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# UTILITY SCALE AGRIVOLTAICS DEVELOPMENT PROXIMATE TO MICHIGAN COMMUNITIES WITH 100% RENEWABLE ENERGY GOALS

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## Abstract

This report aims to assess the potential of agrivoltaics (combined solar and agricultural systems) for development geographically proximate to the six Michigan (MI) communities that have set 100% renewable energy (RE) goals. I focus on one major research question: What is the total acreage of low impact sites available for utility-scale (USS) agrivoltaics development proximate (within county boundaries) to MI communities with 100% RE goals? SAM is used to estimate land acreage required for a 10 MW agrivoltaic system development. ArcGIS Pro is used to determine the total acreage of low impact sites proximate to MI communities with 100% RE goals.

Proximate low impact sites are defined as agricultural land with minimal environmental and land use impacts, having access to transmission and distribution infrastructure, and are located within the same county as the community with the RE goal. This study finds that USS agrivoltaics development is possible in all six counties. On the premise that the benefits and ills of an energy technology should be distributed equitably within society regardless of social and economic factors, USS agrivoltaic systems could provide a source of revenue for farmers and promote local employment within the county. In addition, such systems can help support the state of MI to achieve its current RPS of 15% and carbon neutrality by 2050. This report provides a first step in assessing the potential of agrivoltaic development in Michigan, which can inform future work that integrates other considerations relevant to solar development.

# 1 Introduction

The solar industry continues to rapidly expand, but large-scale solar photovoltaic systems can face public resistance, particularly as they encroach on farmland traditionally zoned for agriculture. Research on utility-scale solar (USS) development in the Great Lakes' region states (Indiana, Michigan, Minnesota, and Wisconsin) points out that the development of USS on agricultural land raises concerns about reduced land for food production (Uebelhor et al., 2021). Moreover, farmers are concerned about compromised future land productivity as a result of solar infrastructure being placed on farmland (Pascaris et al., 2020).

The co-location of solar generation facilities and agriculture is an increasingly popular concept often referred to as "agrivoltaics." Research on agrivoltaics shows that these systems can provide additional revenue for farmers and lead to local employment opportunities (Pascaris, Schelly, et al., 2021). Agrivoltaic systems can generate higher yields of certain specialty crops than conventional agriculture, with the potential to increase global land productivity by 35-73%(Dupraz et al., 2011). Therefore, this novel technology generates a synergy allowing clean electricity and food production to occur simultaneously on the same land, particularly important in regions with limited access to land that is not being used for agriculture (Amaducci et al., 2018; Dupraz et al., 2011; Sekiyama & Nagashima, 2019).As of June 2019, a significant portion of farmland has become available for solar energy development in Michigan (MI) under the state Farmland and Open Space Preservation act (PA 116) (Light et al., 2020; Uebelhor et al., 2021).This opens the opportunity for agrivoltaic development on MI farmland.

A growing number of communities in the United States (US) have made 100 % renewable energy (RE) commitments to combat climate change and to create more jobs locally (Adesanya et al., 2020; Hess & Gentry, 2019). A community 100% RE policy may either focus on just electricity or may include transportation and heating for building (Hess & Gentry, 2019). Six MI communities have passed 100% RE goals, the majority of them focusing on electricity (Table. 1). However, local land use policies and local concerns over siting solar on farmland can impede the development of RE projects (Light et al., 2020; Pascaris, 2021).

This report aims to assess the potential development of USS agrivoltaics within the county boundaries of the six MI communities with 100% RE goals by answering the question:

what is the total acreage of low impact sites available for USS agrivoltaics development within county boundaries of MI communities with 100% RE goals?

