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Agriphotovoltaics Code of Ethics

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Abstract

Solar photovoltaic (PV) technologies are recognised globally as a means of supplying affordable renewable electricity, while mitigating global carbon emissions. However, the development of large PV farms requires large surface areas due to the disperse nature of solar energy. Academic literature has identified Agriphotovoltaics (AgriPV); the dual-use of cropland for agriculture and PV electricity production, as a potential solution to reduce conflict between the two sectors. This paper addresses the social dimension of AgriPV systems, by suggesting a code of ethics for the technology. The suggested code of ethics ensures that the livelihoods of farmers and local communities are upheld; ensures farmers are well prepared to work at AgriPV sites; prioritises crop production in AgriPV systems; and ensures the preservation of farmland and local values. A case study of a proposed AgriPV development in Helensville, Aotearoa – New Zealand, is then used to assess the effectiveness of the code of conduct.

Keywords: Agrivoltaics; Ethics; Concerns; Farmers; New Zealand.

1. Introduction

In order to limit 2 degrees of global warming, the IPCC Sixth Assessment Report states that all electricity will need to be supplied by zero emission or low carbon energy sources by 2050 [1]. Solar photovoltaic (PV) technologies are recognised globally as a means of supplying affordable renewable electricity, while mitigating global carbon emissions [1][2]. However, the development of utility-scaled PV farms requires large surface areas due to the diffuse nature of solar energy. While distributed domestic PV systems have reduced land-use conflicts with the housing industry, new niche PV systems are required to reduce land-use conflicts between the energy and agricultural sectors [3][4][5].

Academic literature has identified Agriphotovoltaics (AgriPV); the dual-use of cropland for agriculture and PV electricity production, as a potential solution to reduce conflict between the two sectors [3][4][5]. While AgriPV systems generate less electricity than conventional ground-mounted PV and, in some cases, reductions in crop yield, the overall productivity of the land increases on the same plot area [3]. AgriPV systems can increase land productivity by an estimated 70 percent, increasing revenue for local farmers and stimulating rural economies [4][6]. The development of distributed AgriPV electricity generation also diversifies the revenue stream of farmland, increasing economic resilience [4]. Additionally, AgriPV systems improve the microclimates of cropland, improving air and soil quality; increasing soil moisture retention and water use efficiency; decreasing soil erosion; and reducing evapotranspiration [6][7][8][9]. Improvements to soil moisture retention and water use efficiency reduces the need to irrigate water for crops and livestock, increasing resilience to droughts and climate change [7][8][9].

AgriPV systems are an emerging technology, with experimentation beginning in the early 2010's [5]. As such, there are uncertainties amongst farmers and communities in close proximity to AgriPV projects, as to the local benefits of the technology [10]. Farmers are dependent on land productivity, and it is difficult to predict the shade tolerance of crops [10]. Therefore, there is uncertainty amongst farmers regarding AgriPV systems, as the

benefits are not immediately visible. As the AgriPV sector is emerging, the implications of AgriPV systems are also uncertain, leaving farmers vulnerable to market uncertainties [10][11][12]. AgriPV developers should work in collaboration with farmers to establish AgriPV contracts, to provide a direct way to alleviate uncertainties and develop a mutually beneficial business model [10][11][12][13]. However, in countries such as Aotearoa – New Zealand, there is no code of ethics for the development of AgriPV systems or AgriPV contracts.

1.1 Objective

The objective of this paper is to design a code of ethics for the development of AgriPV systems. I first undertake a literature review, to identify the social benefits and barriers of AgriPV systems. I then design a code of ethics, using information found during the literature review. I conduct a case study on how the devised code of ethics would operate in the development of a proposed AgriPV system in Helensville, Aotearoa – New Zealand. Lastly, I make recommendations to help AgriPV engineers devise their own code of ethics surrounding the technology.

