Sifting through Solar: Land-Use Concerns on Prime Farmland

A report by Alex Delworth,
Center for Rural Affairs

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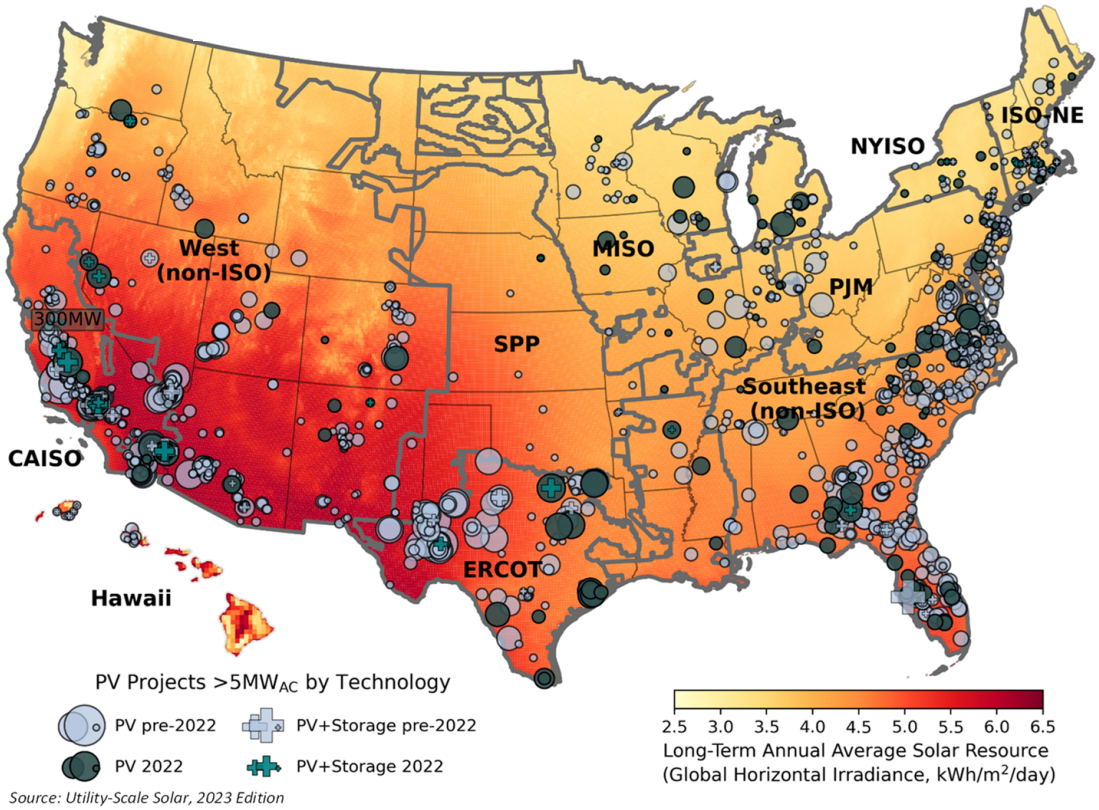
Figure 1. Utility-Scale Photovoltaics (PV) projects through 2022



Source: Utility-Scale Solar, 2023 Edition

I. Introduction

The U.S. is in the beginning stages of a major expansion in the solar energy industry. The Department of Energy's Solar Futures study estimates that to fully decarbonize the energy grid, solar will need to make up 40% to 45% of the energy mix, or about 1,600 gigawatts (GW), of capacity by 2050. That is almost 22 times the current capacity of 73.5 GW, with a majority of that development focused on the coasts. See Figure 1 for existing solar projects.[1,2] That type of expansion will require an estimated 10.3 million acres of land, 90% of which will be in rural areas.[3] Much of the rural landscape is made up of farmland, especially in the Midwest, and some agricultural stakeholders have raised concerns about solar-related land use.

Solar is a boon to rural economic development. Energy projects bring in new tax revenue for local entities, which is determined by either the rated capacity, annual production, or a mixture of both, depending on the state. Counties can then use the money for special public works projects, to increase funding to schools and other essential services, or to decrease property tax levies.

Renewable energy projects also contribute economic benefits directly to community members. In 2022, owners of clean energy projects in Iowa delivered $73.4 million in lease payments to landowners, which provides stable, diversified income to farmers.[4] Solar projects can bring temporary and permanent rural employment opportunities. In 2022, clean energy accounted for 147,000 jobs in rural areas and grew by almost 4%.[5]

1 "Solar Futures Study." U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, September 2021, energy.gov/sites/default/files/2021-09/Solar%20Futures%20Study.pdf. Accessed March 2024.

2 "Utility-Scale Solar." Energy Markets & Policy, Berkeley Lab, emp.lbl.gov/utility-scale-solar. Accessed March 2024.

3 "Solar Futures Study." U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, September 2021, energy.gov/sites/default/files/2021-09/Solar%20Futures%20Study.pdf. Accessed March 2024.