To assess low impact sites proximate to the six MI communities with 100% RE goals, I first estimate land acreage required for a 10 MW agrivoltaic system development using System Advisory Model (SAM). A 10 MW agrivoltaic system is proposed because it is the minimum capacity at which a solar system is deemed USS, according to the US Department of Energy office of energy efficiency and renewable energy (Department of Energy, n.d.). Then, geographic information system (ArcGIS Pro) is used to determine the total acreage of low impact sites proximate to MI communities with 100% RE goals. For the purpose of this study, low impact sites proximate to the six MI communities with 100% RE goals are defined as land with minimal environmental and land use impacts and have access to transmission and distribution infrastructure(Charabi & Gastli, 2011; Light et al., 2020). Protected areas and national wetlands within county boundaries are excluded. Agricultural land in the U.S. is mostly flat, therefore, ideal for solar development (Charabi & Gastli, 2011; Hernández-Hernández et al., 2017). More than 99% of agricultural land has a slope less than $1^{o}$ and generally, areas with slopes less than 5 degrees are suitable for solar development. Therefore, this report considers land area of slope less than 5 degrees. Land within county boundaries located near existing (having access) transmission lines and electric substations is considered.

# 2 Literature Review

Ongoing climate change has led many countries across the globe to commit to transitioning to RE. The US has been making steady progress transitioning to renewable forms of energy. In the year 2020 solar energy contributed to 2% of the total electricity generated in US and is projected to increase by 20% in 2050 (Francis & Sukunta, 2021). In Michigan alone, 599.36 MW of solar energy was installed in 2020 and is projected to increase to 2,550.21 MW in the next five years (Solar Energy Industries Association, 2021).

With electricity demand projected to more than double in the next 40 years, RE investments are crucial (Carlisle et al., 2014). USS is considered a primary source of energy supply to meet this demand (Bolinger et al., 2020). USS installations can be plugged into the existing grid with great cost efficiency as they are generally located near existing electric infrastructure (Hay, 2020; Moore et al., 2021). Usually, every USS system has a power purchase agreement (PPA) with a utility to guarantee market for energy produced for a fixed period of time. Moreover, Michigan USS developers have the opportunity to sell electricity at market price to the Midcontinent Independent System Operator (MISO) interconnection via virtual power purchase agreement (VPPA)(Urban Grid, 2019).The installed costs of USS in the U.S. has dropped 12.3% between 2020 and 2021 compared to rooftop solar (3.3%) and commercial solar (10.7%)(Vignesh Ramasamy et al., 21 C.E.).Therefore, the development of USS on MI farmland presents an opportunity to combat climate change while taking advantage of the declining prices of solar development.

The co-location of agricultural activities and solar development provides a promising source of both energy and food – both things humans need that are threatened by climate change (Carlisle et al., 2016; Proctor et al., 2021). In addition, the benefits of agrivoltaics allow for increased revenue for farmers, greenhouse gas emission reductions, and increased yield for farmers (Pascaris, Handler, et al., 2021).

Research has demonstrated that agrivoltaics can provide 20% of total electricity generation in the U.S. and reduce 330,000 tons of carbon dioxide emissions (Adeh et al., 2018; Proctor et al., 2021). A recent study by Lytle et al. (2020) exploring a new agrivoltaic concept of raising rabbits under solar panels in Pennsylvania (PA) and Wisconsin (WI) indicated that solar development and raising rabbits provide multiple benefits. A rabbit raised under solar panels can sell for as much as $45 while rabbit fur can sell for as much as $5/rabbit. Additionally, 381 MWh and 433 MWh (annually) electricity generation per acre can be achieved in PA and WI respectively (Lytle et al., 2020).

The colocation of solar panels and shade-tolerant plants like lettuce can generate a 30% increase in economic value for agricultural farms (Dinesh & Pearce, 2015).In addition, agrivoltaic systems increase land productivity and promote water use efficiency by plants (Adeh et al., 2018; Dupraz et al., 2011). Studies have also shown that agrivoltaics is ideal for shade-tolerant crops but also typical shade-intolerant crops such as corn can grow under solar panels as well (Sekiyama & Nagashima, 2019).

Although agrivoltaics can increase crop yield for both shade-tolerant and shade-intolerant crops, increase revenue for farmers and provide a synergy that allow for both food and electricity production while conserving arable land and reducing greenhouse gas emissions, research on its various applications is still ongoing and this study recognizes that agrivoltaics might not be the most efficient way to grow all crops.

