agricultural production.

6. Economic Barriers and Opportunities

Co-location adds additional complexity in economic calculations determining the feasibility of agrivoltaics, especially in terms of scale, storage, and deciding whether retail or wholesale costs are more attractive. Workshop participants discussed two main concerns and/or barriers to supporting agrivoltaics implementation via

economic models. First, quantification of upfront costs involved in installing agrivoltaics is achievable, however, it is difficult to quantify the benefits of agrivoltaics for landholders, industry, and broader communities. For example, the use of beehives onsite solar developers could support native vegetation growth and wellbeing. Experiences shared by the workshop participants identified this to be a risk mitigation measure supported by some banks. Second, the current hesitancy to invest in agrivoltaics results from the lack of available data to inform landholder and industry land use decisions. Closing this information gap is necessary to initiate industry upskilling and capacity building (e.g., via a confirmed micro-credential) in order for agrivoltaics to be recognised as a viable business model.

Additional barriers and/or concerns observed by workshop participants included:

- Public liability and insurance costs;
- Uncertainty on the extent horticulture agrivoltaics would increase insurance and public liability costs;
- Existing intra-daily pattern of wholesale electricity prices (e.g. negative prices during the day) restricting agrivoltaics to self-consumption and behind-the-meter usage on farm and agriculture infrastructure;
- Unknown when to seek power purchase agreements in development assessment timeline;
- Increasing level of curtailment a potential issue if not viable over longer term (e.g., time of day etc)
- Misuse of carbon offset market does not provide genuine benefits for landholders and industry proponents; and
- Biodiversity offset market is not mature, nor offers any incentives to adopt agrivoltaics as a collaborative land use which values biodiversity in its own right.

Figure 4: Kevin Nixon discussing economic concerns with workshop participants.

Despite these concerns, the corporate sector was identified by workshop participants as leading the agrivoltaics power purchase agreements and certifications. In doing so, corporate investment will likely look beyond the agrivoltaic cost analysis with the intention of enhancing project sustainability. In this regard, participants suggested that project outcomes could be explicitly diversified, for example to identify agricultural outputs, energy generation and biodiversity improvements. More research on the multi-functional characteristics of agrivoltaics to enable biodiversity

regeneration might inform participation in NSW's biodiversity offset market and how it connects to landholder acceptance on adopting agrivoltaics in partnership with industry. Similarly, agrivoltaics could function akin to a community solar energy system in which the electricity benefits are shared with the broader host community, and as a consequence, potentially aid social acceptance of proposed developments in rural/regional NSW.

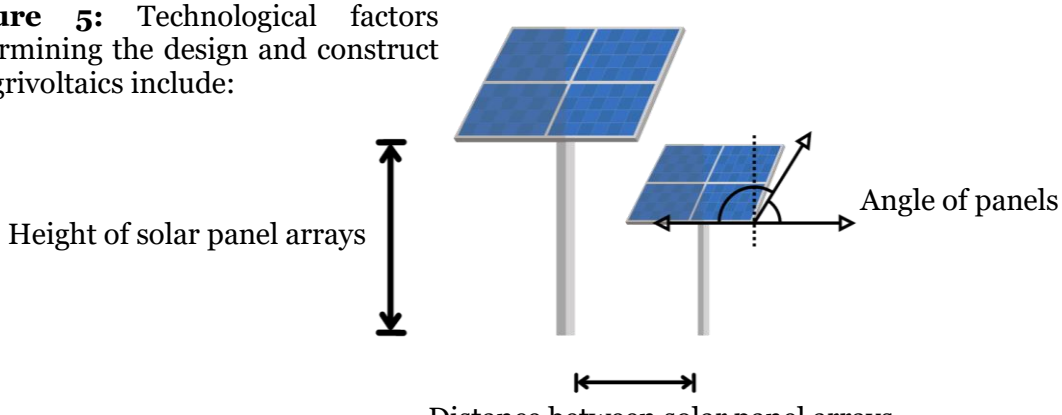
Key takeaways identified by workshop participants;

- **Barriers:** Lack of financial incentive to adopt agrivoltaics, unknown quantification of benefits, additional insurance and public liability costs impede agrivoltaics adoption.
- **Opportunities:** Application in energy hubs and behind-the-meter generation. Power Purchase Agreements might also provide additional opportunities for selling surplus generation. Increase community involvement through agrivoltaic projects (e.g., community grids).
- **Unresolved Issues:** The extent biodiversity and carbon offset markets impact the incentive to develop agrivoltaics in NSW.