2. Literature Review

The aim of the literature review is to understand the social dimension of AgriPV systems. I focus primarily on analysing academic literature, with secondary focus on grey literature such as news articles and websites. I organised literature in a synthesis matrix, extracting themes of the benefits of AgriPV systems; social context of AgriPV developments; concerns of local farmers; and the desires of AgriPV developers. Where agreements and disagreements were found among the literature, I analysed them before making final conclusions.

I primarily used Google Scholar to source literature for the analysis. I set limitations so literature predating 2017 were excluded, as AgriPV is an emerging technology. I did not consider number of citations when selecting literature for the review. Keywords to limit searches included “Agriphotovoltaics”; “Agrivoltaics”; “AgriPV”; “farmers”; “social”; “socio-economic”; “barriers”; “concerns”; and “sustainability”.

Regarding the social dimensions of AgriPV development, I have identified five key academic literature. Ketzer et al. [12] conduct a citizens-participation workshop to identify and analyse public attitudes toward AgriPV systems. Li et al. [11] conduct a survey to determine the incentives for and barriers to AgriPV and identify the major factors which influence AgriPV adoption. Lastly, Pascaris et al. [10][13][14] conduct in-depth interviews with agriculture sector experts, solar PV professionals, and the American public in three separate papers, investigating perceptions on the opportunities and barriers to AgriPV systems.

The primary concern of farmers, local communities, and solar industry professionals is the lack of an established and secure AgriPV market. Pascaris et al. [10] found market unknowns imposed constraints on farmers’ ability to establish long term plans for their businesses, which affected their perception of the long-term financial return of AgriPV systems. Li et al. [11] support these findings, identifying that the uncertainty of the associated risks and benefits of AgriPV reduces the likelihood and willingness of farmers adopting AgriPV. Ketzer et al. [12] also found that participants of their citizen-workshop were unable to pass a final judgement on the preferability of AgriPV to other renewable energy systems until AgriPV are introduced into the market. Additionally, Pascaris et al. [13] found that solar industry professionals are doubtful that investors would fund APV due to these uncertainties and are sceptical that APV would generate additional revenue for solar companies. However, prioritising an increase in farmer revenue may result in an

increase in the public acceptance of AgriPV systems. This claim is supported by Pascaris et al. [14], which states being deliberate in providing economic opportunities to farmers and the local community in the form of jobs increases public support for AgriPV. AgriPV developers should, therefore, ensure business model transparency with farmers and local communities to gain community acceptance [14].

While the market unknowns may be more critical than the technical unknowns of APV, the long-term land viability is the underlying challenge of agrivoltaic systems. Pascaris et al. [10] state that the preservation of farmland quality is of utmost importance, as farmers' livelihood is economically dependent on land quality. The interviews conducted by Pascaris et al. [10] found considerations about long-term land use and farmland preservation were the prime basis of decision making, with farmers concerned AgriPV could affect land viability. Pascaris et al [10] states that long term planning and partnership between agrivoltaic industries alleviates these concerns, with contracts between solar developers and farmers being a common solution. The quality of land was of less of a concern of the public, however. Ketzer et al. [12] found participants were more concerned with AgriPV changing the character of the land, from farmland to land characterised by technical elements. Participants were also concerned about the visual impact of AgriPV systems, though, this was less of a concern to those surveyed by Pascaris et al. [14][12]. Nevertheless, solar industry professionals see the upholding of land quality and the local cultural values of the land as beneficial to AgriPV developers, as it strengthens local acceptance of AgriPV.

The workload of farmers and their interactions with AgriPV was a concern associated with AgriPV. Ketzer et al. [12] found that participants thought the workload of farmers should decrease with the introduction of AgriPV systems. Pascaris et al. [10] found that farmers were seeking ways to reduce their workload and are disinterested in making their work more complex. Li et al. [11] also found that farmers' perception of the usability of the technology significantly influenced AgriPV adoption, and that technical training also had a significant positive effect on AgriPV adoption. However, Pascaris et al. [13] found that solar industry professionals are also deterred by the development complexities associated with implementing AgriPV systems and are concerned of the logistics and health and safety concerns of hosting a farmer on an electrical site. However, the complexities of involving farmers in the development stage increases stakeholder engagement, with solar industry professionals valuing this as greater than the added burden of development complexities [13].