In the U.S., concerns about land-use competition and zoning standards remain the primary barriers for large-scale solar projects (Becker, 2019; Light et al., 2020). Zoning can limit solar development to certain areas within a community and hence make certain projects financially infeasible. However, zoning has the potential to provide many opportunities for solar development that might attract developers. In Michigan, if a community does not include the development of RE projects in its zoning ordinance, that particular community may unintentionally be prohibiting the development of RE projects. However, a community is not permitted to prohibit lawful land use of a RE project, if there is a need in the community and there is an appropriate location (Light et al., 2020).

Research shows that farmers are open to solar development on agricultural land (agrivoltaics), if this novel technology taps into community benefits such as increased revenue for farmers and local employment (Pascaris, Schelly, et al., 2021). Therefore, the development of novel technologies such as agrivoltaics bring to light issues of equity and justice in RE planning and development. Energy justice provides a means of integrating community benefits in the planning and development of energy projects. It does this through distributive justice (all ills and benefits should be equally distributed), procedural justice (equitable involvement of all stakeholders within a community), and recognition justice (considering community needs and vulnerabilities in relation to development of an energy project) (Banerjee et al., 2017; Jenkins et al., 2016; Sovacool & Dworkin, 2015). This study aims to address a practical application of distributive energy justice, that all ills and benefits of an energy project should be equally distributed within a community that is utilizing the energy, by proposing the development of USS agrivoltaics within county boundaries of MI communities with 100% RE goals. Locating solar energy within communities that have committed to renewable energy goals is one way to address distributive justice. Agrivoltaics can also address distributive justice by providing benefits to farmers for the use of their lands, community benefits through tax revenues, increased viability of agricultural activities, and/or increased amenities such as pollinator habitat. Using methods like those used in this report may also help to address procedural justice, by giving communities knowledge and tools to proactively engage with solar energy development projects.

# 3 MI communities that have passed 100% renewable energy goals

Policy scholars argue that cities will be the drivers of sustainable energy solutions (Monstadt & Wolff, 2014). Several cities in the U.S. including MI communities (Table.1) have made 100%

RE commitments in an effort to combat climate change and reduce dependency on fossil fuels. Moreover, Gov.Whitmer has signed an executive order for MI to achieve carbon neutrality by 2050 (The Office Of Governor Gretchen Whitmer, 2020).

The implementation of sustainable energy solutions such as agrivoltaics in MI is affected by federal, state, and local policies. Developers of agrivoltaic systems can benefit from the federal Business Energy Investment Tax Credit (ITC) – ITC is administered by the internal revenue service (IRS). To be eligible for ITC, developers have to be for-profit. Therefore, non-profit developers (e.g.: small scale or low-income firms) are not eligible for ITC. In addition, developers are also eligible for the Rural Energy for America Program (REAP) Grants & Loan Guarantees – REAP is administered by the U.S. Department of Agriculture (USDA). Under REAP, developers can cover up 25% of project cost and this can be combined with a loan guarantee which cannot exceed $25 million dollars. In the event of solar development on agricultural land as a joint venture between a solar company and an agricultural landowner, it is possible to receive both REAP from USDA and ITC from IRS (Pascaris, 2021).

At the state level, the development of RE project is affected by the state Renewable Portfolio Standard (RPS). A state RPS require that a certain percentage of electricity retail electric providers sell comes from renewable sources. According to the Michigan Public Service Commission, RPS in MI applies to all electric providers (investor-owned utilities, cooperative utilities, municipal utilities, and electric suppliers) (Michigan Pubic Service Commission, n.d.; Pascaris, 2021). As of 2021, MI RPS was increased from 10% in 2015 to 15% (Moore et al., 2021; Uebelhor et al., 2021). The MI RPS is low compared to states like New York (70% by 2030) and California (60% by 2030), so it may not function to proactively incentivize solar energy development (National Conference of State Legislatures, 2021).