4 "Clean Energy Powers Iowa." American Clean Power Association, September 2023, cleanpower.org/wp-content/uploads/2023/12/Clean_Energy_Powers_Iowa.pdf. Accessed March 2024.

5 "Midwest Clean Energy & Transportation Jobs are Growing." Clean Jobs Midwest, 2023, cleanjobsmidwest.com/state/midwest. Accessed March 2024.

With the growing development of renewables in rural areas, concerns over the protection of agricultural lands have targeted utility-scale solar energy systems. Solar projects like these can often take up significant land—hundreds, or even thousands, of acres. Utility-scale solar offers many benefits to the electric utility grid by helping meet peak demand periods and improving the ability to persevere through extreme weather conditions, increasing grid reliability.[6] Wind and solar sources were also more than 36% cheaper than coal in 2020.[7]

II. Land-use concerns in rural areas

When assessing potential locations for siting utility-scale solar projects, developers look for key factors including a primarily neutral slope, annual sunlight radiation, situation outside of floodplain zones, minimal shading obstructions, and certain soil features. Many of these key factors are often also associated with high-rated farmland. Additionally, developers target certain areas due to their proximity to transmission lines or larger demand centers, as ensuring a project's financial viability is an important siting consideration.[8]

Because of the similarities in site characteristics, farmland may be eyed for solar development in regions where agriculture is the primary land use. The overlap has sometimes generated opposition to solar development in dense agricultural areas due to the potential loss of fertile farmland. Specific concerns have included the contribution to food scarcity, permanent soil degradation, loss of biodiversity, and water runoff leading to potential flooding. Some state and local policymakers have addressed these concerns by implementing restrictive siting regulations, or moratoriums to limit solar development.

Balanced regulations can ensure development is done in a way that allows communities to take advantage of the economic benefits of clean energy while also demonstrating good land stewardship. Following is a list of important considerations when addressing agricultural land-use concerns.

Farmland may be eyed for solar development in regions where agriculture is the primary land use due to the similarities in site characteristics. Balanced regulations can ensure development is done in a way that allows solar communities to take advantage of economic benefits while also demonstrating good land stewardship.

- Planting native or perennial vegetation under panels can improve soil health and provide pollinator and wildlife habitat; sites managed in native vegetation have been shown to have a restorative effect.[9]
- Agrivoltaic practices like livestock grazing, growing crops, and beekeeping allow land to stay in agricultural use while producing energy.
- Solar projects have a minimal impact on land quality, and land can be restored to farmland at the end of the project's life cycle, which is estimated to be 30 to 35 years.[10]
- Once solar arrays reach the end of their life cycles, county decommissioning plans should require restoration of the pre-construction environment.[11]

6 "Winter Storm Elliot Frequently Asked Questions." pjm, April 12, 2023, pjm.com/-/media/markets-ops/winter-storm-elliott/faq-winter-storm-elliott.ashx. Accessed March 2024.

7 "Projected Costs of Generating Electricity 2020." International Energy Agency, Nuclear Energy Agency, December 2020, iea.org/reports/projected-costs-of-generating-electricity-2020. Accessed March 2024.

8 "What Do Solar Developers Look For In a Property?" SolarLandLease, solarlandlease.com/what-do-solar-developers-look-for-in-a-property. Accessed March 2024.

9 Smith, Cody. "Amplifying Clean Energy with Conservation, Part One: Pollinator-Friendly Solar." Center for Rural Affairs, October 2020, cfra.org/publications/amplifying-clean-energy-conservation-part-one-pollinator-friendly-solar. Accessed March 2024.

10 "End-of-Life Management for Solar Photovoltaics." U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, Solar Energy Technologies Office, energy.gov/eere/solar/end-life-management-solar-photovoltaics. Accessed March 2024.

11 Smith, Cody, et al. "Iowa Solar Siting Resource Guide: A Roadmap for Counties." Center for Rural Affairs, Iowa Environmental Council, cfra.org/publications/iowa-solar-siting-resource-guide. Accessed March 2024.

III. Land designations and siting restrictions

Concerns around the use of agricultural lands for renewable energy development have resulted in some states and counties adopting policies that use land designations to restrict clean energy development. This includes restricting development on prime farmland in Minnesota and on land with a high farmland Corn Suitability Rating in Iowa.

