Large-Scale Solar Siting:

ENCOURAGING ECOSYSTEM ENHANCEMENT AND CONSERVATION WHILE PRODUCING MUCH NEEDED ZERO-CARBON ELECTRICITY

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I. INTRODUCTION

With passage of the landmark Inflation Reduction Act (IRA), the first significant step toward addressing climate change through federal statute, Congress has taken a major step forward. Through tax policy, Congress locked down long-term incentives for renewable energy projects and storage projects and put new policies in place to encourage U.S. production of the materials used in those projects at fair wages.

These changes will accelerate the clean energy revolution that is already underway and incentivize the installation of renewable energy projects to help achieve 2030 and longer-term decarbonization goals. Although these policy changes are welcome and needed, many other barriers to reaching federal and state decarbonization goals remain. One such area is large-scale project siting.

As electricity production moves away from central station, fossil fuel-fired power plants, and toward more spread-out clean energy projects that occupy more land, questions around where to put projects have come to the forefront. Siting large-scale projects also raises questions about changing land use patterns, the environmental impact of large-scale solar projects, as well as their impacts on the host community.

This new Solar and Storage Industries Institute policy brief proposes a siting framework for large-scale solar projects which will produce much needed zero-carbon electricity and can serve important ecosystem enhancement and conservation roles.[1] This paper argues that large-scale solar projects should be designed and operated to maximize preservation of our natural capital and ecosystems and sited to minimize negative impacts on land.

Responsible siting such as we propose here can help preserve community character while protecting individual property rights and the environment. Modelled on our framework for siting community solar projects, this brief looks at siting through the lens of large-scale projects, which can have their own unique permitting challenges. The paper describes the decarbonization challenge, discusses current trends in large-scale solar and storage deployment, puts the acreage need of large-scale solar deployment consistent with decarbonization goals in the context of other types of land use, offers three foundational principles for siting and introduces a permitting framework to help guide responsible siting.

[1] The Solar and Storage Industries Institute is accelerating the transition to carbon-free electricity through clean energy research and analysis. The newly created Institute is the charitable and education arm of the Solar Energy Industries Association and is a 501 c3 non-profit. See http:www.ssii.org

II. THE DECARBONIZATION CHALLENGE, LARGE-SCALE SOLAR PROJECTS & CHANGES IN LAND USE PATTERNS

a. The Fundamental Issue of Our Time

In its most recent assessment, the United Nation's Intergovernmental Panel on Climate Change issued its most dire warning to date. Unless we make drastic reductions in greenhouse gas (GHG) emissions in the next 10 years, our planet is at risk of suffering the dramatic negative impacts of a changing climate including significant sea level rise, increasing severe storms, drought, and mass displacement of vulnerable populations.[2] Across the globe, countries and subnational governments have set greenhouse gas reduction objectives, but until recently the U.S. had only pursued limited regulatory measures to reduce GHG emissions. With the passage of the IRA, which is expected to help reduce GHG emissions by 40% from the electric sector and stimulate additional economy-wide reductions, the U.S. is now taking meaningful steps to transition away from dirty fuels. Although the IRA is a significant step in the right direction, challenges to deploying enough clean energy remain.

b. Large-Scale Solar Projects

Large-scale solar projects, sometimes called "utility scale" projects because they sell power directly to utilities or are scaled to meet utility needs, have been generating clean, reliable power for decades. Although the definition of what a large-scale project is can vary, for this paper we will define major projects as anything greater than one megawatt (MW) in capacity consistent with the projects in the Solar Energy Industries Association "Major Solar Projects List."[3]

For the year ending 2021, despite significant headwinds such as the inability to procure materials due to supply chain problems, shipping bottlenecks at the nation's ports, and rising commodity prices, the large-scale solar sector still installed 17 gigawatts (GW) direct current (dc) capacity.[4] Furthermore, in 2021 the number of large-scale projects in the pipeline — a project in some stage of development but not yet completely installed — was a whopping 80.2 GW_{dc} of capacity.[5] That's roughly equivalent to 40 significantly-sized nuclear generating stations. Even with rising prices of installing solar projects based on the aforementioned factors, in many places across the country, large-scale solar projects are the "go-to" resource for the nation's utilities.

c. Expect Much More Solar to Come Online Soon

Based in part on the low price of solar now reinforced by long-term federal tax policy established in the IRA, significantly more projects will be coming online by 2050 replacing dirtier sources of electricity. In September 2021, the U.S. Department of Energy released its Solar Futures Study, which showed, even *without* major changes in government policy, "market forces and technology advances will drive significant deployment of solar and other clean energy technologies as well as

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[2] IPCC, 2022: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, February 2022.

[3] See https://www.seia.org/research-resources/major-solar-projects-list

[4] Wood Mackenzie/ SEIA, "US. Solar Market Insight Report, YIR 2021," March 2022, p. 35.

[5] Ibid.

substantial decarbonization."[6] The vast majority of this capacity will be large-scale solar installations combined with storage.