In the U.S., the authority over land use is reserved to local governments. Zoning can limit the development of RE project or provide opportunities for development within a community. In Michigan, zoning is under the jurisdiction of local municipalities. Counties can, however, establish zoning ordinances for which townships or cities may or may not defer. In the six Michigan communities (Table 1) that have passed 100% RE goals, Emmet County does not include USS in their renewable energy zoning ordinance. For other counties, no data is available regarding USS zoning (Mills, 2021; Pascaris, 2021).

Table 1 MI communities that have passed 100% RE goals.

| County | Community | Electric Service Provider | RE Goal | By year: | Source |
|---|---|---|---|---|---|
| Washtenaw | Ann Arbor | DTE | 100% community-wide carbon neutrality within the power sector | 2030 | (A2Zero, 2020) |
| Kent | Grand Rapids | Consumers Energy | 100% energy used for city operations | 2025 | (DSIRE, 2021) |
| Emmet | Petoskey | Consumers Energy | 100% clean energy citywide | 2035 | (Perkins, 2020) |
| Grand Traverse | Traverse City | Traverse City Light & Power (TCL&P) | 100% clean, renewable electricity citywide (TCL&P) | 2040 | (Fox et al., 2018) |
| Ingham | Meridian Township | Consumers Energy | 100% energy used for township operations | 2035 | (Climate Sustainability plan, 2017) |
| Leelanau | Leelanau Township | Consumers Energy | 100% of its electricity needs from local, renewable sources | | (Cecco et al., 2016) |

# 4 Methods

The overarching goal of this report is to assess the potential development of USS agrivoltaics within the county boundaries of MI communities with 100% RE goals. Development within county boundaries is proposed in this report to establish a practical application of distributive energy justice. To determine total acreage of low impact sites for USS agrivoltaics development, SAM is used to estimate total land acreage of a 10MW agrivoltaic system. In this report, a 10MW agrivoltaic system is proposed as minimum size for which a solar system is deemed USS. ArcGIS Pro is then used to determine the total acreage of low impact sites for development. In this report, low impact sites exclude protected areas and wetlands within county boundaries and include sites located near transmission lines and electric substations. In addition, land area with a slope of less than 5 degrees was considered as solar developers typically prefer lower slopes for solar development.

The following steps were followed to answer the question: what is the total acreage of low impact sites available for USS agrivoltaics development within county boundaries of MI communities with 100% RE goals?

***1- Estimate land acreage required for a 10 MW agrivoltaic system using SAM***

Estimating land acreage of a 10 MW agrivoltaic system was conducted using the National Renewable Energy Lab's open-source System Advisor Model (SAM) software using inputs from (Table 5). Six counties within which the communities in MI that have passed 100% renewable energy goals are used. All systems are assumed to be ground mounted, fixed tilt, grid tied, and with an array height of one-story building or lower. It was assumed for all systems that there were no shading losses, the annual average soiling loss was 5%, and that there is no grid interconnection limit. The assumptions made aim to reduce installation complexities. Moreover, a typical configuration for an agrivoltaic system is between 2 – 5 meters above ground, hence an array height of a one–story building or lower (Campana et al., 2021; Pearce & Sommerfeldt, 2021). For all six counties, solar radiation and meteorological data were obtained from the National Solar Radiation Database (Sengupta et al., 2018).

***2- Access availability of low impact, proximate sites using ArcGIS Pro***

Previous research on siting analysis for solar development has considered a number of criteria for assessing sites for solar development. These criteria are dependent upon available data. Data collection methods can be primary data or secondary data. Primary data involves data that has been collected first-hand by the researcher, while secondary data involves data that has been previously used by other researchers. These criteria can be categorized in four types including economical, environmental, technical, and social. In addition, they can be categorized as exclusion or preferable data. Exclusion data can include legal restrictions, protected areas, developed areas, and higher slopes, while preferable data can include distance to electric infrastructure, slope, and land cover (Charabi & Gastli, 2011; Katkar et al., 2021).

This study relies on available secondary data to consider technical, environmental, and economical criteria. In addition, I added a distribute energy justice criterion, as county boundaries within which the six MI communities with 100% RE goals are located (Table 2).