7. Technological Barriers and Opportunities

Participants identified fencing, panel height, tilt axis and distance between arrays are key technological considerations which should be determined upfront when designing the development footprint to effectively facilitate agrivoltaics. This is essential to altering the current practice of retrofitting existing solar developments. These technical issues were discussed in the context of AV systems integrated with sheep grazing in NSW. Ensuring the technical aspects of a project were part of the design process up front were emphasised given the additional cost of retrofit or changing the specifications post planning consent. It was also discussed to develop pilot sites where we can conduct test bench studies to share data from engineering design to overall land use productivity, soil health, water usage, weather conditions, and environmental impact. One group suggested the idea of virtual fencing for cell grazing as an innovative approach to managing livestock. One group recommended 6-meter pathway for easy access and maintenance.

Figure 5: Technological factors determining the design and construct of agrivoltaics include:



Source: compiled by authors

Reconfiguring solar development footprints is challenging in terms of relocating or inserting internal fences to manage sheep grazing patterns, location of water troughs and enable machine/vehicle access etc. The technological requirements for horticulture agrivoltaics add additional complexity to managing the microclimate under solar arrays due to influence of shading and precipitation changes upon health and productivity of crops. The use of bifacial panels was considered as a key determinant on the success of growing crops under solar arrays. Soil quality was contemplated by workshop participants as an indicator to quantify crop health and productivity.

The workshop participants also discussed about grid connection and how the legal contract is tied and relates to Generator Performance Standards (GPS) as per Transgrid/AEMO and NEMs rules and policy. Despite the emerging possibilities of utilising technological design to benefit horticulture agrivoltaics, this is not yet a reality in NSW. It is easier to co-locate sheep grazing and solar generation due to associated designs being more readily available and considered 'off the shelf', whereas horticulture agrivoltaics would likely require bespoke planning per individual site conditions and topography.

Technological design was also closely linked to the mitigation of fire and flood risk in the workshop from insurance perspective. Workshop participants emphasised the need for more research, data sharing and development of demonstration sites would inform the technological requirements for grazing and horticulture agrivoltaics, as well as aid risk mitigation from natural hazards. Additionally, the potential for integrating Virtual Power Plants (VPP) and behind-the-meter solutions was noted as a significant factor in enhancing the overall efficiency and resilience of agrivoltaic systems.

Key takeaways identified by workshop participants:

- **Barriers:** Fencing, and distance between arrays, grazing methods (like cell grazing)
- **Opportunities:** Potential behind the meter and VPP solutions for enhancing overall reliability and efficiency, and pilot sites for data sharing.
- **Unresolved Issues:** The grid connection through Transgrid/ AEMO, and slow turnaround of approvals according to Generator Performance standards (GPS) which impacts project timelines and implementation.

