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Office of the Assistant Secretary for Civil Rights
1400 Independence Avenue, SW
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correo postal:
U.S. Department of Agriculture
Office of the Assistant Secretary for Civil Rights
1400 Independence Avenue, SW
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Planning and Zoning for Solar Energy Systems

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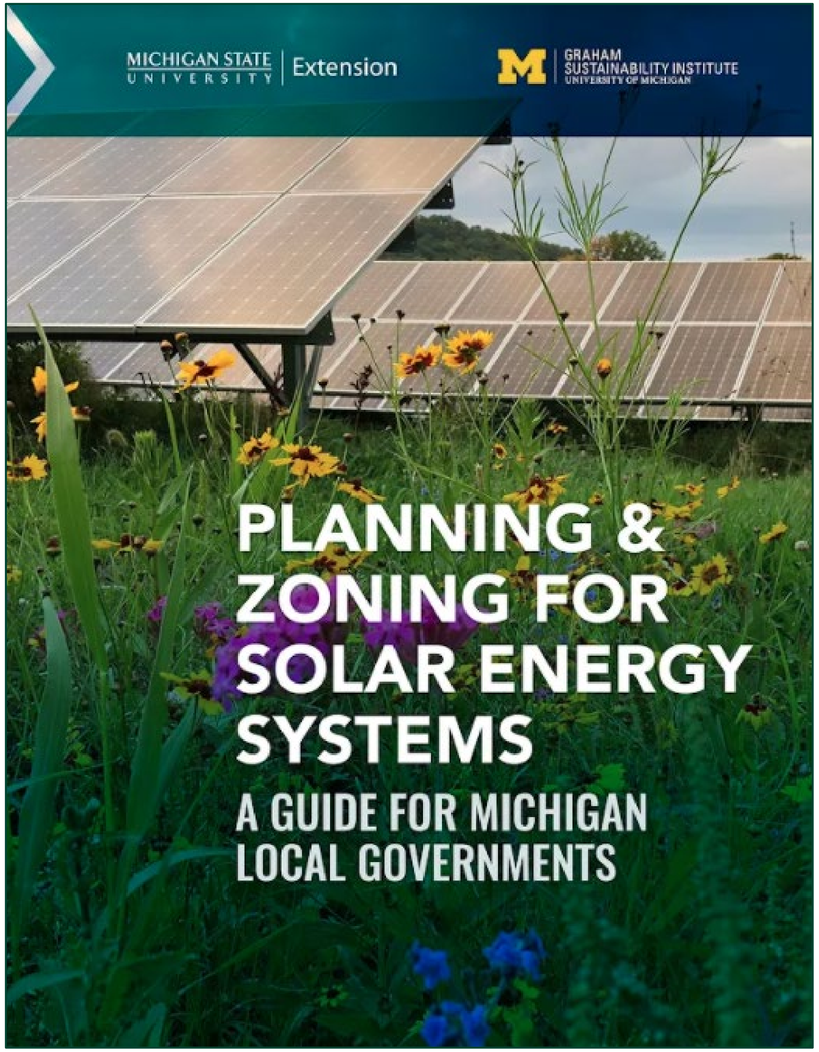
Hannah Smith, University of Michigan graduate student



extension.msu.edu/solarzoning

Drivers behind solar development in Michigan

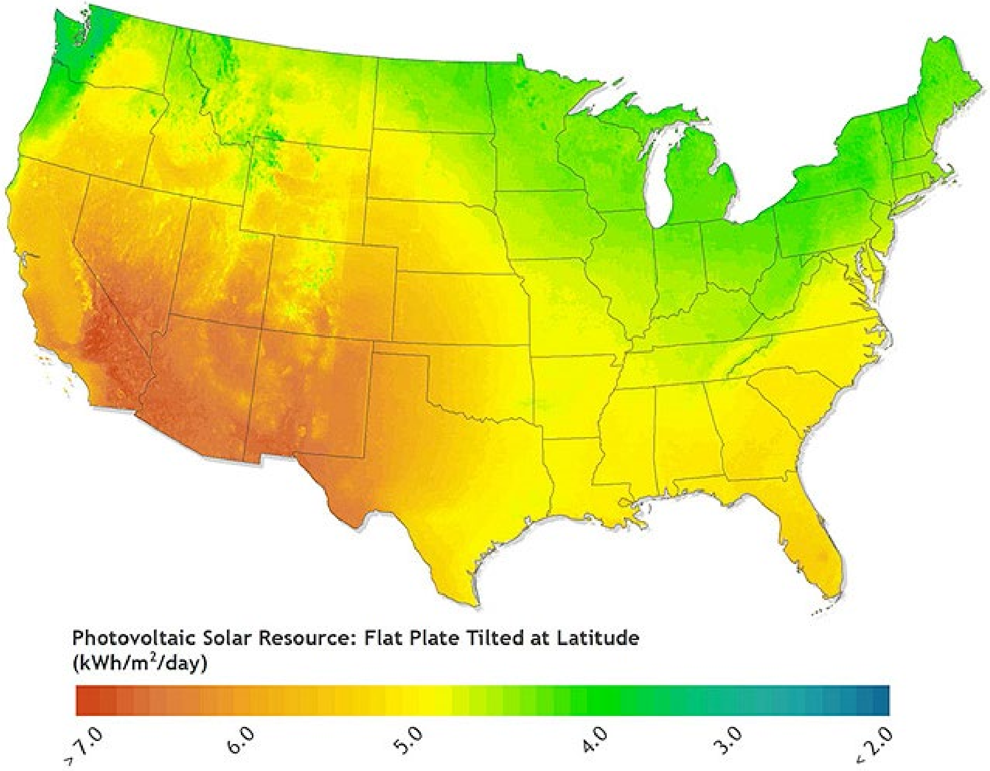
- Local governments
  - Land use and siting permits for solar energy systems are granted by local governments, including cities, counties, and townships.
- State government
  - Mi Healthy Climate Plan
  - PA 116
- Federal government
  - Inflation Reduction Act
- Utility carbon emissions reduction goals
  - Consumers Energy
  - DTE

Photo courtesy of Charles Gould

Michigan's Solar Resource

Is there enough sun in Michigan to use solar?