Table 2 Classification of criteria used for siting analysis.

| Technical | Environmental | Economical | Distributive Energy Justice |
|---|---|---|---|
| Land cover class<br>Electric substations<br>Transmission lines | Protected areas<br>Wetlands | Slope | County boundaries |

Table 3 Criteria used for siting analysis and their corresponding sources.

| Criteria | Description | Source | Format | Year |
|---|---|---|---|---|
| Land Cover Class | National Land Cover Database – 30m resolution, Anderson Level II classification system | (Wickham et al., 2021) | Raster | 2016 |
| Electric substations | Department of Homeland Security – Homeland Infrastructure Foundation – Level Data (HIFLD) – Electric Substations | (Homeland Infrastructure Foundation-Level Data, 2021b) | Vector | 2021 |
| Transmission Lines | Department of Homeland Security – Homeland Infrastructure Foundation – Level Data (HIFLD) – Transmission Lines | (Homeland Infrastructure Foundation-Level Data, 2021a) | Vector | 2021 |
| Protected areas | PADUS – A comprehensive database of the protected areas of in the US | (U.S. Geological Survey (USGS) - GAP Analysis Project (GAP), 2021) | Vector | 2021 |
| Wetlands | MI Wetlands – National Wetlands Inventory (NWI) from the US Fish and Wildlife Service | (U.S. Fish & Wildlife Service, n.d.) | Vector | |
| Slope | National 3D Elevation Hillshade at 1/3 arc second or ~10m resolution | (Williams, 2022) | Raster | 2022 |

| | | | | |
|---|---|---|---|---|
| County boundaries | MI Government Units – The National Map Website | (U. S. Geological Survey - National Geospatial Program, 2022) | Vector | 2022 |

The following steps were followed for siting analysis using ArcGIS Pro:

1. For all six counties, all criteria in Table 3 were projected according to the projections specified in Table 5
2. Raster and vector criteria were extracted by mask and clipped respectively to all six counties. In addition, raster criteria were converted into polygons using a rectangle polygon. The raster data were summed to the rectangle polygon using the nearest neighbor method.
3. For slope, areas of less than 5 degrees were considered.
4. For all six counties, only Cultivated Crops, Hay/Pasture, and Herbaceous land cover classes were considered for USS agrivoltaics development. According to the National Land Cover Database Class Legend and Description:
    - The **Cultivated Crops** land cover class refers to land area used for crop production such as corn, soybeans, vegetables, and perennial woody crops
    - The **Hay/Pasture** land cover class refers to land used to grow legumes, grass – a mixture of livestock grazing and production of seed or hay crops
    - The **Herbaceous** land cover refers to land predominantly covered with herbaceous vegetation but can be used for grazing (Wickham et al., 2021).
    - The above land cover classes were chosen to capture all agricultural land in the state of MI either used for crop production or livestock grazing.
5. The land cover class were then dissolved to proceed with contiguous land area.
6. Protected areas and wetlands within all six counties were excluded as not viable for USS agrivoltaics.
7. Buffers of (0 – 2500) meters around electric substations and transmission lines were created and then merged within all six counties. The distance to electric infrastructure

was borrowed from a study on strategic land use analysis for solar energy development in New York (Katkar et al., 2021).

8. The dissolved land cover classes were intersected with the area of merged buffers around transmission lines and electric substations and intersected with the area corresponding to slopes of 5 degrees and less. Only land within the (0 – 2500) meters buffers was considered feasible.
9. Since the development of a 10MW agrivoltaic system requires 38.6 acres of land (Table 6), contiguous land area greater or equal to 40 acres in all six counties was finally that meets the aforementioned criteria was considered to determine total acreage of low impact sites for USS agrivoltaics development proximate (within county boundaries) of the six MI communities with 100% RE goals.