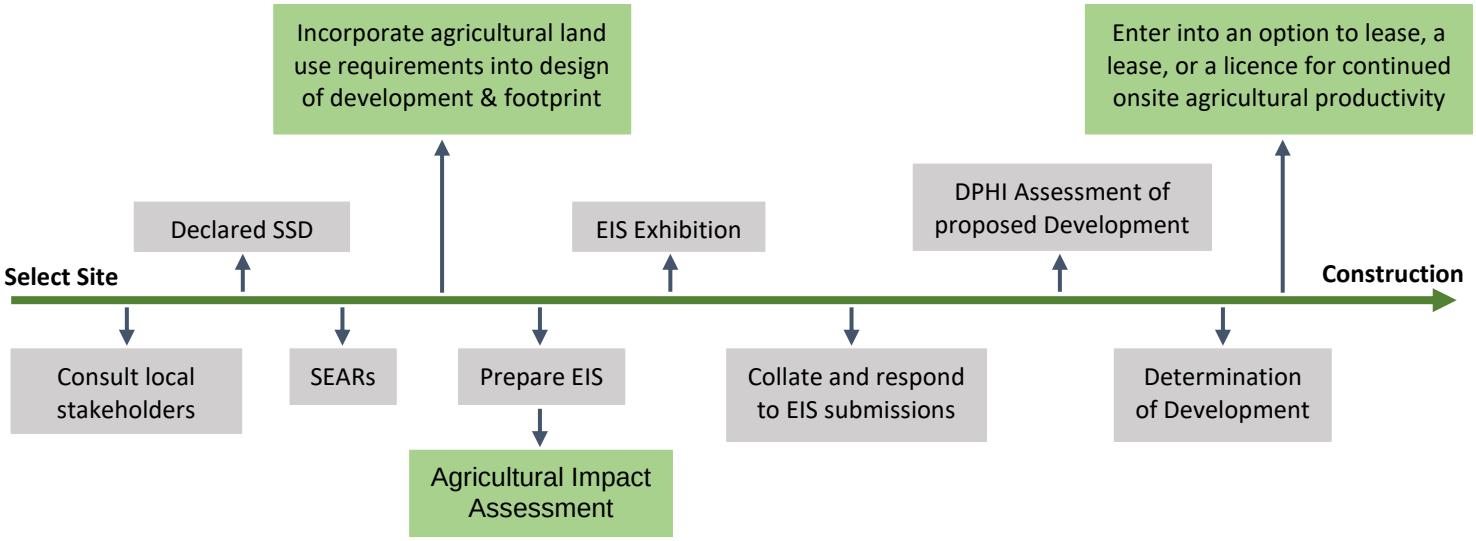

Figures 6 and 7: Workshop engagement activities with facilitators Nischala McDonnell and Dr Sara Deilami

8. The Future of Agrivoltaics in NSW

Agrivoltaics is an emerging land use in NSW seeking to co-locate agricultural production and solar generation. There are two broad categories of agrivoltaics, grazing and horticulture, both hosting different challenges and opportunities to the establishment of agrivoltaics in NSW policy, regulation and economic markets. Following the workshop analysis on the main inhibitors to agrivoltaics implementation in NSW, the final session adopted 'blue sky' thinking to observe trends in what participants identified as core unresolved issues and recommended steps to safeguard the application of agrivoltaics in future NSW developments.

An overall absence impeding the development of agrivoltaics is understanding when grazing and horticulture co-location should be pursued in the development assessment process. Workshop participants repeatedly mentioned the value of creating a timeline to communicate what is expected of industry proponents and their consultation with landholder and neighbours to mitigate legal risks. Figure 1 indicates the provisional inclusion of agrivoltaic land use design, assessment, and stakeholder agreements throughout the development assessment procedure in NSW. This proposed timeline aims to provide greater clarity to all stakeholders to increase the efficient and holistic adoption of agrivoltaics.

Figure 8: Agrivoltaics in NSW's development assessment timeline



Source: compiled by authors

Figure 1 Acronyms:

- SSD = State Significant Development
- SEARs = Planning Secretary's Environment Assessment Requirements
- EIS = Environment Impact Statements
- DPHI + Department of Planning, Infrastructure and Housing

In terms of observed trends, the main unresolved barriers and opportunities to support agrivoltaics establishment in NSW are listed below from highest-lowest priority per workshop participant responses.

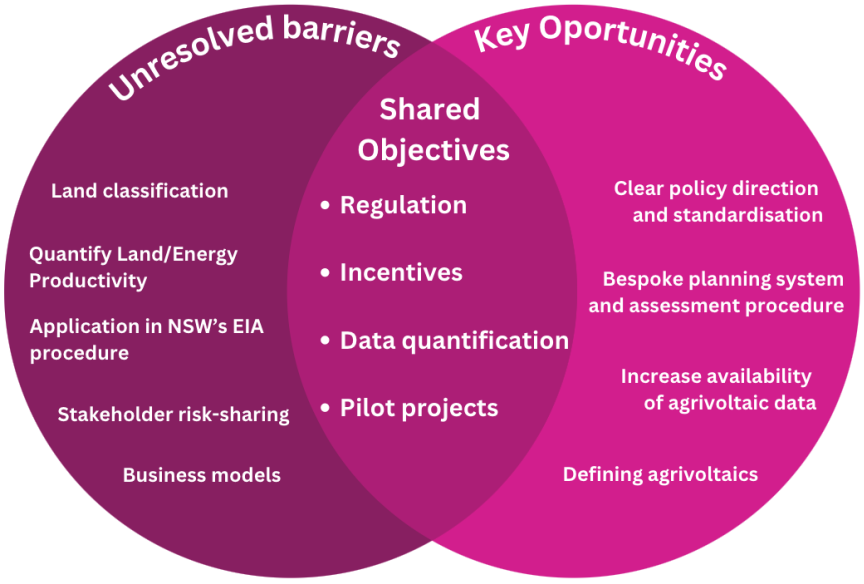
1. NSW's existing large-scale solar regulation does not effectively facilitate agrivoltaics implementation. The development of an agrivoltaic specific regulation is needed to: develop best practice standards for co-located grazing and horticultural production; identify roles and responsibilities between industry and landholder stakeholders; define dominant land use; and balance risk sharing and associated costs.