A. Prime farmland designation

According to the U.S. Department of Agriculture, prime farmland is land that has the best combination of physical and chemical characteristics for producing food and other commodity crops.[12] It has the combination of soil properties, growing season, and moisture supply needed to produce sustained high yields of crops in an economical manner.[13]

In 1982, the Minnesota Public Utilities Commission passed an administrative rule that restricts the siting of large electric power generating plants on prime farmland. Specifically, the rule states that a facility cannot be built if the site has more than 0.5 acres of prime farmland per megawatt (MW) of net generating capacity, unless there is no feasible and prudent alternative.[14]

Prime farmland is defined by specific measures, including moisture levels, slope, and temperature, along with other metrics.[15] The phrasing "no feasible and prudent alternative" has, in some cases, created an ambiguous and undefined process for those wishing to develop solar on locations that may include prime farmland. In a survey conducted by the Minnesota Department of Commerce on solar siting in agricultural landscapes, energy developers and local governments expressed interest in a standardized and predictable process toward siting around the prime farmland rule.[16] But the competing interests of encouraging the development of solar while also protecting prime farmland create regulatory barriers in the siting of solar projects.[17]

Advocates argue that the prime farmland exclusion rule was not designed to address solar development, as it was passed before solar energy was economically viable.[18] When the prime farmland rule was adopted in 1985, coal and nuclear made up 94% of Minnesota's energy consumption, and both are known to be sources of numerous environmental and health concerns.[19] While coal and nuclear plants have a permanent impact on the land, solar energy projects are generally temporary, and with proper management and conservation practices, the health of soil underneath panels can be enhanced.[20]

B. Corn Suitability Rating (CSR)

Corn Suitability Rating (CSR) is an index analysis developed in 1971 by Iowa State University that rates the crop productivity of different soils. The equation that informs the value has many of the same factors that determine prime farmland.[21]

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12 "Prime Farmland Definition, Field Office Technical Guide, Section II, Soils Information, Prime and Statewide Important Farmland." Natural Resources Conservation Service Colorado, March 2015, efotg.sc.egov.usda.gov/references/public/CO/5a_Prime_Farmland_Definition.pdf. Accessed March 2024.

13 Ibid.

14 "7850.4400 Prohibited Sites, Minnesota Administrative Rules." Minnesota Legislature, Office of the Revisor of Statutes, Sept. 18, 2009, revisor.mn.gov/rules/7850.4400. Accessed March 2024.

15 "7 CFR § 657.5 - Identification of important farmlands." Cornell Law School, Legal Information Institute, law.cornell.edu/cfr/text/7/657.5. Accessed March 2024.

16 Klein, Erica, and Kris Van Amber. "Solar Siting in Agricultural Landscapes: Stakeholder Input Summary." Minnesota Management and Budget - Management Analysis and Development, Minnesota Department of Commerce, Minnesota Department of Agriculture, Sept. 16, 2019, mn.gov/eera/web/doc/13928. Accessed March 2024.

17 Birkholz, David, et al. "Solar Energy Production and Prime Farmland, Guidance for Evaluating Prudent and Feasible Alternatives." Minnesota Commerce Department, May 19, 2020, mn.gov/eera/web/doc/13929. Accessed March 2024.

18 Smerillo, Madelyn. "Permitting and Prime Farmland: An Outdated Rule Stands in the Way of Minnesota's Clean Energy Transition." Clean Grid Alliance, Sept. 20, 2023, cleangridalliance.org/blog/207/permitting-and-prime-farmland-an-outdated-rule-stands-in-the-way-of-minnesotas-clean-energy-transition. Accessed March 2024.

19 "Coal explained: coal and the environment." U.S. Energy Information Administration, Nov. 16, 2022, eia.gov/energyexplained/coal/coal-and-the-environment.php. Accessed March 2024.

20 "Environmental Co-Benefits of Maintaining Native Vegetation With Solar Photovoltaic Infrastructure." AgriSolar Clearinghouse, June 9, 2023, agrisolarclearinghouse.org/environmental-co-benefits-of-maintaining-native-vegetation-with-solar-photovoltaic-infrastructure. Accessed March 2024.

21 Sassman, Aaron M., et al. "A Comparison of Iowa's Original Corn Suitability Rating Index to the new Corn Suitability Rating 2 Index." Iowa State University Extension and Outreach, Department of Agronomy, agron.iastate.edu/glsi/files/2022/12/CSR-vs-CSR2-Poster.pdf. Accessed March 2024.