Table 4 GIS projection for all six counties.

| County | City | Projection |
|---|---|---|
| Washtenaw | Ann Arbor | NAD_1983_StatePlane_Michigan_South_FIPS_2113(Meters) |
| Kent | Grand Rapids | NAD_1983_StatePlane_Michigan_South_FIPS_2113(Meters) |
| Emmet | Petoskey | NAD_1983_StatePlane_Michigan_Central_FIPS_2112(Meters) |
| Grand Traverse | Traverse City | NAD_1983_StatePlane_Michigan_Central_FIPS_2112(Meters) |
| Ingham | Meridian Township | NAD_1983_StatePlane_Michigan_South_FIPS_2113(Meters) |
| Leelanau | Leelanau Township | NAD_1983_StatePlane_Michigan_Central_FIPS_2112(Meters) |

| Parameters | | Input | Source |
|---|---|---|---|
| Location and Resources | Solar Resource Library<br><br>Global Horizontal | Grand Traverse County, Station ID 944122<br>3.74 kWh/m²/day | NSRDB<br><br>NSDRB |
| | Solar Resource Library<br><br>Global Horizontal | Washtenaw County, Station ID 983619<br>3.93 kWh/m²/day | NSRDB<br><br>NSDRB |
| | Solar Resource Library<br><br>Global Horizontal | Kent County, Station ID 943087<br>3.88 kWh/m²/day | NSRDB<br><br>NSDRB |
| | Solar Resource Library<br><br>Global Horizontal | Emmet County, Station ID 878492<br>4.03 kWh/m²/day | NSRDB<br><br>NSDRB |
| | Solar Resource Library<br><br>Global Horizontal | Ingham County, Station ID 971970<br>3.91 kWh/m²/day | NSRDB<br><br>NSDRB |
| | Solar Resource Library<br><br>Global Horizontal | Leelanau County, Station ID 944387<br>3.84 kWh/m²/day | NSRDB<br><br>NSDRB |
| Module | | Trina Solar TSM-500DE18M(II)<br>Mounting standoff<br>Array height | Default<br><br>Ground or rack mounted<br>One story building height or lower |
| Inverter | | Advanced Energy Industries: AE 1000NX (3159700-XXX) | |
| System Design | System nameplate capacity (kWdc) | 10,026.653 | |

| | | | |
|---|---|---|---|
| | Number of inverters<br>DC to AC ratio<br>Inverter efficiency<br>Array type<br>Modules per string in subarray<br>Strings in parallel in subarray<br>Tilt | 10<br>1.00<br>97.829 %<br>Fixed open rack<br>30<br>668<br>Latitude | Optimal for annual generation<br>Default<br>Default<br>Default<br>Optimal for annual generation<br>Optimal for annual generation<br>Optimal for annual generation |
| Shading and layout | | None | Default |
| Losses | Average annual soiling loss | 5% | Default |

Table 5 System Advisory Model Version 2020.11.29 simulation parameters, inputs, and sources.

# 5 Results

Table 6 shows estimated land acreage required to build a hypothetical 10MW agrivoltaic project in the six counties under study. The total land area required for a 10MW agrivoltaic system development is the same in all the six counties under study. Although, the global horizontal is different in all six counties (GHI) (Table 5), it does not affect the estimated land acreage required to build a 10MW agrivoltaic system. GHI represents the total amount of shortwave radiation received from above by a surface horizontal to the ground and is measured in (kWh/$m^2$/day), therefore, it affects energy production of a given solar system.

Table 7 shows the total acreage of contiguous sites greater than or equal to 40 acres available for 10MW agrivoltaic systems development proximate to MI communities with 100% RE goals. This study finds that there is ample space for 10 MW agrivoltaic systems development in all six counties.