Yes! (>3.5 kWh/m2/day)

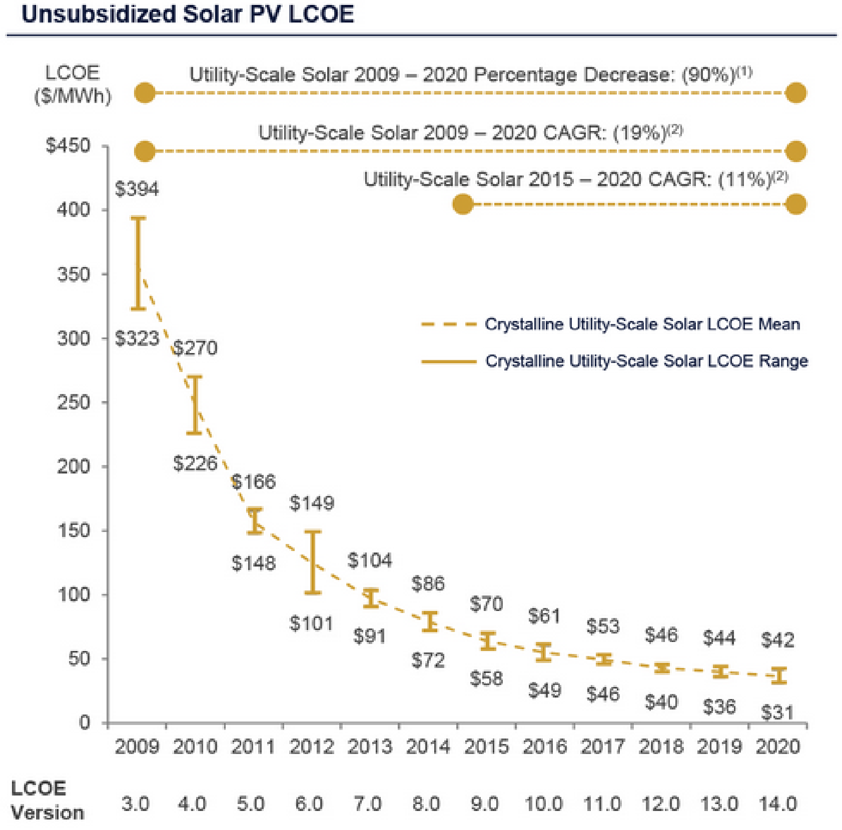


Source: SolarGIS

Costs of Solar Declining

- 90% decrease in cost in utility-scale solar from 2009 to 2020.

Source: https://www.lazard.com/perspective/lcoe2020



Dual Use

Land should never be used exclusively for solar power production.

Photo credit: Charles Gould

Photo credit: Charles Gould

Photo credit: Rob Davis

Photo credit: Charles Gould

Grazing and Forage Production

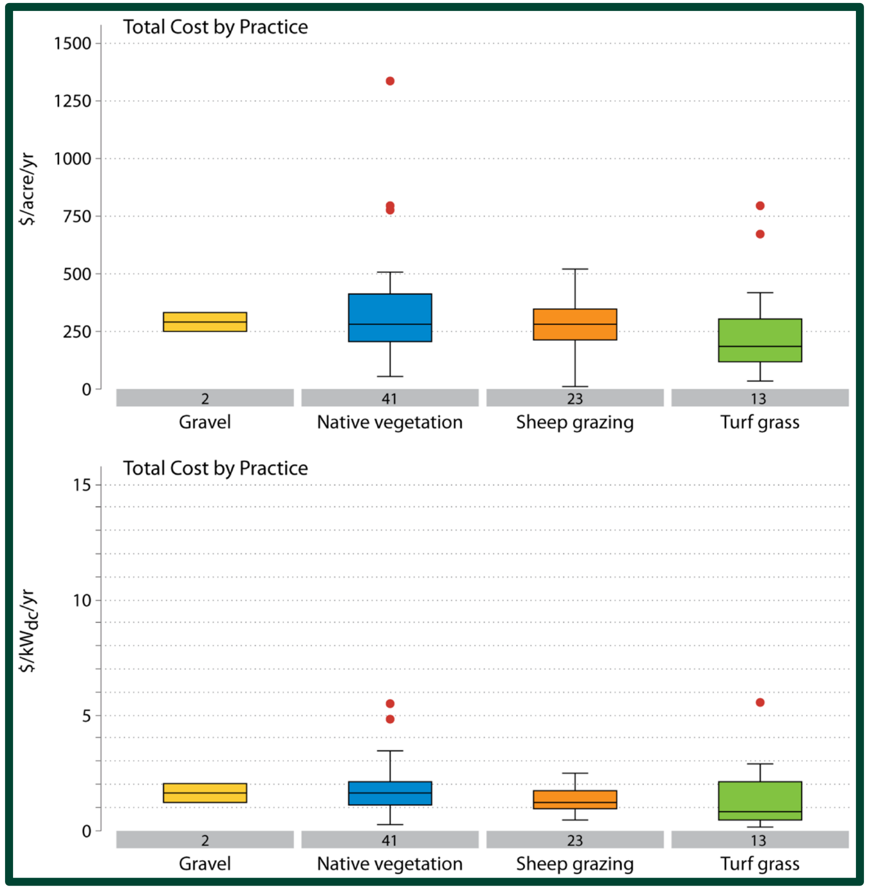
- Solar sites that incorporate rotational livestock grazing and forage production as part of an overall vegetative maintenance plan.