2. Develop incentives to encourage agrivoltaics adoption. Determining the type and function of incentive(s) was not examined, however, workshop participants recognised the formulation of incentives will be necessary to encouraging industry proponents to adopt agrivoltaics and pursue it beyond weed maintenance.

3. Additional information and quantification on the benefits of agrivoltaics were identified by workshop participants as an unresolved issue and future method to safeguard grazing and horticulture co-location during the lifecycle of solar developments. Transparent and effective community consultation were also recognised as the third highest priority by workshop participants as necessary to standardising future implementation of agrivoltaics. These interrelated issues reaffirm the need for more agrivoltaic research in NSW, and throughout Australia more broadly, to assist the renewable energy transition.

In total, the expert workshop participants unearthed the policy, regulatory, economic market and technological issues requiring future research, and the opportunities to actualise the vision of implementing a responsive and collaborative agrivoltaics system throughout NSW.

Figure 9: Summary of workshop participant responses



Source: compiled by authors

9. Workshop Recommendations and Future Research

Five key broad recommendations emerged from the NSW Agrivoltaics workshop:

The typologies of agrivoltaics/ agrisolar require clear and consistent definitions.

Specific and flexible planning guidance for agrivoltaics for both energy developers and landholders is needed.

Agrivoltaics licensing and/or leasing requires further research and specific legal considerations including establishing clear protocols around issues like grazing management, vegetation maintenance, decommissioning responsibilities, and providing flexibility to allow for different agricultural and ecological practices.

Economic incentives to ensure agrivoltaics are feasible as an established sectoral market in NSW are urgently required.

Additional research and quantification on the benefits of agrivoltaics to safeguard grazing and horticulture co-location during the lifecycle of solar developments is required.

Following our workshop and this workshop report, the Transforming Energy Markets Agrivoltaics Research Team will be publishing several peer-reviewed scholarly outputs.

For further information, please visit: https://www.mq.edu.au/research/research-centres-groups-and-facilities/centres/transforming-energy-markets

Appendix A: Workshop Team

Dr Madeline Taylor
Macquarie University

Dr Madeline Taylor is Director of Research Training and Senior Lecturer at Macquarie Law School, Deputy Director of the Centre for Energy and Natural Resources Innovation and Transformation (CENRIT), Co-Lead of the Regulation and Social Acceptability Stream of the Transforming Energy Markets Research Centre, Honorary Associate at the Sydney Environment Institute, and Member of the Sydney Institute of Agriculture.

Madeline specialises in issues at the intersection of socio-legal aspects of the energy transition. Her research focuses on embedding energy justice into law and policymaking in response to the urgent need to reach net-zero energy systems while ensuring wider community-level sustained benefits. Madeline will be an Australian Research Council (ARC) ECR Industry Fellow from 2025-2028 working with her Industry Partners NSW Department of Primary Industries and Spark Renewable on their project entitled "The Foundational Australian Agrivoltaics Regulation Model (FAARM) Project".

A/Prof Peter Davies
Macquarie University

Dr Peter Davies is an Associate Professor of environmental planning and policy at Macquarie University within the Faculty of Science and Engineering. Peter undertakes interdisciplinary research bridging the theoretical and scholarly focus to support sustainability outcomes for society.

He has published over 70 peer review articles, book chapters and industry reports. Peter is a member of various government environmental and sustainability advisory committees including the NSW Government's Independent Metropolitan Water Advisory Panel and is also an executive member of the Macquarie University Smart Green Cities Centre and the Centre for Environmental Law.

