Incentivizing Agrivoltaics to Improve Farmland Resiliency and Meet Renewable Energy Demands in Indiana

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Executive Summary: As Indiana looks to the future, it must balance the long-term success of its large agricultural sector with the need to increase renewable energy production and combat climate change. Often these goals seem to conflict with one another, but agrivoltaics – the dual use of land for active agricultural use and solar farming – is one technology uniquely situated to address these competing interests. However, current policies do not explicitly consider agrivoltaic systems and are ill-suited to spur further solar development in Indiana. Therefore, we propose amending Indiana Code § 6-1.1-8 to establish a preferential land use assessment program for a new "dual-use solar" land type code. Such a change would initiate investment in agrivoltaics technology and incentivize farmland preservation in the solar energy sector.

I. INTRODUCTION

i. Statement of issue

For the future of its climate and economy, Indiana needs policies that appeal to both the agricultural and energy sectors. Given the realities of climate change, there is an increasing desire to move towards a "clean energy" grid that affords local resilience, climate readiness, and health benefits. In recognition of this, utility companies such as AES Indiana and Duke Energy have committed to shutting down coal-fired power plants by 2025 and 2035, respectively (Russell 2022; Saenz 2022), and new power sources will be necessary to fill these gaps in energy production. Solar is a promising replacement, and production is expected to increase by nearly 6,000 MW over the next five years, making Indiana #4 for projected growth in the U.S and requiring as much as ~60,000 acres of land (Solar Energy Industries Association 2022). Although expanding solar energy (and other renewable energy sources) is beneficial on multiple fronts, this growth is commonly in conflict with the desire to protect farmland and the state's vital agricultural sector. With over 56,000 farming operations and nearly 15 million acres of cultivated land (Figure 1), agriculture generates $31 billion annually in Indiana and represents a significant portion of the state's GDP (Indiana State Department of Agriculture 2022). The rapid development of solar energy in Indiana will lead to large expanses of arable soil being replaced with photovoltaic panels (Figure 1), which is seen as a threat to farmland by residents and legislators. Related to this social resistance, statewide legislation in favor of renewable infrastructure has been difficult to enact, and more than 30 counties restrict or prohibit the construction of commercial wind and solar power projects. These issues highlight the need for creative policies that support farmland resiliency in a changing climate and energy landscape.

ii. Agrivoltaic technology

The dual use of farmland for agriculture and solar farming, agrivoltaics (or agelectric), presents a solution for some of the political and agricultural challenges posed by renewable energy expansion in Indiana. Technological advancements have made possible the co-location of raised photovoltaic panels and agriculture on the same plot of land, allowing for

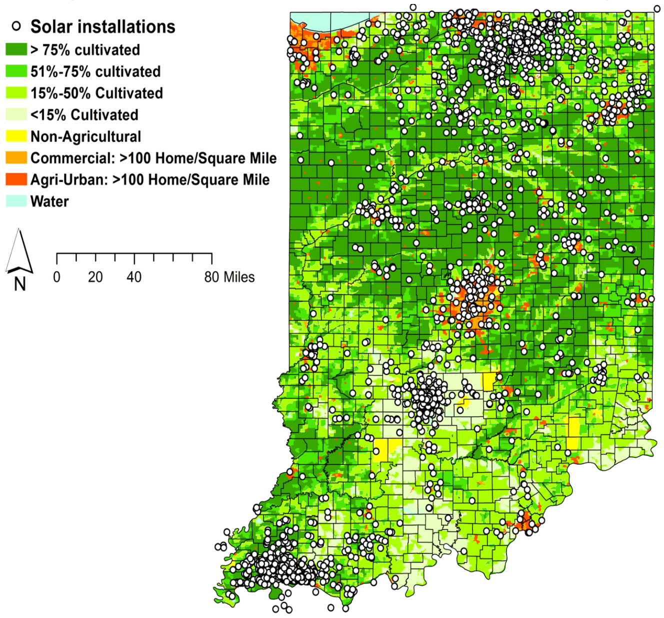

Figure 1*: Map of solar installations (Southern Indiana Renewable Energy Network, n.d.) and cultivated land (USDA, National Agricultural Statistics Service 2004) in Indiana, including percent (%) cultivation and non-agriculture, commercial, and agri-urban areas. Figure 1 illustrates that most solar panels are installed on agricultural land or in agri-urban regions within Indiana.*