Photo credit: Charles Gould

Photo credit: Charles Gould

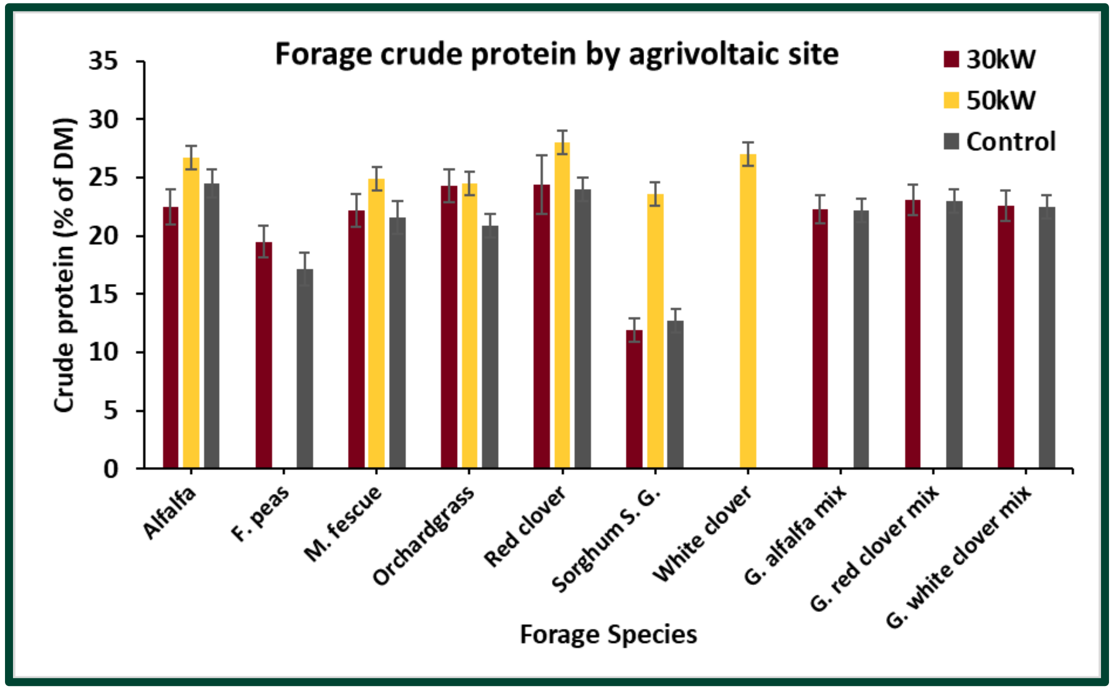
Cost Differences in O&M by Ground Cover

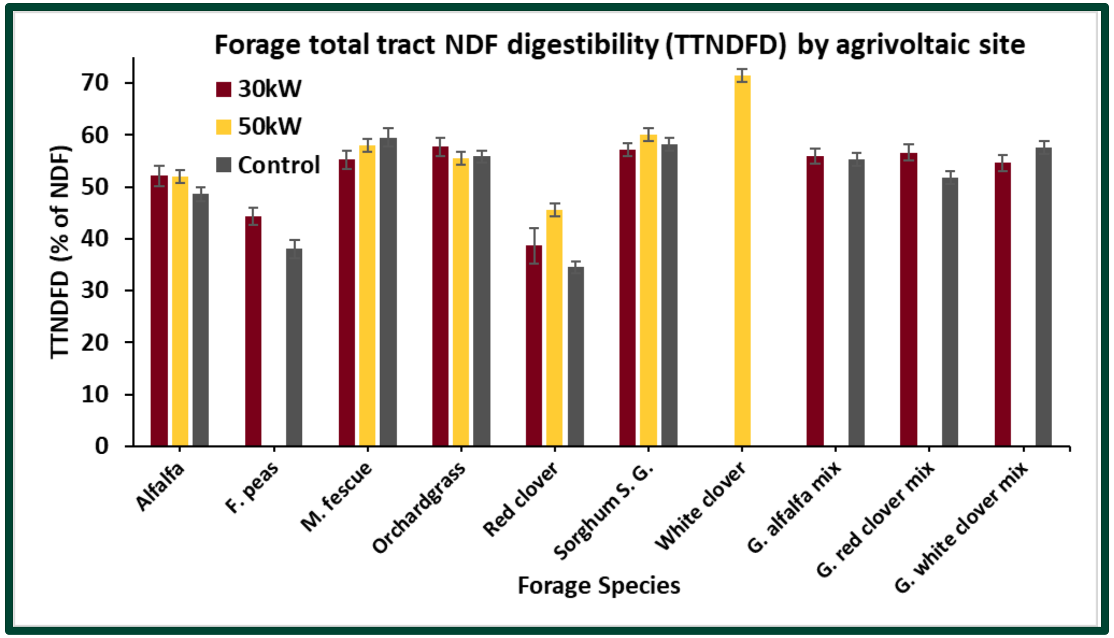
- The lowest vegetation O&M cost was turfgrass, with a mean cost of $265/acre/yr ($1.51/kWdc/yr) and a median cost of $184/acre/yr ($0.94/kWdc/yr)
- Gravel and sheep grazing mean costs were lower than native vegetation mean costs, but median values were similar among the three when evaluated per land area.
- Mean values for sheep grazing per unit of PV capacity ($1.55/kWdc/yr) were nearly identical to turfgrass.



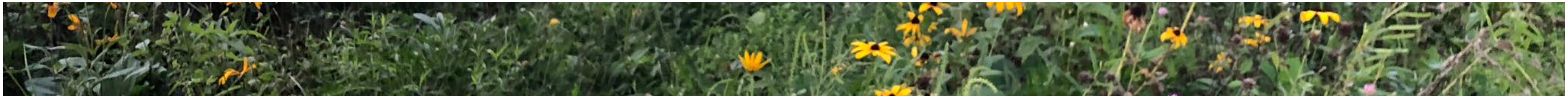
Source: McCall J, Macdonald J, Burton R, Macknick J. Vegetation Management Cost and Maintenance Implications of Different Ground Covers at Utility-Scale Solar Sites. Sustainability. 2023; 15(7):5895. https://doi.org/10.3390/su15075895

Grazing and Forage Production





Source: S.L. Portner, B.J. Heins, E.S. Buchanan, M.H. Reese. 2022. Agrivoltaics site effects on forage biomass and nutritive value, University of Minnesota.



Pollinator Habitat

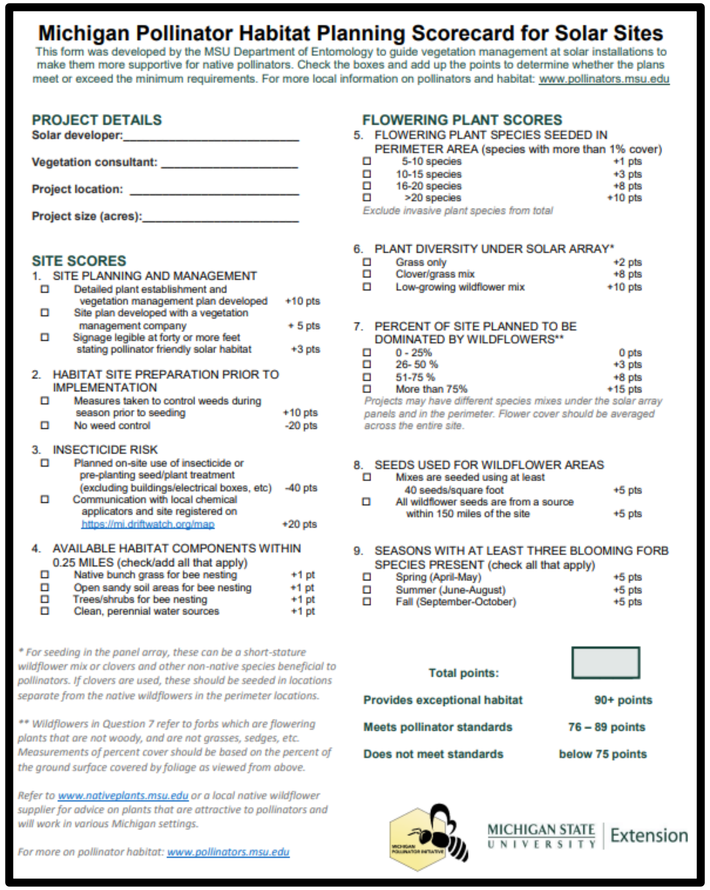
The site should be designed and planted to achieve a score of at least 76 on the Michigan Pollinator Habitat Planning Scorecard for Solar Sites.

Developed by the MSU Department of Entomology to guide vegetation management decisions at solar installations to be more supportive of native pollinators.

Check the boxes and add up the points to determine if the plan meets or exceeds pollinator habitat establishment standards.

Use during initial planning stages to ensure the desired outcome is achieved.

For more local information on pollinators and habitat visit www.pollinators.msu.edu.