Nischala McDonnell
Macquarie University

Nischala McDonnell is a PhD candidate at Macquarie Law School investigating the legal opportunities and barriers in co-locating biodiversity improvement activities and photovoltaic generation (i.e., ecovoltaics). She completed an internship with Spark Renewables before commencing her PhD, integrating her knowledge with hands-on application to support Spark Renewables adopt nature positive planning.

Nischala was awarded a high-distinction in 2023 for her socio-legal Masters of Research thesis on ecovoltaics. In 2022 Nischala graduated her Bachelor of Environment and Bachelor of Laws degree with First Class Honours and was awarded the John Peden Memorial Prize for Best Legal Research Project for her high distinction honours thesis completed in 2021.

She is a research fellow working on the legal implications of agrivoltaics and the rights of stateless refugees. Her academic research specialises on embedding human and nonhuman voices within renewable energy regulatory frameworks to reach a nature positive and just energy transition.

Prof Stefan Trück
Macquarie University

Professor Stefan Trück is an ARC Future Fellow and Professor of Business Analytics and Director of the Transforming Energy Markets Research Centre at Macquarie University. Previously, he has held positions at Queensland University of Technology and Karlsruhe Institute of Technology in Germany where he received a PhD in Business Engineering.

Stefan's research interests focus on risk management, financial econometrics and business analytics. He is a world leading expert in the area of electricity markets and energy finance, while his research also comprises the areas of and commodity markets, credit risk, systemic risk, emissions trading, climate change economics and international financial markets. He has published in many high impact journals.

Dr Sara Deilami

Macquarie University

Dr Sara Deilami completed her masters and Ph.D. degrees in Electrical and Power Engineering from Curtin University. She currently holds the position of Senior Lecturer in the School of Engineering at Macquarie University, where she also serves as the Associate Director of Smart Grid Cities (SGC) and a member of the Transforming Energy Market (CTM).

Her primary research interests focus on Grid Integration, including Electric Vehicle Charging, Wireless Technology, Renewable Energy Integration, Power Quality, and Power System Protection. with 20 years of work experience in both Academia and Electrical Engineering industry, she is leading the power and energy research and works on numerous industry projects on electrified transportation, buildings, and communities at Macquarie University. Additionally, she is an advocate for sustainable development goals.

Dr Deilami is the Chair of IEEE Power and Energy Society (PES) in NSW.

Dr Reza Aghdam

Sultan Qaboos University and Macquarie University

Dr Reza Fathollah Zadeh Aghdam is a casual academic at Macquarie University (MQU) and the University of Technology Sydney (UTS). He worked as an Assistant Professor of Economics at Sultan Qaboos University (SQU, 2015-2024) and the University of Petroleum and Minerals (PMU, 2007-2015) in the Middle East. He obtained his PhD in energy economics and policy from UTS in 2007. He worked as an energy economist in reputable energy organisations for over six years before his PhD. His research interest has focused on energy and environmental economics. He is a member of several professional energy associations, including IAEE (since 1999). He has published several articles in quality academic journals.

[i] Madeline Taylor, Jordie Pettit, Takashi Sekiyama, Maciej Sokolowski, 'Justice-driven agrivoltaics: facilitating agrivoltaics embedded in energy justice' (2023) 188 *Renewable and Sustainable Energy Reviews* 1-11.
[ii] Workshop participants also discussed the merit of using dual land use, co-location, intermingling and co-existence terms to describe the interrelationship between this shared land use.
[iii] See Clean Energy Council, *Australian guide to agrisolar for large-scale solar* (Report, 2021) <https://assets.cleanenergycouncil.org.au/documents/resources/reports/agrisolar-guide/Australian-guide-to-agrisolar-for-large-scale-solar.pdf>.
[iv] A Goetzberger and A Zastrow, 'On the Coexistence of Solar-Energy Conversion and Plant Cultivation' (1981) 1 *International Journal of Solar Energy* 55-69.
[v] Halo effect refers to the unconscious judgement of an individual's or company's attributes (i.e., either positive or negative) which can influence social acceptability.
[vi] The tax implications of energy compared to agricultural land uses productivity were also contemplated in determining the primary land use classification.
[vii] NSW Department of Planning and Environment, *Large-Scale Solar Energy Guideline* (August 2022).