Table 6 Estimated land acreage for a 10 MW agrivoltaic system.

| County | Estimated land acreage (acres) |
|---|---|
| Kent | 38.6 |
| Washtenaw | 38.6 |

| | |
|---|---|
| Emmet | 38.6 |
| Grand Traverse | 38.6 |
| Ingham | 38.6 |
| Leelanau | 38.6 |

Table 7 Total viable acreage available for USS agrivoltaics development.

| County | Community | Total Viable Acreage |
|---|---|---|
| Washtenaw | Ann Arbor | 339,356 |
| Kent | Grand Rapids | 222,830 |
| Emmet | Petoskey | 24,668 |
| Grand Traverse | Traverse City | 64,987 |
| Ingham | Meridian Township | 116,828 |
| Leelanau | Leelanau Township | 14,673 |

# 6 Study limitations

It is important to note that nothing was done to assess whether USS agrivoltaics is of interest to the six MI communities with 100% RE goals. Additionally, Leelanau township has not yet actually passed a 100% RE commitment, however, a local non-profit in Leelanau called Leelanau Energy is committed to transforming the Leelanau peninsula into a peninsula powered by 100% sustainable energy sources. While one of the counties studied here is zoned for renewable energy development, none of the counties have accessible zoning associated with agrivoltaics. Without proactive zoning that encourages USS agrivoltaics, this form of solar development could be a challenge for farmers who, for example, aim to maintain their agricultural land tax status, or are unsure how to navigate solar development giving the lack of guidance in local zoning policies.

This study has some technical limitations as well. In designing a 10MW agrivoltaic system in SAM, only height was considered as a factor that affects the development of an agrivoltaic system. Spacing is another technical factor that affects agrivoltaics. Since, crops grow at different heights and need different spacing for optimal growth. Future studies need to consider these factors for agrivoltaics development.

Moreover, since it is hard to find contiguous land area owned by a single owner in MI compared to states like Texas, the results of this study could greatly be overestimated. If there are multiple owners, developers would have to get them all on board in a contiguous area to get enough territory to build an agrivoltaic system. Therefore, future studies should include landownership as a criterion to assess the development of USS agrivoltaics in MI.

# 7 Discussion

This study demonstrates that USS agrivoltaic development is technically possible proximate to the six MI counties with communities that have made 100% RE goals. USS agrivoltaics can help MI communities achieve their 100% RE goals, which has the potential to address distributive energy justice by geographically locating energy generation within the county where the energy is used. Fossil fuel energy production produces negative impacts for local communities near generation facilities (poor air quality, decreased property values etc.) and typically fossil fuel energy systems are designed for sue outside the local area where it is produced. RE has the potential to eliminate the negative impacts of fossil fuel energy production, however, still has impacts such as land use competition, and loss of natural beauty. Locating RE locally can help support distributive energy justice by equitably distributing benefits within the community and alleviating burdens such as poor air quality and decreased property values. Energy justice scholars also emphasize the importance of procedural justice, and this report does not address that.

Moreover, the development of USS agrivoltaics can help the state of MI achieve carbon neutrality by 2050 as per the executive order of Gov.Whitmer. MI has recently experienced climate change effects including a polar vortex, historic floods, dam breaks, and week-long power outages. The state recognizes that it is important to take action to combat climate change while ensuring good sustainable jobs, clean air and water, and home powered by clean energy. USS agrivoltaics can be one way among many others for MI to achieve carbon neutrality by 2050.

Although USS agrivoltaics is proposed in this study, it is important to recognize that several solutions are needed for MI to achieve carbon neutrality – agrivoltaics being one of them. Other solutions such as rooftop solar, commercial solar, and other sustainable energy solutions are also needed to achieve carbon neutrality. This study proposes agrivoltaics as a means to achieve carbon neutrality while potentially addressing distributive energy justice. It is worth noting that other aspects of energy justice namely procedural and recognition justice need to be clearly investigated in future studies.

# 8 Conclusion

This study is relevant as previous research on agrivoltaics have only considered economic benefits, social acceptance, and the legal framework to establish this technology (cite). However, siting opportunities have not previously been considered in the state of MI. Given the fact MI communities presented in this study have passed 100% RE goals and that Governor Whitmer has set a goal for MI to achieve carbon neutrality by 2050, this study aims to inform policy makers at the state and local levels, decision makers in electric utilities at the local level, and the general public on the possibility of USS agrivoltaic development as a technology that can tap into community benefits and at the same time help mitigate climate change and help achieve carbon neutrality.

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