Michigan Pollinator Habitat Planning Scorecard for Solar Sites

This form was developed by the MSU Department of Entomology to guide vegetation management at solar installations to make them more supportive for native pollinators. Check the boxes and add up the points to determine whether the plans meet or exceed the minimum requirements. For more local information on pollinators and habitat: www.pollinators.msu.edu

PROJECT DETAILS

Solar developer:____________________

Vegetation consultant: ____________________

Project location: ____________________

Project size (acres):____________________

SITE SCORES

1. SITE PLANNING AND MANAGEMENT
   - ☐ Detailed plant establishment and vegetation management plan developed +10 pts
   - ☐ Site plan developed with a vegetation management company + 5 pts
   - ☐ Signage legible at forty or more feet stating pollinator friendly solar habitat +3 pts
2. HABITAT SITE PREPARATION PRIOR TO IMPLEMENTATION
   - ☐ Measures taken to control weeds during season prior to seeding +10 pts
   - ☐ No weed control -20 pts
3. INSECTICIDE RISK
   - ☐ Planned on-site use of insecticide or pre-planting seed/plant treatment (excluding buildings/electrical boxes, etc) -40 pts
   - ☐ Communication with local chemical applicators and site registered on https://mi.driftwatch.org/map +20 pts
4. AVAILABLE HABITAT COMPONENTS WITHIN 0.25 MILES (check/add all that apply)
   - ☐ Native bunch grass for bee nesting +1 pt
   - ☐ Open sandy soil areas for bee nesting +1 pt
   - ☐ Trees/shrubs for bee nesting +1 pt
   - ☐ Clean, perennial water sources +1 pt

FLOWERING PLANT SCORES

5. FLOWERING PLANT SPECIES SEEDED IN PERIMETER AREA (species with more than 1% cover)
   - ☐ 5-10 species +1 pts
   - ☐ 10-15 species +3 pts
   - ☐ 16-20 species +8 pts
   - ☐ >20 species +10 pts

   Exclude invasive plant species from total
6. PLANT DIVERSITY UNDER SOLAR ARRAY*
   - ☐ Grass only +2 pts
   - ☐ Clover/grass mix +8 pts
   - ☐ Low-growing wildflower mix +10 pts
7. PERCENT OF SITE PLANNED TO BE DOMINATED BY WILDFLOWERS**
   - ☐ 0 - 25% 0 pts
   - ☐ 26- 50 % +3 pts
   - ☐ 51-75 % +8 pts
   - ☐ More than 75% +15 pts

   Projects may have different species mixes under the solar array panels and in the perimeter. Flower cover should be averaged across the entire site.
8. SEEDS USED FOR WILDFLOWER AREAS
   - ☐ Mixes are seeded using at least 40 seeds/square foot +5 pts
   - ☐ All wildflower seeds are from a source within 150 miles of the site +5 pts
9. SEASONS WITH AT LEAST THREE BLOOMING FORB SPECIES PRESENT (check all that apply)
   - ☐ Spring (April-May) +5 pts
   - ☐ Summer (June-August) +5 pts
   - ☐ Fall (September-October) +5 pts

** For seeding in the panel array, these can be a short-stature wildflower mix or clovers and other non-native species beneficial to pollinators. If clovers are used, these should be seeded in locations separate from the native wildflowers in the perimeter locations.*

*** Wildflowers in Question 7 refer to forbs which are flowering plants that are not woody, and are not grasses, sedges, etc. Measurements of percent cover should be based on the percent of the ground surface covered by foliage as viewed from above.*

Refer to www.nativeplants.msu.edu or a local native wildflower supplier for advice on plants that are attractive to pollinators and will work in various Michigan settings.

For more on pollinator habitat: www.pollinators.msu.edu

Total points: ☐

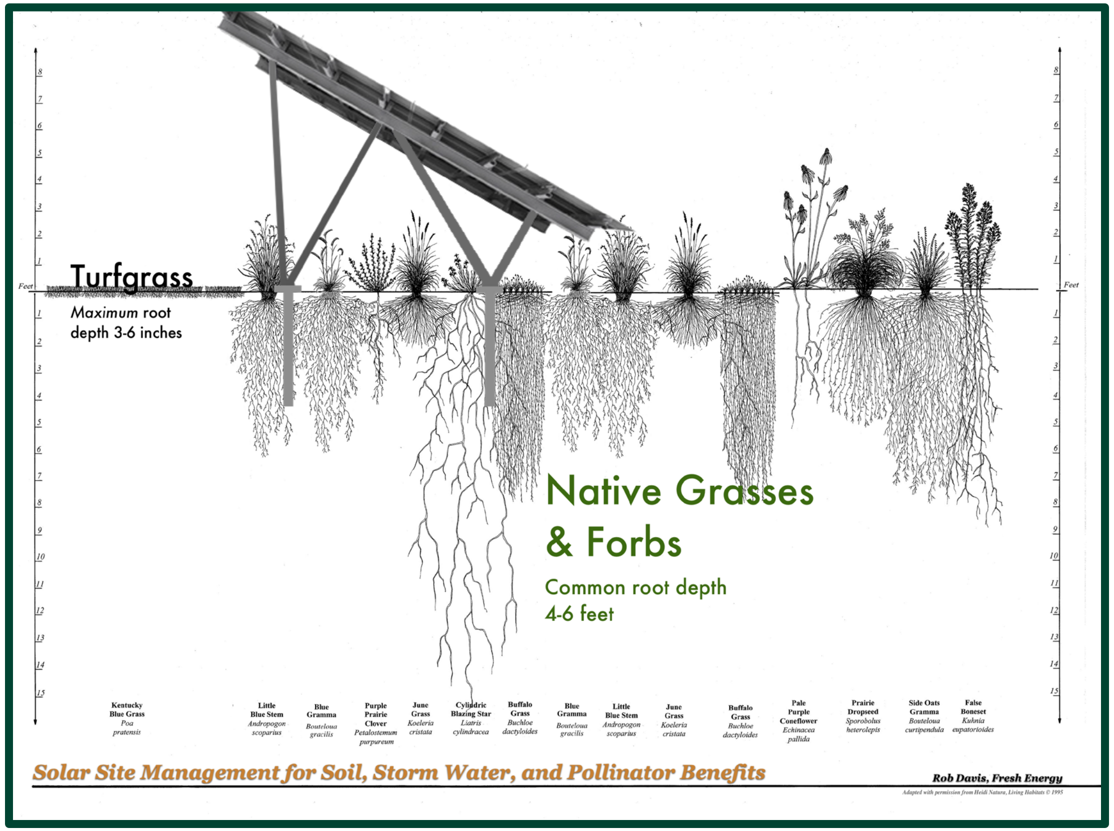
Provides exceptional habitat	**90+ points**
Meets pollinator standards	**76 – 89 points**
Does not meet standards	**below 75 points**

MICHIGAN POLLINATOR INITIATIVE

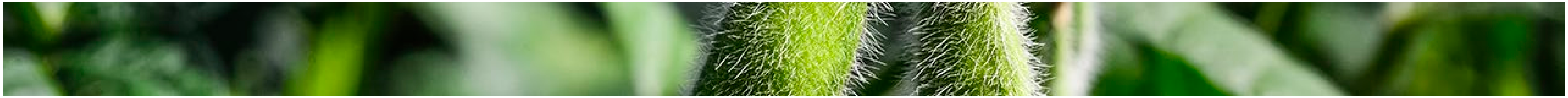
MICHIGAN STATE UNIVERSITY | Extension

Reasons for Establishing Pollinator Habitat

- Deep roots improve water infiltration, recharge groundwater, sequester carbon, and reduce soil compaction.
- Contributes to local biodiversity and other ecological benefits like soil health.
- Stem the decline of pollinators.
- Provides nesting and feeding habitat, which supports healthy populations of native pollinators.
- Enhancing crop pollination leads to improved crop yield.