the simultaneous harvest of solar energy and crops (Miskin et al. 2019). This increases land use efficiency (Dupraz et al. 2011), diversifies income for farmers, provides economic opportunity for rural communities (Proctor et al. 2021), and decreases social resistance to solar development because farmland is not retired (Pascaris et al. 2021). Further, agrivoltaics have mutual benefits for crops and solar energy capture. Solar panels create a microclimate for crops that protects from heat, water, and wind stress; shading from the panels contributes to cooler temperatures, reduced evaporation, and increased crop water use efficiency that could help to combat the negative impacts of a warmer climate (Barron-Gafford et al. 2019), including mid-century reductions in Indiana corn and soybean yields by as much as 20% and 11%, respectively (Bowling et al. 2019). In return, the cooling effect of transpiration from agriculture also lowers temperatures under solar panels and increases the efficiency of solar energy capture (Adeh et al. 2019; Barron-Gafford et al. 2019). However, crop type needs to be considered for the orientation and design of agrivoltaic systems, as light requirements vary, and panel shading can have negative effects on specific agriculture (Miskin et al. 2019; Zainol Abidin et al. 2021). Multiple technologies have been proposed to adapt systems for diverse agricultural production (e.g., Thompson et al. 2020), and dual-use solar systems can be engineered to limit impacts on crop growth and maximize land use efficiency. Overall, agrivoltaics technology is uniquely suited to balance Indiana's agricultural and renewable energy needs.

iii. Current outlook and practices

Current policies in Indiana treat dual-use systems the same as conventional solar installations, which are subjected to costly increases in property taxes and often restrictive local zoning ordinances. While large-scale traditional solar operations are underway in the state, including the 13,000-acre Mammoth Solar Project that is expected to generate enough energy to power a quarter million homes (Bowman 2021), awareness of and incentives for agrivoltaic technology are lacking. This is in part because agrivoltaics is a relatively new technology that has not been widely implemented across the U.S., with its success and promise for sustainable food systems demonstrated mainly in experimental fields (e.g., Barron-Gafford et al. 2019; Sekiyama and Nagashima 2019) and model studies (e.g., Amaducci et al. 2018). Indiana's own Purdue University (Miskin et al. 2019) and neighboring University of Illinois at Urbana-Champaign are both research centers for agrivoltaics working to optimize solar technology for co-location with crops typically grown in the Midwest, such as corn and soybeans. While research is ongoing, states like Vermont and Massachusetts have already begun implementing policies that support the use of agrivoltaics, including voluntary performance standards for dual-use systems that allow projects to be certified and marketable as "agriculture friendly" and the Solar Massachusetts Renewable Target (SMART) program, which incentivizes agrivoltaics statewide with feed-in tariffs paid by utility companies (Farm and Energy Initiative 2022; Massachusetts Department of Energy Resources 2022). Feed-in tariffs are commonly used to promote renewable power production by guaranteeing an above-market price for clean energy delivered to the power grid, but this policy tool has not yet been utilized in Indiana for agrivoltaics.

Surveys conducted to gauge U.S. farmers' perception of agrivoltaics have shown that uncertainties regarding the long-term impact of solar panels on land viability, market instability, and the flexibility of agrivoltaic systems are primary concerns for the agricultural sector (Pascaris et al. 2020). Compatibility with crop type may draw particular skepticism from farmers in Indiana, where shade-intolerant corn and soybeans, which require the operation of large equipment, are leading sources of agricultural income (Indiana State Department of Agriculture 2022). Despite some of these concerns, 9 out of 10 U.S. participants were open to exploring the use of agrivoltaics on their property, and findings suggest that policymakers should consider financial incentives, like feed-in tariffs and tax breaks, to promote long-term land agreements between solar developers and farmers and catalyze the adoption of agrivoltaics (Pascaris et al. 2020).

II. Policy options

As a nationally important agricultural hub with expanding renewable energy needs, Indiana is poised to lead the way for agrivoltaics. Although solar energy policy is often met with resistance in Indiana, agrivoltaics helps address some of the concerns of lawmakers and residents that have previously stalled legislation, such as the loss of farmland. In this memorandum, we provide policy options suited to incentivize agrivoltaics in a state with divided opinions on renewable energy development.

i. Option 1: Establish a statewide tariff program for energy generated by agrivoltaic systems.

To incentivize agrivoltaics, we propose the development of a tariff-based program in Indiana similar to SMART. Under the SMART program, solar energy that is produced by an agrivoltaic system receives a higher market price (+$0.06/kWh) that can be adjusted with different rate adders and subtractors to encourage optimal placement of solar panels for crop growth and deter new land disturbance (Farm and Energy Initiative 2022; Massachusetts Department of Energy Resources 2022). These systems are defined by the SMART program as Agriculture Solar Tariff Generation Units (ASTGU) that meet narrative, performance, and design standards, which are established to maximize and safeguard agricultural production (Farm and Energy Initiative 2022). To accomplish this, ASTGUs may need consultations to ensure the compatibility between solar panel design and crop type and site-specific analysis to document land and solar system characteristics (Farm and Energy Initiative 2022). The additional structural and operational requirements of agrivoltaic systems can be costly for developers, and tariff-based incentives like those established by the SMART program are important for stimulating development (Pascaris 2021).

