

Iowa Climate Statement 2023: It's Time to Tap Iowa's Vast Solar Energy Resources

2023 was another year in which global and regional temperatures broke multiple records, and distant heat-exacerbated wildfires degraded Iowa's air quality. Scientists continue to find that warming temperatures in the global atmosphere and ocean, caused largely by greenhouse gases from fossil-fuel combustion, are interconnected and are a root cause of increasing regional weather disasters¹. In Iowa, new evidence links a warmer Gulf of Mexico to wetter spring planting conditions and a warmer atmosphere to rapid drying that creates flash drought and intensified storm systems.^{2,3} Iowa has multiple opportunities to help mitigate these climate changes with technologies that will also stimulate the economy and produce high-paying jobs.

One of these technologies, solar photovoltaics, has made astounding progress recently: the average cost of solar energy production in 2020 was one-tenth of what it was in 2000.^{4,5} Today, the cost of new solar energy is often below the cost of energy from existing fossil-fuel plants.^{6,7} Energy-efficient design can significantly reduce energy demand, enabling grid-tied solar buildings that produce as much energy as they consume (net-zero), even in Iowa. For example, the Interlock House at Iowa's Honey Creek Resort State Park was designed and built by Iowa State University students in 2009 and is a publicly accessible example of a net-zero home.⁸

Studies indicate that the effectiveness of renewable energy is highest and service intermittency is minimized when complementary renewable sources are utilized and geographically distributed.⁹ In Iowa, wind speeds tend to be high in the winter and spring when solar energy is less available, and lowest in the late summer when solar radiance is plentiful.¹⁰ Iowa currently generates a higher proportion of its electricity from wind than any other state (58% in 2021), but solar is well under 1%, about one tenth the national average.¹¹ This is a function of policy, not poor solar availability. For example, Minnesota produced nearly ten times as much solar energy as Iowa in 2022¹² In terms of balancing our energy portfolio, mitigating climate change, and reaping the benefits of complementary renewable sources, Iowa is under-invested in solar.

Solar is highly effective from a land-use perspective: a one-acre solar farm produces as much energy as 100 acres of corn-based ethanol.¹³ Using far less than the amount of land devoted to rural roads in Iowa, solar could produce as much energy in Iowa as wind does today.¹⁴ Moreover, as with wind, solar farms need not be single-use systems. Shade provided by panels during mid-day heat can be beneficial for some crops, and "agrivoltaics" — combining solar and agriculture—is a recognized land-use opportunity. Some native plants thrive in the partial shade, introducing restoration of soil quality, pollinator habitat, and improved aesthetics among solar installations.¹⁵ Solar can also be sited on already used land, such as rooftops and parking lots.

Solar also produces benefits to communities where it is installed, including skilled, local construction jobs with benefits, and potential energy security with micro-grids. Stakeholder involvement in decision making can lead to positive outcomes. For example, after the approval of 200 MW of solar photovoltaics at the former Duane Arnold nuclear facility, Linn County supervisors organized five citizen committees to draft a new solar ordinance that could meet needs and concerns across the spectrum.^{16, 17} This type of cooperative process could be replicated statewide.

Now is a great time to install solar, both in residential settings and at the utility scale, because federal tax credits will reduce the cost of residential solar by 30% through 2034,¹⁸ and up to 50% for commercial solar, with an additional credit for energy produced.¹⁹

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References:

1. IPCC, 2021: Summary for Policymakers. In: *Climate Change 2021: The Physical Science Basis. WG I Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., et al. (eds.)]. Cambridge University Press, New York, NY, USA, pp. 3–32, doi:[10.1017/9781009157896.001](https://doi.org/10.1017/9781009157896.001).
2. Yuan, Xing, Yumiao Wang, Peng Ji, Peili Wu, Justin Sheffield, and Jason Otkin, 2023: A global transition to flash droughts under climate change. *Science* **380**, 187- 191.
3. Takle, Eugene S., and William J. Gutowski, Jr., 2020: Iowa's agriculture is losing its Goldilocks climate. *Physics Today* **73**, 2, 26-33. <https://doi.org/10.1063/PT.3.44>.
4. International Renewable Energy Agency, 2021: Renewable power generation costs in 2020. <https://www.irena.org/publications/2021/Jun/Renewable-Power-Costs-in-2020>
5. Feldman, David, Vignesh Ramasamy, Ran Fu, Ashwin Ramdas, Jal Desai, and Robert Margolis. 2021. U.S. Solar Photovoltaic System Cost Benchmark: Q1 2020. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-77324. <https://www.nrel.gov/docs/fy21osti/77324.pdf>.
6. Clarke, L., Y.-M. Wei, A. De La Vega Navarro, A. Garg, A.N. Hahmann, S. Khennas, I.M.L. Azevedo, A. Löschel, A.K. Singh, L. Steg, G. Strbac, K. Wada, 2022: Energy Systems. In IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla *et al.* (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. p. 18 doi: 10.1017/9781009157926.008
7. Lazard, 2023: Levelized cost of energy analysis—Version 16.0. <https://www.lazard.com/research-insights/2023-levelized-cost-of-energyplus/>
8. Iowa State University, Center for Building Energy Research. About the House (Interlock House). <https://interlockhousedata.com/about-the-house/> [accessed July 20, 2023]
9. Jurasz, J., and Beduco, A, 2022: Complementarity of Variable Renewable Energy Sources. Academic Press, Cambridge, MA. 713 pp.
10. Takle, E. S., and R. H. Shaw, 1979: Complementary nature of wind and solar energy at a continental mid-latitude station. *Int. J. of Energy Res.*, **3**, 103-112. <https://doi.org/10.1002/er.4440030202>
11. U.S. Energy Administration. State Profile and Energy Estimates: Iowa. <https://www.eia.gov/state/analysis.php?sid=IA> [accessed July 20, 2023]
12. U.S. Energy Administration. Solar Explained. <https://www.eia.gov/energyexplained/solar/where-solar-is-found.php>
13. Mathewson, P. and Bosch, N. 2023: Corn ethanol vs. solar land use comparison. CleanWisconsin. <https://www.cleanwisconsin.org/wp-content/uploads/2023/01/Corn-Ethanol-Vs.-Solar-Analysis-V3-9-compressed.pdf>
14. Iowa wind production in 2022: 44,664 GWh (<https://www.eia.gov/energyexplained/wind/where-wind-power-is-harnessed.php>); average land-use requirement for large-scale solar generation 3.4 acres per GWh per year (<https://www.nrel.gov/docs/fy13osti/56290.pdf>); total land required: 152,000 acres. Total miles of rural roads in Iowa: 97,600 ([https://iowadot.gov/analytics/images\(annual\)/MIPUBRDS15.pdf](https://iowadot.gov/analytics/images(annual)/MIPUBRDS15.pdf)); assuming average 35 foot width, rural roads require roughly 414,000 acres (97,600 mi * 5280 ft/mi * 35 ft / 43,560 sq ft/acre).
15. For example: NREL, 2022: The 5 Cs of Agrivoltaic Success Factors in the United States: Lessons From the InSPIRE Research Study. <https://www.nrel.gov/docs/fy22osti/83566.pdf>
16. Linn County, Iowa. Balancing Agriculture and Solar Committee Statements [accessed July 20, 2023] <https://www.linncountyiowa.gov/DocumentCenter/View/21807/Final-BAS-Statements?bidId=>

17. Linn County, Iowa. Renewable Energy Review Committees. [accessed July 20, 2023].
<https://www.linncountyiowa.gov/1705/Renewable-Energy-Review-Committees>
18. U.S. Dept of Energy, Office of Energy Efficiency and Renewable Energy. Homeowner's Guide to the Federal Tax Credits for Solar Photovoltaics [accessed July 20, 2023].
<https://www.energy.gov/eere/solar/homeowners-guide-federal-tax-credit-solar-photovoltaics>
19. U.S. Dept of Energy, Office of Energy Efficiency and Renewable Energy. Federal Solar Tax Cuts for Businesses [accessed July 20, 2023].
<https://www.energy.gov/eere/solar/federal-solar-tax-credits-businesses>