Source: Rob Davis, Center for Pollinators in Energy, Fresh Energy



Evaluating the impact of increased pollinator habitat on bee visitation and yield metrics in soybean crops

- How does the presence of the habitat, and resulting pollinator community, impact soybean yield?
  - Heavier seeds and more seed per plant.

Source: Hannah K. Levenson, April E. Sharp, David R. Tarpy, Evaluating the impact of increased pollinator habitat on bee visitation and yield metrics in soybean crops, Agriculture, Ecosystems & Environment, Volume 331, 2022, 107901, ISSN 0167-8809,

Impact of flower plantings on pollination-dependent crops

- Fifteen perennial wildflower species were established adjacent to highbush blueberry fields to determine if they would increase the abundance of wild pollinators during crop bloom and enhance pollination and yield.
  - Honeybees visiting blueberry flowers had similar abundance in enhanced and control fields in all 4 years of this study.
  - Wild bee and syrphid abundance increased annually in the fields adjacent to wildflower plantings.
  - Higher crop yields and the associated revenue exceeding the cost of wildflower establishment and maintenance.

Source: Blaauw, Brent R. and Rufus Isaacs. 2014. Flower plantings increase wild bee abundance and the pollination services provided to a pollination-dependent crop. *Journal of Applied Ecology* 2014, 51, 890-898.

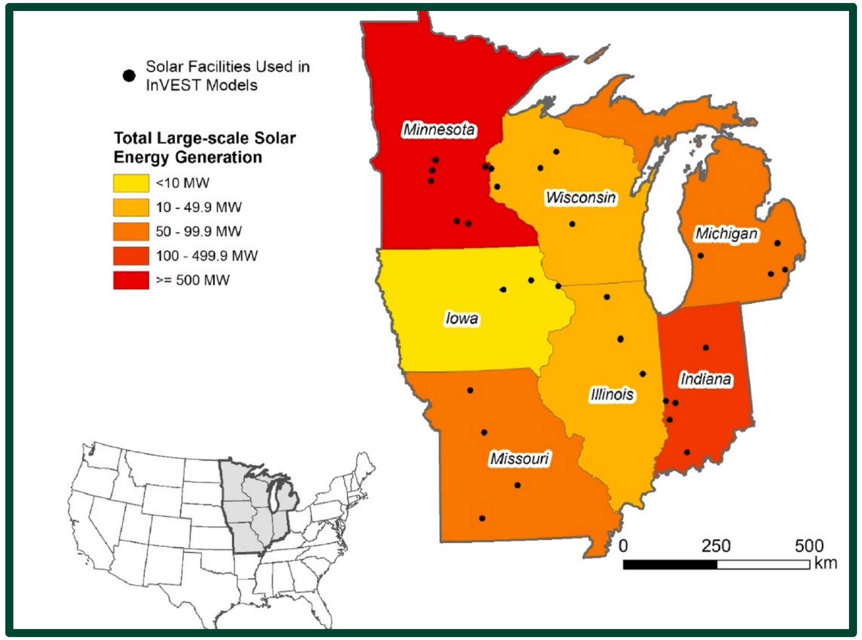
Conservation Cover

- Solar sites designed in consultation with conservation organizations that focus on restoring native plants, grasses, and prairie with the aim of protecting specific species (e.g., bird habitat) or providing specific ecosystem services (e.g., carbon sequestration, soil health).

Photo courtesy of Charles Gould

Conservation Cover: Ecosystem services

- Walston et al. examined the potential response of four ecosystem services (carbon storage, pollinator supply, sediment retention, and water retention) to native grassland habitat restoration at 30 solar facilities across the Midwest United States.
- Results
  - Compared to presolar agricultural land uses, solar-native grassland habitat produced:
    - A 3-fold increase in pollinator supply.
    - A 65% increase in carbon storage potential.
    - Increases in sediment and water retention of over 95% and 19%, respectively.



Source: Walston, L.J. et al. (2021). Modeling the ecosystem services of native vegetation management practices at solar energy facilities in the Midwestern United States, Ecosystem Services, Volume 47, February 2021.

Agrivoltaics

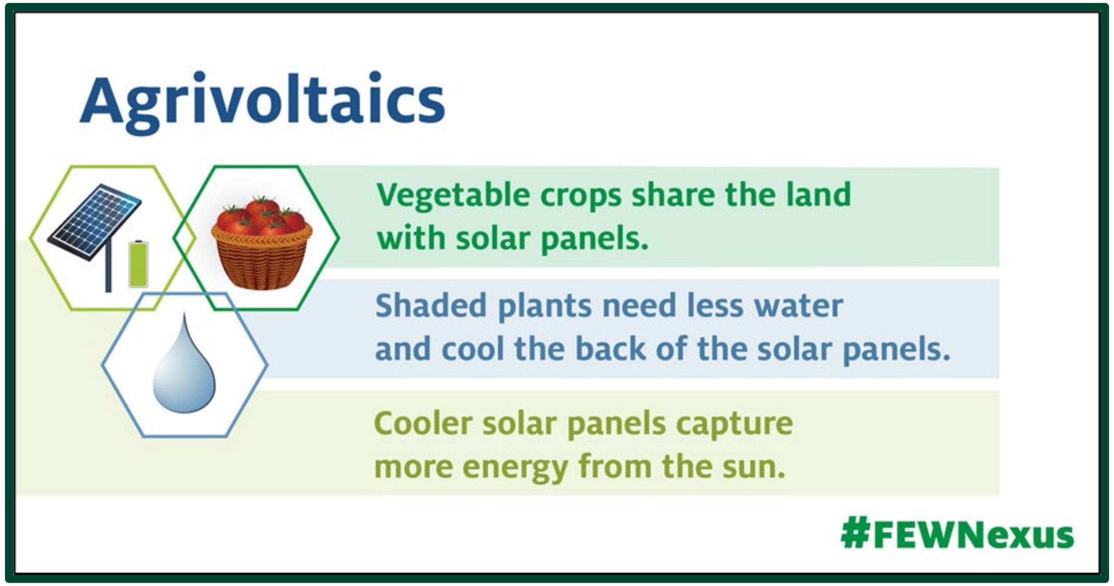


Photo credit: Charles Gould

Agrivoltaics

Photo credit: Charles Gould

Crops that can be grown under solar arrays

- Greens (lettuce, spinach, kale, Swiss chard, mustard)
- Brassicas (broccoli, cauliflower, cabbage, Brussel sprouts)
- Root crops (carrots, rutabaga, beets, radishes, potatoes, garlic)
- Herbs (parsley, mint, coriander, basil, cilantro)
- Berries (strawberries, blueberries, gooseberries)
- Peas, bush beans, peppers, tomatoes, leeks, onions

Agrivoltaic influence on soil moisture, micrometeorology and water-use efficiency

- The goal of this study was to show that the impacts of microclimatology, soil moisture, water usage, and biomass productivity should be considered in designing solar energy systems to take advantage of potential net gains in agricultural and power production.
- Significant differences in mean air temperature, relative humidity, wind speed, wind direction, and soil moisture were observed.
- A significant increase in late season biomass was observed for areas under the PV panels (90% more biomass).
- Areas under PV panels were significantly more water efficient (328% more efficient).