Figure 2. Percentage of total acres by CSR2 value

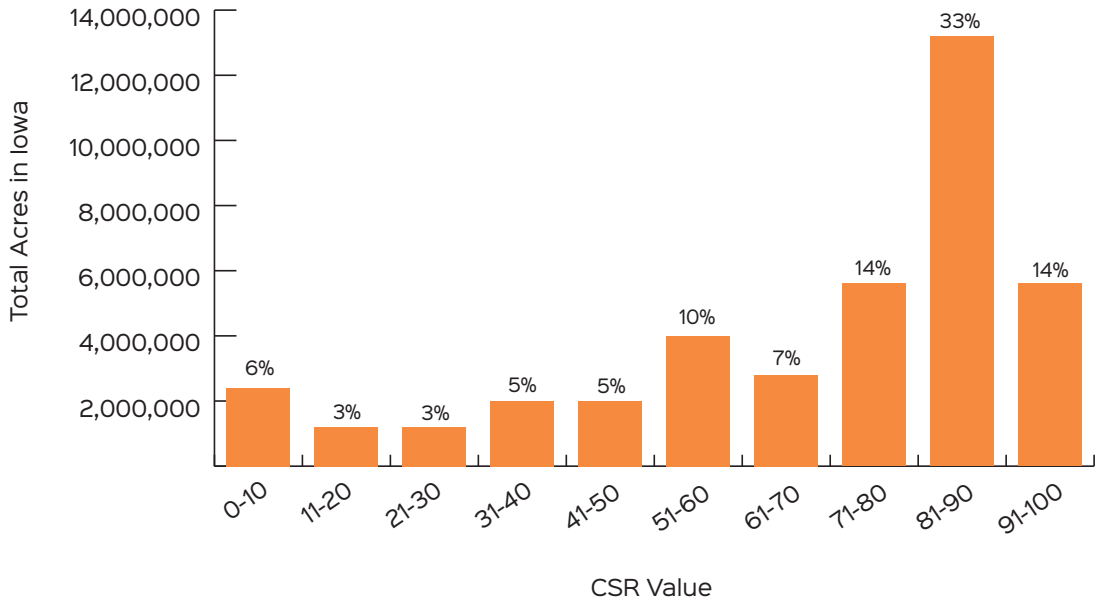


Figure 3. Impact of a 2022 bill in Iowa that would have eliminated 65% of land for utility-scale solar development

This equation has been used for decades to determine land values. In 1977, it was written into Iowa state law to help county assessors assess land values. In 2015, Iowa State University came out with an updated equation, CSR2, which eliminates the rainfall correction factor due to an increase in the average precipitation in northwest Iowa. Figure 2 shows the distribution of total acres of land based on CSR2.[22] The updated equation resulted in an overall increase in CSR metrics because the original equation had been devaluing soils in northwest Iowa due to low rainfall averages.[23]

A few counties in Iowa have also used CSR in their Land Evaluations and Site Assessment, a rating system based on soil quality and other factors that affect agricultural practices.[24] The Land Evaluations and Site Assessment system was designed by the USDA's Natural Resources Conservation Service (NRCS) to preserve agricultural land from urban sprawl, and in 1984, the service released a guidebook for local governments to implement the system.[25] Linn County, Iowa, implemented Land Evaluations and Site Assessment in 2006 and followed

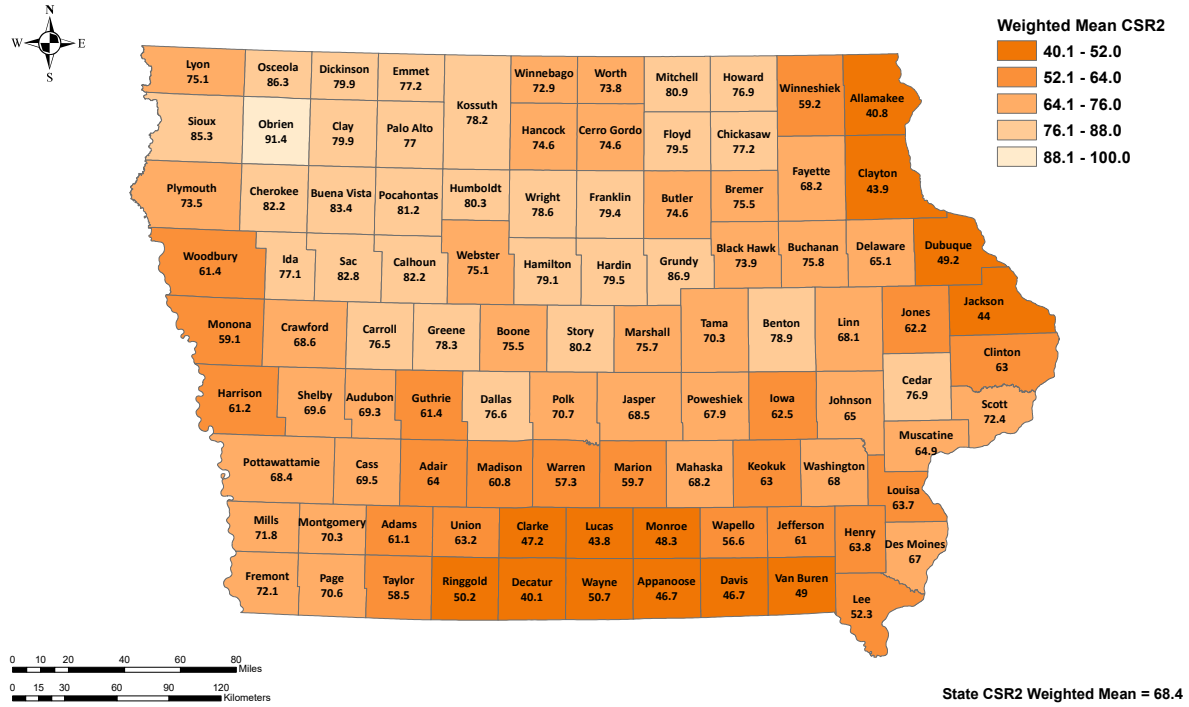
22 Personal communication, Patrick Chase, state soil scientist, U.S. Department of Agriculture, Oct. 4, 2022.