But with the addition of concerted action by different levels of government, such as the policy changes included in IRA, two decarbonization scenarios in the study peg the cumulative needed deployments of solar in 2050 between 760 GW and 1,570 GW, with much of that solar coming from large-scale resources. This represents a nearly sixfold increase over the cumulative amount of solar installed today, and a massive increase in annual solar deployment.

d. The Benefits of Large-Scale Solar

In addition to the clean energy benefits to society by avoiding the pollution that is changing our climate, large-scale solar installations produce many other types of benefits. Large-scale solar projects compensate property owners for the use of their land. Lease payments to property owners can often be the difference between keeping a family farm in business or selling property off to real-estate development.[7]

Large-scale solar projects provide employment opportunities in rural communities where jobs are sometimes scarce. They can also provide other community support through tax revenue to local governments and school districts or through payments in lieu of taxes where the solar project is located.

And these projects can provide important environmental benefits beyond reducing carbon emissions, such as clean air, preserving agricultural land for productive use after the life of a solar facility, creating habitat for a variety of helpful species including pollinators and bats, and providing soil and runoff management.

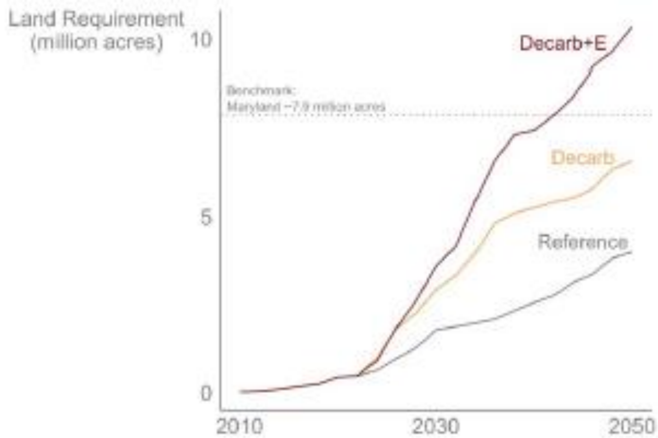
e. Large-Scale Solar Development and Changing Patterns of Land Use

With the current state of technology, large-scale solar projects can require hundreds of acres of land, setting off debates about managing the footprint of solar development and protecting community character.[8] But it is important to keep the overall impact of solar deployment on overall land use in mind.

Even under the highest levels of solar deployment modeled as part of the Solar Futures Study, "ground-based solar technologies require a land area equivalent to 0.5% of the contiguous U.S. surface area…"[9] The DOE report estimates the acreage required would be approximately equivalent to the size of the state of Maryland, the eighth smallest state in the U.S. See Figure 1.

Figure 1. "National solar deployment land use projections for three core scenarios 2010-2050." Source U.S. DOE p.179.

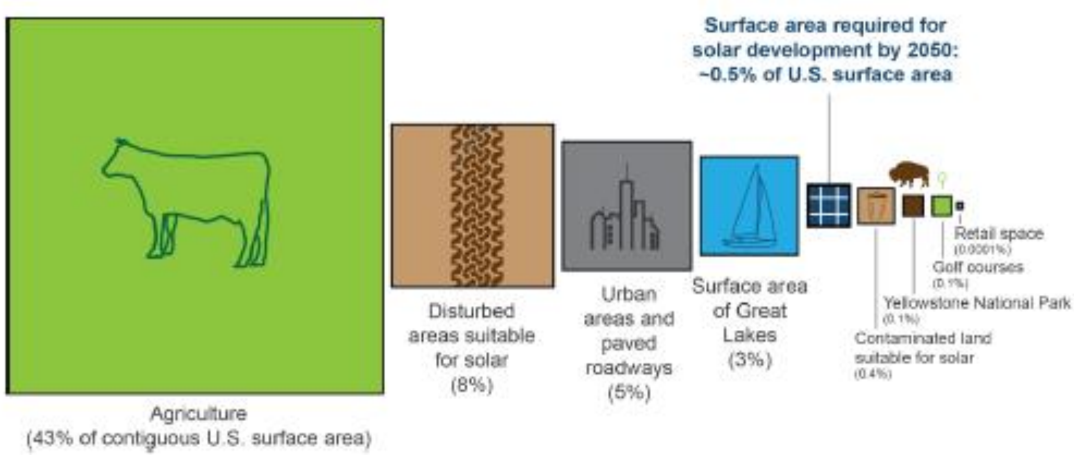
[6] US Department of Energy, Office of Energy Efficiency and Renewable Energy, "Solar Futures Study" September 2021 p. vi.
[7] See https://www.seia.org/blog/how-community-solar-supports-rural-communities-and-farmers
[8] See https://www.brookings.edu/research/renewables-land-use-and-local-opposition-in-the-united-states/
[9] US Department of Energy, Office of Energy Efficiency and Renewable Energy, "Solar Futures Study" September 2021, p. 177.