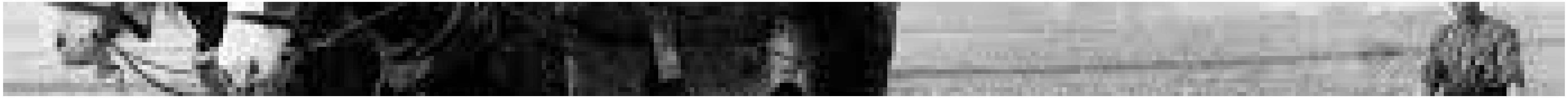
Source: Hassanpour Adeh E, Selker JS, Higgins CW (2018) Remarkable agrivoltaic influence on soil moisture, micrometeorology and water-use efficiency. PLoS ONE 13(11): e0203256. https://doi.org/10.1371/journal.pone.0203256

Vertical Bifacial Solar Arrays

- Vertical bifacial panel reduces snow and dust accumulation.
- Provides two output peaks during the day, with the second peak aligned to peak electricity demand.
- Regardless of the geographical location, a vertical bifacial farm will yield 10-20% more energy than a traditional monofacial farm for a practical row spacing of 6.5 feet (4 feet high panels).

Photo credit: Jean-Philippe Delacre

Khan, M., Hanna, A., Sun, X., and Alam, M. (2017). Vertical Bifacial Solar Farms: Physics, Design, and Global Optimization. Applied Energy. 206. 10.1016/j.apenergy.2017.08.042.



Some things to consider

- Agriculture has evolved over time.
- Craft ordinances that create opportunities for farming.
- Community solar.
- Land use resources comparison
  - 2022 Ford F-150 V8 4WD using E85 at 13 mpg => 200 bu corn per acre => 7,280 miles per year
  - 2023 Ford Lightning takes 49 kWh per 100 miles => 553,000 miles per year
- Climate change.

Keys to implementing dual use practices

- To implement dual use practices successfully, rigorous planning with all the parties is needed.
- Conversation and clear communication of expectations and outcomes before construction or engaging in a partnership ensures a greater chance of long-term productive partnerships.

Photo credit: Harvest Solar

Planning for dual use solar projects…

The Zoning Plan: Connecting the Plan to Zoning

The Master Plan

The **Plan** includes well-supported vision and goals that provide a framework to implement renewable energy objectives. Consider farm viability, historic preservation, natural features, other goals.

The Zoning Plan

The **Zoning Plan** includes the preferred scale and/or location of renewable energy within each land use classification [and by extension, zoning district]. This will require consensus and community input.

The Zoning Ordinance

Detailed amendments addressing scale/location of renewable energy technologies will serve to implement the zoning plan.

Solar is Scalable Across all Landscapes

Solar Energy System Type	Natural	Rural	Urban	General Urban
Accessory Roof Mounted				
Accessory Ground Mounted				
Principal Use (Small)				
Principal Use (Large)				

Dual-Use and Accessory Use Solar Design

Solar can allow for more than one use of the property.

Photo: Lexie Hain

- **Solar-pollinator habitat (dual use)**
- **Solar-agriculture (agrivoltaics)**
- Solar- parking lot (parking garage, carports)
- Solar-rooftop
- Solar- school grounds
- Solar-rights of way (ROW)
- Solar-brownfields
- Solar- community garden

Principal-Use SESs: Megawatt Output to Acres Needed

Megawatts (DC)	Acres
1 MW*	5-8
2 MW	10-20
20 MW	100-200
100 MW	500-1,000
200 MW	1,000-2,000

* Current national average (through 2018) 1 MW provides enough power to serve about 190 homes annually. Past averages range from 150-210 homes/MW.

Steps to Plan

- Resource analysis
- Goals analysis
  - ✓ Energy-specific
  - ✓ Synergies and conflicts

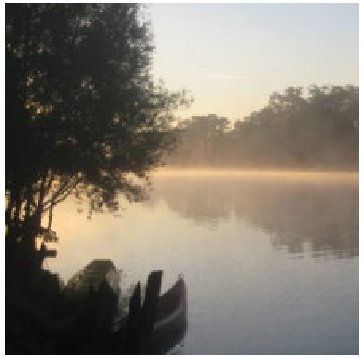
Goals Analysis for Compatibility Across Scale

	Solar	
Typical Principles and/or Goals	Small	Large
Mixed-Use (density, walkability); Enhance Existing Neighborhoods	Yes	No
Farmland Preservation (conventional definition)	Y	N
Farm Viability	Y	Y
Tourism Development (viewsheds, outdoor recreation)	Y	Y/N
Natural Resource (Open Space) Protection (community-wide)	Y	N
Natural Feature Protection (onsite)	N	N
Historic Preservation	N	N
Sustainability; Resiliency; Energy Waste Reduction; Green Buildings	Y	Y
Economic Diversification (job creation)	Y	Y
Other goals – Could there be a conflict at a certain scale?		

This table is hypothetical!
'Compatibility' dependent on your community goals and public opinion.

Solar: Compatibility with Existing Goals?

Sustainability Goals (support)



Natural Resource Protection? (context specific)

Economic Development?

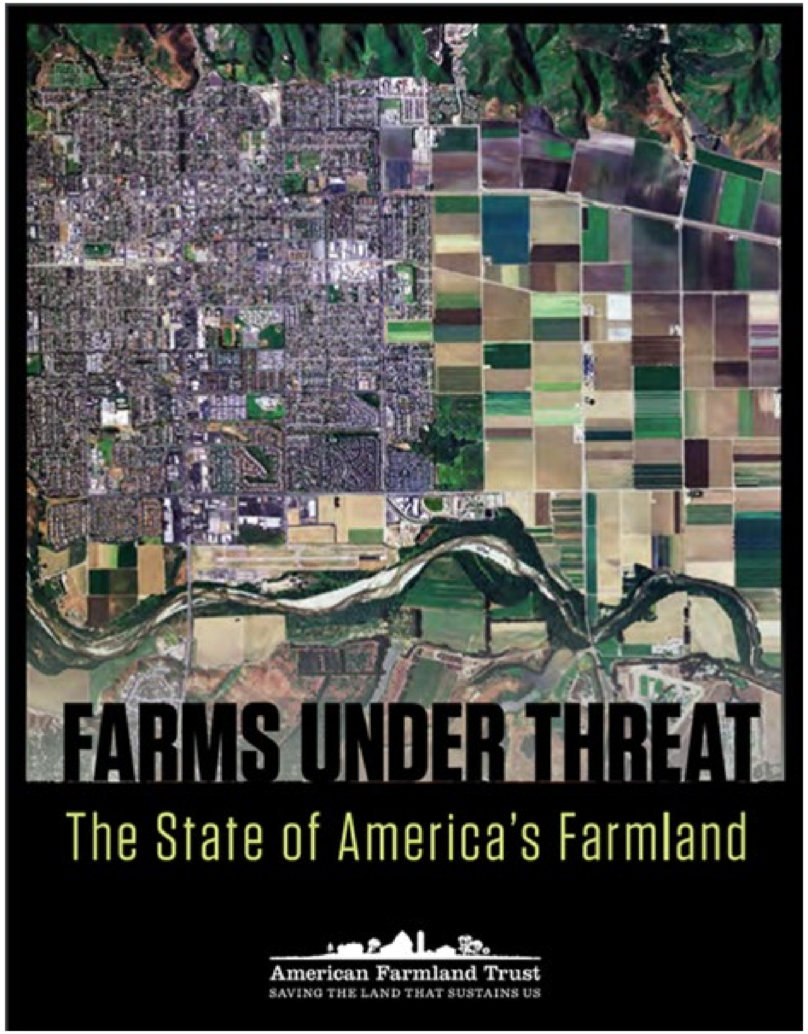
Historic Preservation (competing or context specific)

Tree Preservation (competing)

Farm Viability or Preservation (context specific)

Ag Protection - What are you trying to preserve?