3. Code of Ethics

In this section, I detail my suggested code of ethics, based on the best practice identifies from the literature review. In the literature review, I identified the following concerns to be addressed by the code of ethics:

- Market uncertainties;
- Reduction in farmer revenue;
- Reduction in land viability;
- Reduction in visual appeal;
- Increase in farmer workload; and
- The health and safety concerns of hosting a farmer on an electrical site.

Uphold and improve the livelihood of the farmer and the local community

As AgriPV will be developed within communities and will directly affect these groups, it is imperative that the livelihood, values, and priorities of farmers and local communities are upheld. AgriPV developers will:

i. Engage stakeholders in the early stages of development;

ii. Consider the values and priorities of farmers and local communities;
iii. Be flexible and adaptable to the current functions of the land; and
iv. Ensure minimal visual impact to local communities.

Ensure farmers are well prepared to work at the AgriPV site

Farmers will need to be informed of the benefits of AgriPV systems and keep updated on current AgriPV market trends. Additionally, farmers will need to be trained to operate AgriPV systems. AgriPV developers will:

i. Inform farmers of the benefits of AgriPV systems;
ii. Keep farmers updated on AgriPV market trends;
iii. Technically train farmers to operate an AgriPV system; and
iv. Formulate location specific health and safety plans, to ensure no injuries come to the farmers.

Prioritise crop production over electricity generation, to the financial benefit of the farmer

As farmers are reliant on cultivating crops, AgriPV developers will need to ensure the PV system does not compromise crop production. AgriPV developers will also need to ensure PV systems provide additional benefit to the farming process. AgriPV developers will:

i. Ensure the continuation of current agricultural practices;
ii. Ensure the system provides additional support to crop production. For instance, a sprinkler or pesticide system attached onto and powered by the AgriPV system; and
iii. Develop a mutually beneficial AgriPV contract, that supports both parties financially.

Preserve the viability of the farmland and the cultural significance to the local community

To ensure community acceptance of AgriPV developments, the quality of farmland and viability of crop production will need to be preserved. The cultural significance of the land to the local community will also need to be preserved. AgriPV developers will:

i. Monitor soil quality, crop yield and crop quality;
ii. Ensure the development is reversible, without significant impacts to farmland viability or community values; and
iii. Minimise impact to the visual aesthetic of the land by:
    a. Building the AgriPV system on flat plains; and
    b. Define the minimum distance to farmhouse and local community.

4. Case Study

The case study I have selected is the development of an AgriPV system in Helensville, West Auckland, Aotearoa – New Zealand. Aotearoa – New Zealand currently underutilises their solar resource, with solar PV systems accounting for 0.94 PJ of the country's electricity generation in 2022. Transpower [15] projects solar PV to generate between 36 and 115 PJ (of a total of 317 PJ) by the year 2050. Transpower [15] expect that distributed solar PV will generate at least half of the country's solar PV generation by 2050, with land-based systems generating the remaining generation capacity. However, the agriculture sector in Aotearoa – New Zealand is both economically and culturally significant, resulting in land-use conflicts with land-based utility-scaled PV farms [16]. The implementation of AgriPV systems in Aotearoa – New Zealand could be a potential solution to increasing the country's solar PV generation capacity, whilst minimising PV land use and reducing the need for irrigation.

However, there is currently no code of ethics for the development of AgriPV systems or AgriPV contracts in Aotearoa – New Zealand, as AgriPV systems are not currently established in the market. This has created conflict in Helensville, West Auckland, where the local community is in heavy opposition for the AgriPV project [17][18][19]. The project; proposed by NZ-owned, UK-operated solar company, HES Aotearoa, will comprise 82 thousand east-west facing solar PV panels at a rated capacity of 20 MW [19][20]. The development will require 116 hectares of land and the gaps between the rows of PV panels will be used for crops or sheep grazing [17]. Residents of the Helensville township are opposed to the AgriPV development, as it is located on a residential street in a prominent valley and will cause severe visual impacts to the existing view of the upper Helensville township [17][19][21]. Additionally, there are concerns that the project will affect the local environment, as the location is largely encased by the Kaipara River [21]. As of the 29th of April, a petition against the Helensville AgriPV development has gained 144 signatures [21].