23 Ibid.

24 Nelson, Gabriel. "Building an Automated Land Evaluation and Site Assessment System for Story County, Iowa." Iowa State University, 2020, dr.lib.iastate.edu/server/api/core/bitstreams/13ff6b82-388b-48c2-9e13-3b06889ec494/content. Accessed March 2024.

25 Pease, James R., and Robert E. Coughlin. "Land Evaluation and Site Assessment: A Guidebook for Rating Agricultural Lands, Second Edition." U.S. Department of Agriculture, Natural Resources Conservation Service, nrcs.usda.gov/sites/default/files/2022-06/Land%20Evaluation%20and%20Site%20Assessment%20%28LESA%29_0.pdf. Accessed March 2024.

Figure 4. Average weighted CSR2 values by Iowa counties



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Calculated from NRCS acreages and CSR2 values contained in ISPAID (Iowa Soil Properties and Interpretations Database) version 8.1 as of May 2017

the guidebook for the site assessment and used CSR as the land evaluation criteria.[26] The guidebook recommends using soil data from local agencies such as NRCS, USDA Forest Service, or land grant universities, which for Iowa is Iowa State University.

Decision makers have recently turned to using CSR to prohibit the development of solar projects on higher-quality land. In 2022, a bill passed through an Iowa legislative committee that would have banned solar facilities on land with a CSR2 rating higher than 65.[27] Had the bill become law, it would have eliminated 65% of potentially developable land from being used for solar developments. See Figure 3 on page 4. The remaining 35% narrowed even further due to unsuitable characteristics, such as high-sloping areas, unstable soils, or other factors that make solar installation unviable.[28] See Figure 4; a statewide CSR2 restriction at 65 would be less than the average of 66 of the 99 counties.[29,30]

CSR restrictions have also been passed at the county level. In 2022, Scott County, Iowa, passed an ordinance banning solar development on land rated at 60 CSR or above, which eliminated 75% of the county's developable areas.[31] See Figure 5 on page 6.

26 "Linn County, Iowa - Code of Ordinances, Part II - Land Development Ordinances, Chapter 107 - Unified Development Code." Linn County, Iowa, Dec. 22, 2023, library.municode.com/ia/linn_county/codes/code_of_ordinances?nodeId=PTIILADEOR_CH107UNDECO. Accessed March 2024.

27 "Senate File 2127 - Introduced." Iowa Legislature, 2022, legis.iowa.gov/legislation/BillBook?ba=SF2127&ga=89. Accessed March 2024.

28 Personal communication, Patrick Chase, state soil scientist, U.S. Department of Agriculture, Oct. 4, 2022.

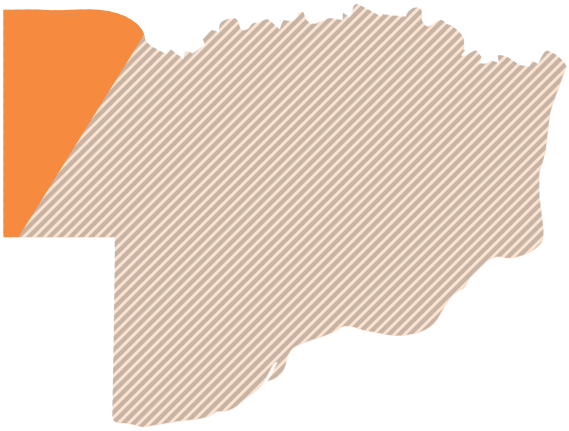
29 Ibid.

30 Miller, Bradley. "County Weighted Average CSR2." Iowa State University, Geospatial Laboratory for Soil Informatics, Dec. 3, 2022, agron.iastate.edu/glsi/2022/12/03/county-weighted-average-csr2. Accessed March 2024.

31 Whiskeyman, Danny. "Scott County Board of Supervisors approves new solar ordinance." KWQC, Sept. 20, 2022, kwqc.com/2022/09/21/scott-county-board-supervisors-approves-new-solar-ordinance/. Accessed March 2024.

An average of 7 to 10 acres of land are required to produce one megawatt of electricity from solar. The U.S. Department of Energy predicts 1,600 GW of solar will be needed to meet federal decarbonization standards by 2050.

Figure 5. Limitation of solar development on land greater than 60 CSR, eliminating 75% of land for solar in Scott County, Iowa



This type of restriction makes it difficult, if not impossible, to develop utility-scale solar in the county. Linn County, Iowa, included CSR within a utility-scale solar scorecard designed to discourage, rather than ban, development on land rated 65 CSR or above.[32] Buchanan County, Iowa, debated adding CSR restrictions, but the measure has not passed.[33]

C. Impacts of a statewide CSR and other restrictions

Using land designations to restrict solar is a response to some agricultural stakeholders' perceptions that large amounts of farmland will permanently be taken out of production. However, current data does not support that premise.