- Is the goal to:
  - Limit urban/suburban growth?
  - Protect rural vistas?
  - Prevent moving, compacting soil?
  - Maintain farm livelihoods?
- **Are there existing adopted tools to implement those Ag protection goals?**
  - i.e., Are other types of development prohibited?
  - e.g., Ag protection zoning, purchase of development rights program, etc.



Dual use zoning for large principal use solar…

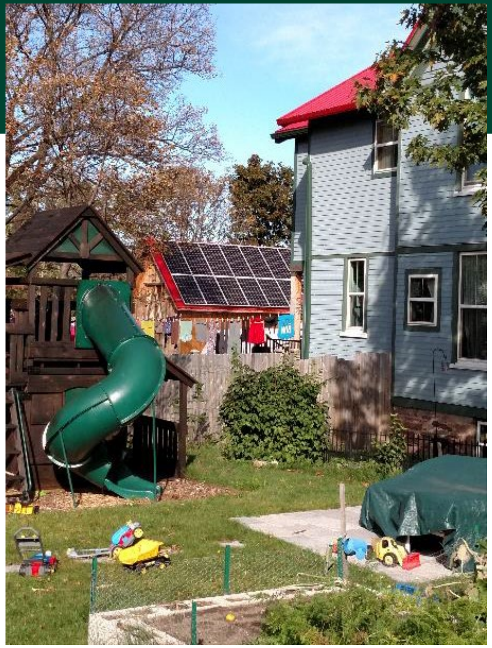
SES Scale, Type as applied to Example Zoning Districts

Example Zoning District:	Resource Production / Agricultural	Low-Density Residential	Commercial / Office	Industrial	Medium-Density Residential	Mixed Use
Roof-Mounted	P	P	P	P	P	P
Accessory Ground-Mounted	P	P	P	P	P	P
Principal Use (Small)	SPR	SLU	SPR	SPR	SLU	SPR
Principal Use (Large)	SLU	X	SLU	SLU	X	X

General Provision – Roof Mounted

An Accessory-Use SES is a permitted accessory use in all zoning districts where structures of any sort are allowed…

- **Roof-Mounted SES**
  - **Height:** not to exceed __ [e.g. 5-10] feet above the finished roof (or add to exceptions)
  - Not an expansion of a nonconformity



Marquette; Brad Neumann

Ludington; Mary Reilly

General Provisions – Accessory Ground-Mounted

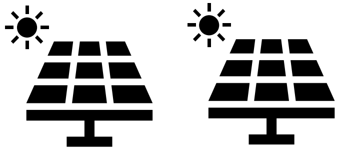
Ground-Mounted SES

- **Height:** Not to exceed __ [e.g. 20] feet to the top of the system when oriented at maximum tilt; OR same height standard as other accessory structures in the district.

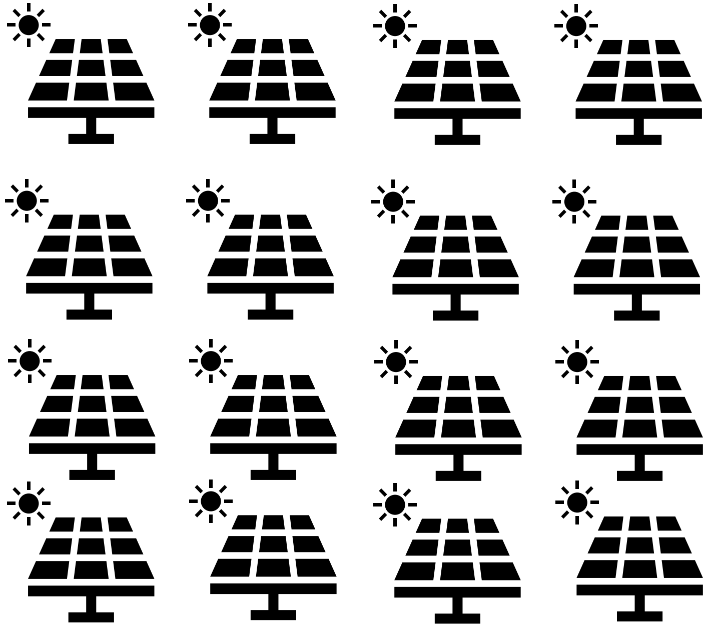
- **Setback:** Min. of __ [e.g. 5] feet or ½ the required setback for accessory structures in the district, whichever is greater.

Rock River Township; Brad Neumann

Principal-Use SES Small and Large



Principal Use (Small) SES
Up to and including ____ [e.g. 2] MW DC (or ____ [e.g. 5-20] acres).



Principal Use (Large) SES
More than ____ [e.g. 2] MW DC (or ____ [e.g. 5-20] acres.

General Provisions – Small Principal-Use

- **Height:** Not to exceed ___ [e.g. 20 ft]
- **Setbacks:** Shall follow the setbacks for primary structures for the district.
  - Not subject to setbacks for common property lines of participating lots.
- **Fencing:** May [shall] be secured… (i.e. be flexible - no fencing, wood split rail, 7' chain link, wildlife fencing)
- **Screening:** Follow the screening and/or landscaping standards for the district.
  - When adjoining non-participating lot has existing residential or public use
  - Can include flexibility for the ZA

Large Principal-Use SES (more than ___ [e.g. 2] MW)

- Similar sample standards as Small Principal-Use, but permitted as a **special land use** with detailed site plan requirements