I used this case to theorise how the suggested code of ethics would be applied and the benefits and limitations of each principle.

Uphold and improve the livelihood of the farmer and the local community
HES have already recognised the visual impacts of the AgriPV farm and have planned for riparian planting to obstruct the view from neighbouring properties [17][19]. The plants would also reduce the development's impact on the Kaitoke River's water quality. However, as the development is located in a valley and covers a surface area of 116 hectares, it is likely that the riparian plants will fail to prevent visual impacts to residents living in upper Helensville.

Using the suggested code of ethics principle, HES Aotearoa would engage with residents of Helensville in the early stages of development, to gauge their values and priorities. Through this process, HES Aoteraoa would recognise concerns of the development being too close to residential dwellings, visually impacting residents' views. HES Aotearoa would also recognise the significance of the Kaitoke River to the region. Subsequently, HES Aotearoa would either relocate, redesign, or reduce the size of the AgriPV development, with aid from residents in Helensville.

Ensure farmers are well prepared to work at the AgriPV site
Currently, there is no public information suggesting a collaboration between HES Aotearoa and local farmers. This principle is currently limited to solely farmers. However, the local community should also be informed about the socio-economic benefits of AgriPV systems, and keep residents updated on AgriPV trends.

HES Aotearoa has stated that the development will require four full time workers to maintain the AgriPV site. These individuals will need to be technically trained, and health and safety plans will need to be devised.

In applying this principle to the case study, I identified a limitation regarding the employment or involvement of the local community in maintaining the AgriPV farm. This means HES Aotearoa could hire an individual outside of Helensville. In order to stimulate the local economy, local residents should be hired to maintain the AgriPV farm. Local employment would also expected to raise community acceptance of the project.

Prioritise crop production over electricity generation, to the financial benefit of the farmer
As there is no public information suggesting a collaboration between HES Aotearoa and local farmers. Therefore, it is assumed that the AgriPV development will introduce

agricultural activity to the location. This may highlight a limitation of the code of ethics, as the purpose of the principle is to financially benefit the farmer currently residing on the property.

Preserve the viability of the farmland and the cultural significance to the local community

Similarly, the lack of public information regarding the current land practices hinders the ability to assess the effectiveness of this principle. If there were agricultural activity, the principle would ensure that the quality of the land and produce would be preserved.

As covered in the first principle, HES Aotearoa considered the visual impact of the AgriPV development. However, the development is located in a valley where it will be visible to residents living on the hills. Additionally, it is clear that the minimum distance away from the Helensville township was not discussed with residents, as residents are opposed to the development being located on a residential street. This principle would ensure that HES Aotearoa would consider locating the AgriPV project on flat plains, to reduce visibility. Additionally, HES Aotearoa would discuss the minimum distance away from the Helensville township with local residents, to increase community approval of the project.

5. Conclusion

In this paper, I reviewed literature regarding the social dimension of AgriPV systems and suggested a code of ethics for AgriPV development. I applied this code of ethics to the case study of Helensville, where a proposed AgriPV project has been contested by the local community.

A code of ethics for AgriPV development should ensure that AgriPV developers consider the livelihoods, priorities, and values of local farmers and communities. It should also ensure that the AgriPV involves local communities in the development and operation of AgriPV farms, hiring and training residents for AgriPV operation and maintenance. Agricultural activity should be mandatory in AgriPV developments and new developments should be flexible to the current land practices. Additionally, AgriPV developers should ensure that the technology offers residents benefits outside of electricity generation, such as a sprinkler system powered by the PV panels. Lastly, a code of ethics would ensure both the farmland and its cultural significance is restored at the project's end of life.

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