An average of 7 to 10 acres of land are required to produce one megawatt of electricity from solar.[34] On a national scale, the U.S. Department of Energy predicts that by 2050, 1,600 GW of solar will be needed to meet federal decarbonization standards. The department used two scenarios of low- and high-electrification and expects between 210 to 420 GW to come from the Midwest region. See Figure 6 on page 7.[35] As of 2017, 144.8 million acres of prime farmland exist within the Midwest.[36] If all 210

32 "Linn County Board of Supervisors Approves Updated Utility-Scale Solar Ordinance." Linn County, Iowa, Sept. 20, 2023, linncountyiowa.gov/CivicAlerts.aspx?AID=3368&ARC=5945. Accessed March 2024.

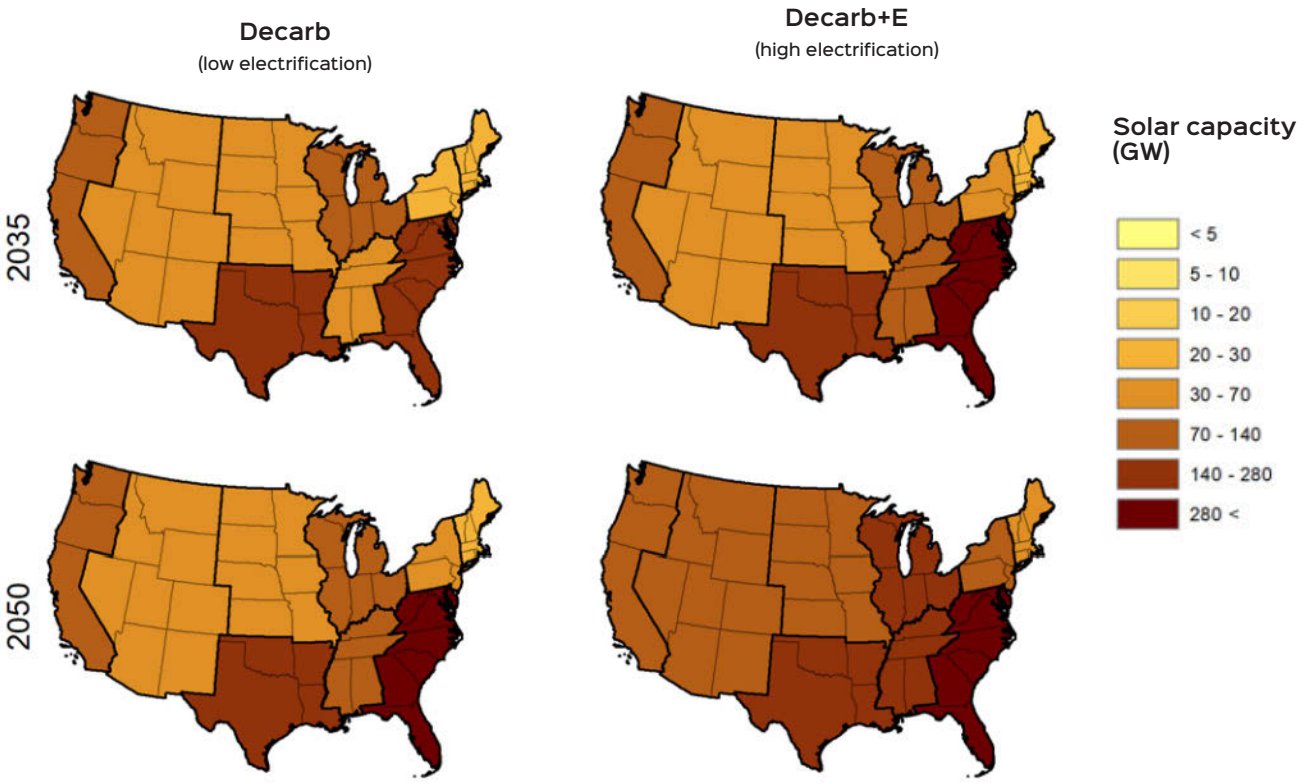
33 Klotzbach, John. "County Rejects Wind Turbine Ordinance Changes." Independence Bulletin Journal, Nov. 18, 2022, communitynewspapergroup.com/independence_bulletin_journal/county-rejects-wind-turbine-ordinance-changes/article_66266016-c1de-5cf3-a00b-4b4afac4076b.html. Accessed March 2024.

34 Birkholz, David, et al. "Solar Energy Production and Prime Farmland, Guidance for Evaluating Prudent and Feasible Alternatives." Minnesota Commerce Department, May 19, 2020, mn.gov/eera/web/doc/13929. Accessed March 2024.

35 "Solar Futures Study." U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, September 2021, energy.gov/sites/default/files/2021-09/Solar%20Futures%20Study.pdf. Accessed March 2024.