- Additional standards apply, e.g., **Dual Use** ground cover

Lapeer Solar Park; DTE Energy

Solar Overlay Zone Option

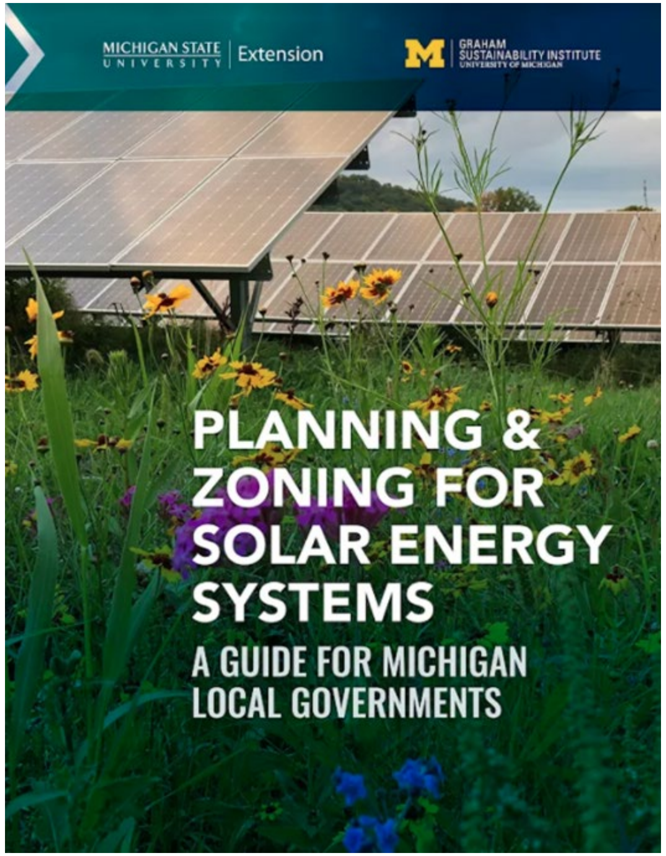
- **Option 1:** establish the overlay zone text and map based on analysis of geographic features (slope, solar orientation, proximity to substation/transmission, marginal land, brownfields, etc.)

- **Option 2:** offer solar overlay as a rezoning option (a legislative decision)…*Requires clear goals/purpose for overlay zone.*

- **Pros:** provides criteria to limit the prospective area for large-principal use solar (i.e. not the entire the agricultural district)

- **Cons:** Requires additional planning/analysis to determine eligible areas for the overlay zone.

Special Land Use or Overlay– Large Principal-Use SES



- “*Ground Cover: A large principal-use SES **shall include the installation of ground cover** vegetation maintained for the duration of operation until the site is decommissioned.*
- *The applicant shall include a ground cover vegetation establishment and management plan **as part of the site plan**.”*

(Page 32, *Planning and Zoning for Solar Energy Systems Guidebook)*

Special Land Use or Overlay– Large Principal-Use SES

(continued) Ground cover at sites not enrolled in PA 116 must meet one or more of the four types of Dual Use defined in this ordinance.


Photo credit: Rob Davis

i. **Pollinator Habitat:** Solar sites designed to meet a score of 76 or more on the Michigan Pollinator Habitat Planning Scorecard for Solar Sites.
ii. **Conservation Cover:** Solar sites designed **in consultation with** conservation organizations that focus on restoring native plants, grasses, and prairie with the aim of protecting specific species (e.g., bird habitat) or providing specific ecosystem services (e.g., carbon sequestration, soil health).


Photo credit: Charles Gould

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Special Land Use or Overlay– Large Principal-Use SES

(continued)

Photo credit: Charles Gould

iii. Forage: Solar sites that incorporate rotational livestock grazing and forage production as part of an overall vegetative maintenance plan.

Photo credit: Charles Gould

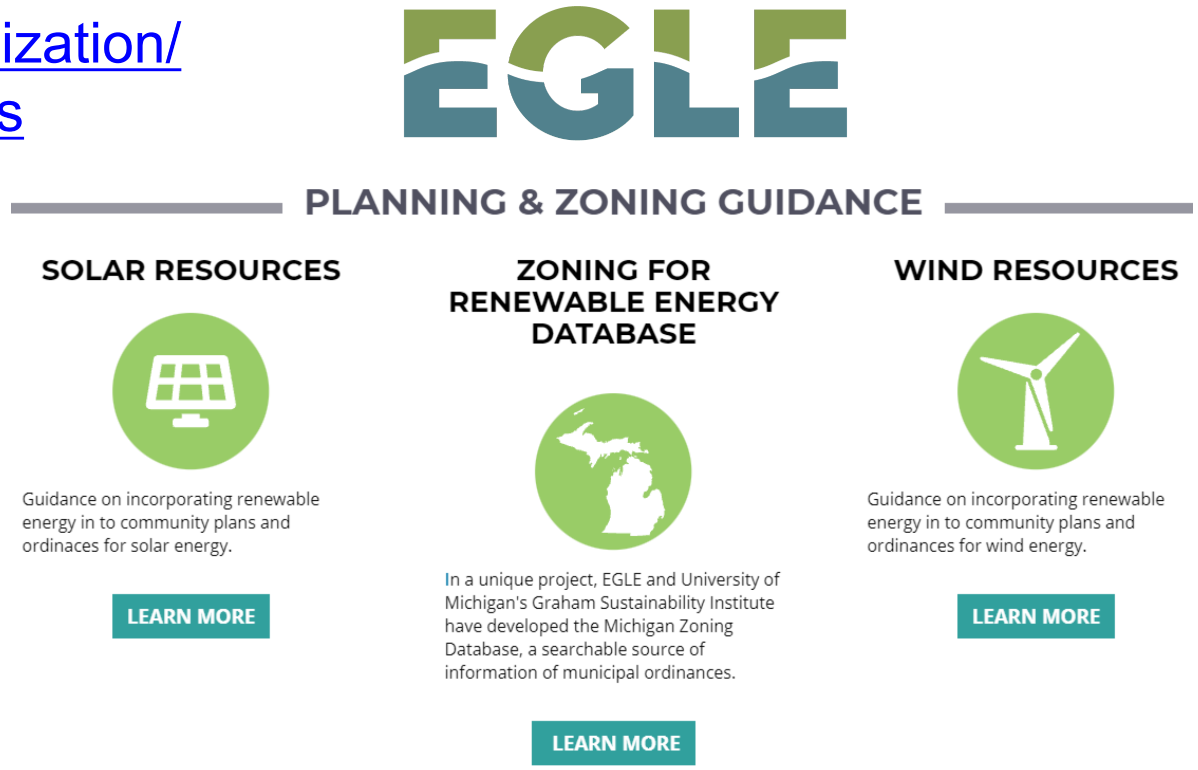
iv. Agrivoltaics: Solar sites that combine raising crops for food, fiber, or fuel, and generating electricity within the project area to maximize land use. **(Page 32)**

Ground cover considerations- context and scale

- Perennial ground cover (turf grass) can be suitable for smaller systems, such as 20-acres or less. Such as for
  - Schools/college campus/other institutional settings
  - Park settings (context dependent)
- Brownfield exception: no soil disturbance or paved area
- Parking lot exception: dual use in non-agricultural settings
- PA 116 exception: existing groundcover requirement

Planning and Zoning Resources

- Curated repository of templates, guidance
  - https://www.michigan.gov/egle/about/organization/materials-management/energy/communities
- Case Studies, FAQs
- March-April 2020 issue of *Planning & Zoning News*



Please complete our evaluation

Survey Name: P&Z for SES - Ottawa County

Use the link or QR code below to take this survey

https://bit.ly/3LUcibh

Numbers are highlighted green, and **letters** are in blue text.

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Questions?

Thank you for your time and interest!