Advantages

- Program framework already established by the state of Massachusetts
- Tariffs help offset the higher costs for installing and maintaining agrivoltaic systems
- Ensures optimal placement and performance of dual-use solar systems
- Effectively incentivizes farmland preservation
- Provides some assurance to farmers and solar developers that the market for agrivoltaic energy is viable and stable

Disadvantages

- Consideration of the differences in state policies are necessary: MA has mandatory standards that require utility companies to purchase and distribute renewable energy sources while IN does not
- Revision of Indiana's clean energy portfolio standards, which are currently voluntary and conservative, would help ensure program compatibility with state policies, but this is an additional legislative hurdle for IN that is unlikely to be successful at this time
- Without updated energy standards that mandate investor-owned utility companies, a tariff-based program for IN would potentially need to be supported by state funding and the purchase of ASTGU-generated power
- Disagreement over the party responsible for tariff payment (state vs. utility companies) has caused previous incentives to be dropped from IN legislation, e.g., Senate Bill 411, Indiana General Assembly (Commercial solar and wind energy 2022).

ii. Option 2 Develop a preferential solar land assessment and taxation program that values properties with agrivoltaic systems at a lower base rate.

Indiana state guidance for agricultural and solar land assessment subjects farmland to substantial property tax increases if solar panels are installed for commercial energy production and distribution. For 2022, the agricultural land base rate value is $1,500, whereas the median land base rate for commercial solar energy ranges between $5,250 and $13,000 depending on whether the property is in the northern, central, or southern region (Wood 2021). According to the most recent guidance for solar land assessment, House Bill 1348, these base rates apply for the land underneath and between solar panels on property owned or used by utility companies, regardless of groundcover or continued agricultural production (Assessment of utility grade solar projects 2021). To encourage the preservation of agricultural land as solar energy development grows, we propose that the state amends Indiana Code § 6-1.1-8 to include a new land type code that explicitly considers dual-land use scenarios and allows for preferential taxation of agrivoltaic systems.

Advantages

- Defining a lower base rate for a new dual-use solar land type would reduce the tax penalty for installing solar panels on active agricultural land
- Logistically and politically, it is relatively easy to implement because it is very targeted
- Incentivizes long-term cooperation between farmers and solar developers that is mutually favorable

Disadvantages

- May require additional consultations or inspections to certify the proper operation of agrivoltaic systems, similar to a SMART program framework
- Property tax income associated with solar farm development is reduced for townships

III. Policy recommendations

Given the current political climate and a balanced consideration of pros and cons, our top recommendation is to amend Indiana Code § 6-1.1-8 to establish a preferential land use assessment program for a new "dual-use solar" land type code (Taxation of Public Utility Companies 2021). This would define a reduced tax rate for properties that install and maintain utility-grade agrivoltaic systems. The new monetary benefits of implementing agrivoltaics would incentivize the protection of valuable farmland while still diversifying farmer income and meeting the growing need for renewable energy in Indiana. Although revised clean energy targets and a parallel SMART program for Indiana would be effective for both incentivizing agrivoltaics and reducing greenhouse gas emissions at the state level, more intensive efforts are required to develop these programs and it will be difficult to enact legislation that mandates utility companies. As such, a tariff-based program for agrivoltaics is an alternative policy solution likely to be more feasible and successful when solar energy is more widely used in Indiana and political barriers are relatively relaxed.

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Audrey Taylor recently graduated from the University of Notre Dame with a Ph.D. in Earth Sciences. Her research focused on reconstructing past climate and ecosystem change in southeastern Africa and the Mediterranean region using sedimentary biomarker proxies. As a 2023 John A. Knauss Marine Policy Finalist with the Illinois-Indiana Sea Grant program, she is also interested in science policy and using her knowledge of environmental variability through Earth's history to improve climate science communication and action.

Morgan Munsen recently graduated from the University of Notre Dame with a Ph.D. in Psychology and a minor in Quantitative Studies. Her research focused on how pre-existing factors (such as confirmation bias) shape how humans process new information and integrate information into memory. More broadly, she is interested in individual decision-making and belief-formation processes, and, in particular, how individuals (whether citizens, policymakers, or otherwise) evaluate information and communicate about it. She is soon starting work with a Notre Dame interdisciplinary research institute that investigates how we live meaningful lives, shaped by the 2022-2023 theme: "The Public".