36 "2017 National Resources Inventory Summary Report." U.S. Department of Agriculture, Natural Resources Conservation Service, Center for Survey Statistics and Methodology, September 2020, nrcs.usda.gov/sites/default/files/2022-10/2017NRISummary_Final.pdf. Accessed March 2024.

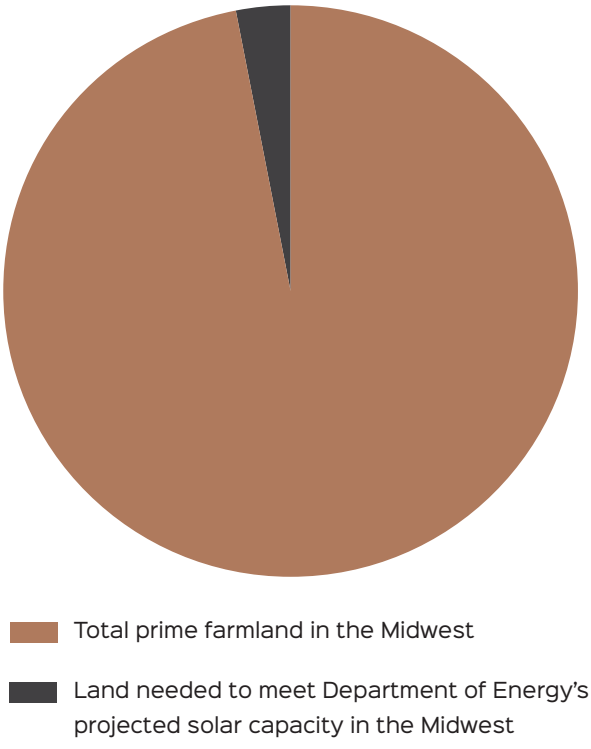
Figure 6. Projected solar capacity by region in 2035 and 2050



to 420 GW of potential solar in this region were developed on prime farmland, it would occupy between 1.45% and 2.90% of prime farmland. See Figure 7.[37,38]

Another way to analyze the impact of solar development on land use is by looking at regional interconnection queues, which are lists of proposed projects waiting for connection to the electrical system that regional independent system operators manage. In the queue, projects undergo a series of impact studies to determine any necessary transmission upgrades before projects can be built. Interconnection queues can be used to identify short-term developer interest in solar by looking at projects that could be ready to go online in the next few years. The queue can also identify project applications for specific states like Iowa and Minnesota, which are located in the Midcontinent Independent System Operator's (MISO) region.

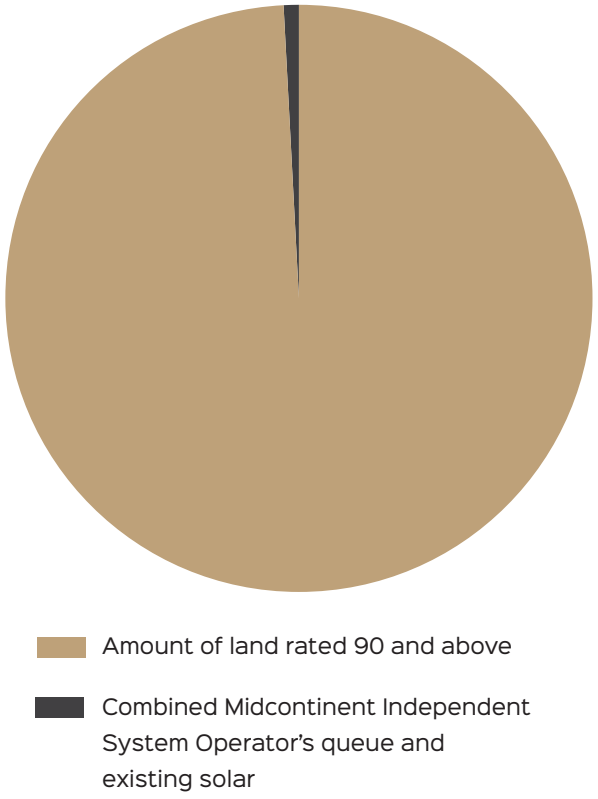
Figure 7. Impact if all projected solar is sited on prime farmland in the Midwest



37 Ibid.

38 "Solar Futures Study." U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, September 2021, energy.gov/sites/default/files/2021-09/Solar%20Futures%20Study.pdf. Accessed March 2024.

Figure 8. Solar impact on land rated CSR 90 and above



At the state level, Iowa has 31 million acres of farmland, with 6.1 million acres of land above a CSR of 90. As of September 2023, there were 3,267 MW of solar in the MISO queue in Iowa, which would take up about 33,000 acres.[39] If every acre of proposed solar projects were built on farmland rated CSR2 higher than 90, it would make up 0.54%, and 0.14% of land rated higher than 65. See Figure 8 and Table 1.

Using the same analysis method, Minnesota has approximately 5,800 MW of solar in the MISO queue, which would require about 50,000 acres of land.[40] Per Figure 9 on page 9, if all of this was located on prime farmland, it would use up less than 0.3% of the land.[41] Both comparisons show that solar development has minimal impact on the overall land use for agriculture.

Table 1. Percent of farmland impact at different CSR2 ratings

CSR2	Acres of land above different CSR2 levels	Impact of 3,972 MW of solar in MISO queue
65	23,016,007	0.14%
70	21,871,268	0.15%
80	17,760,538	0.19%
90	6,121,832	0.54%

IV. Conclusion

Implementing rules that work with solar development rather than limit it will offer economic opportunities for rural residents across the nation who want to voluntarily lease their land for solar projects. In turn, these projects provide lease payments to landowners and a stable and diversified source of income for farmers. They also generate new tax revenue for local government entities to reinvest in their communities. As a result, policy efforts should be focused on working with solar development rather than restricting the property rights of landowners.

The U.S. is expected to increase solar capacity by 76 times by 2050 to meet national and state decarbonization goals, with rural areas becoming a major target for the siting of utility-scale solar projects because of their overall suitability. The accelerated growth of solar development has created a perceived threat that solar may permanently eliminate large amounts of prime farmland. While the analysis in this paper shows that the threat is overstated, the concern has led some state and local policymakers to attempt to implement restrictions on the use of prime farmland, which would severely impact solar energy generation's potential.

Groups like the American Farmland Trust have laid out potential alternative approaches through their Smart Solar Principles.[42] These principles seek to balance farmland protection by encouraging solar development on marginal lands when it is possible.

39 "Generator Interconnection Queue – Active Projects Map, Fuel Type." MISO Energy, giqueue.misoenergy.org/PublicGiQueueMap/index.html. Accessed March 2024.

40 Smerillo, Madelyn. "Permitting and Prime Farmland: An Outdated Rule Stands in the Way of Minnesota's Clean Energy Transition." Clean Grid Alliance, Sept. 20, 2023, cleangridalliance.org/blog/207/permitting-and-prime-farmland-an-outdated-rule-stands-in-the-way-of-minnesotas-clean-energy-transition. Accessed March 2024.

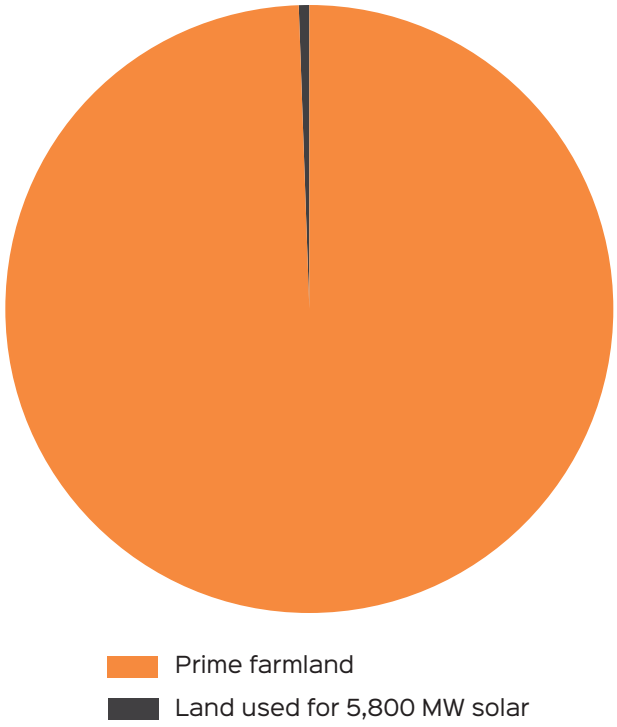
41 Ibid.

42 Sallet, Lori. "American Farmland Trust Releases Smart Solar Guiding Principles to Save the Land that Sustains Us." American Farmland Trust, Sept. 22, 2022, farmland.org/american-farmland-trust-releases-smart-solar-guiding-principles-to-save-the-land-that-sustains-us. Accessed March 2024.

The organization also offers best practices for when solar projects are placed on agricultural lands, such as using dual-use practices and managing sites with native vegetation. The Center for Rural Affairs has evaluated how policymakers can encourage dual use in a 2023 paper, "Policy Approaches for Dual-Use and Agrisolar Practices."[43]

Agriculture and solar do not require an either/or approach. The two interests can work together to create policies that both respect the property rights of local landowners and allow them to take advantage of financially advantageous activities while encouraging dual-use practices that preserve agricultural lands.

Figure 9. Minnesota prime farmland



About the Center for Rural Affairs

Established in 1973, the Center for Rural Affairs is a private, nonprofit organization with a mission to establish strong rural communities, social and economic justice, environmental stewardship, and genuine opportunity for all while engaging people in decisions that affect the quality of their lives and the future of their communities.

43 Kolbeck-Urlacher, Heidi. "Policy Approaches for Dual-Use and Agrisolar Practices." Center for Rural Affairs, AgriSolar Clearinghouse, April 2023, cfra.org/publications/policy-approaches-dual-use-and-agrisolar-practices. Accessed March 2024.