To help put that statistic into further context, and as shown in the Figure 2 below, under the study's parameters, 43% of the U.S. contiguous surface area is dedicated to agriculture. Urban areas and paved roadways only account for 5% of U.S. surface area, and golf courses across the country account for 0.1% of U.S. surface area. Based on this analysis, five times the amount of land currently dedicated to the pursuit of golf would be required to help meet the nation's clean electricity needs.

Although the study goes on to point out the acreage requirement for solar could be met using less than 10% of already disturbed lands, such as landfills and brownfields or even parking lots, not all of these sites are located near enough to critical electric infrastructure and others may not be suitable for large scale development for different reasons.[10]

Figure 2. "Maximum land use required for solar in 2050 in the Solar Futures scenarios compared with solar-suitable disturbed and contaminated areas and examples of other U.S. areas." Source: U.S. DOE. p 180.



f. The Need for a Large-Scale Solar Siting Framework

Even at the low overall level of national acreage required to hit our clean energy objectives, large-scale solar development is having and will continue to have a noticeable impact on communities.

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[10] Ibid.

The debate over where to put a large-scale solar project and how it is permitted is not a trivial matter.

Solar, like any kind of new development, may run into opposition from nearby residents. Unfortunately, this opposition has at times used false information to call into question the benefits of the new solar project by questioning the greenhouse gas reduction benefits of transitioning to solar power, to speciously arguing that some regions of the country do not have enough sunlight to make solar a reliable source of energy, to suggesting, falsely, that all materials in solar panels are hazardous and should be treated as hazardous waste. Obscured by these arguments are legitimate concerns about potential land use impacts and the legitimate interest in preserving community character. Too often, opponents of large-scale solar ignore the underlying problem: that the United States needs massive amounts of clean energy to avoid the devastating effects of climate change.

Likewise, some stakeholders may ignore legitimate arguments from neighbors about the ways in which a sizable solar farm may impact local lands. It is understandable that neighborhoods accustomed to a particular viewshed would raise concerns about solar or any type of land use change. And although lands for solar projects today make up a tiny fraction of the nearly 81 million acres of land across the nation dedicated to energy production, to reach an emissions free grid, the amount of land utilized by renewables projects will need to grow.[11]

If we fail to adequately address concerns about large-scale solar siting, then public acceptance for clean energy may wane, making addressing the climate challenge even more difficult.

[11] See: https://www.bloomberg.com/graphics/2021-energy-land-use-economy/. In Massachusetts, a 2019 analysis by SEIA showed solar installations take up far less acreage than golf courses across the Commonwealth.

Solar as land preservation resource

Solar project development is unlike many other types of development. Large-scale solar installations can enhance natural habitat and may be more temporary in nature. Building a commercial shopping center or residential housing development on farmland, for example, essentially changes the character of that land forever. With solar projects, however, panels, posts and racking may be removed and recycled at the end of a project lease term. In this way, large-scale solar can be seen as a tool for preserving land, encouraging long-term sustainable farming, and in some cases even increasing the value of a piece of property over time.

In the agricultural context, for example, allowing the underlying land the ability to regenerate by lying uncultivated for many years increases the productivity of that land.[12] And some research has demonstrated the benefits of the shade that solar panels provide on grazing livestock, particularly among sheep.[13]

Similarly, there are land use benefits, and benefits to ecosystems brought about by building solar farms that should be considered when making siting decisions. Planting native grasses at solar farms, or including pollinator-friendly seed mixes, can reverse decades of habitat loss for many threatened species and result in co-benefits. For example, research on ecosystem services by projects using solar-pollinator habitat in the U.S. Midwest showed a 65% increase in carbon storage potential, 95% increase in soil/sediment retention, and a 19% increase in water retention.[14] Although more research is needed to examine these benefits beyond the Midwest, the study shows promising results.

Analysis in the United Kingdom also indicates that well-designed solar arrays can not only help achieve needed decarbonization targets but also contribute to maintaining biodiversity and achieving other environmental goals.[15] A study in 2020 using project level data at solar parks and a decision support tool found that solar installations can "offer[s] more potential than any other land use change to deliver natural capital and ecosystem service benefits…[16] In other words, more so than other uses, solar development can be used as a tool toward improving environmental quality.

Additional research by the U.S. Department of Energy in conjunction with the national labs should be undertaken to better understand and help further quantify the ecosystem benefits provided by ground mounted solar projects. Ecosystem services should also be accounted for in making permitting decisions.

III. THE LARGE-SCALE PERMITTING PROCESS TODAY

[12] See https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/

[13] Alex Sandro Campos Maia, Eric de Andrade Culhari, Vinícius de França Carvalho Fonsêca, Hugo Fernando Maia Milan, Kifle G Gebremedhin, 'Photovoltaic panels as shading resources for livestock," Journal of Cleaner Production, Volume 258, 2020. See: https://doi.org/10.1016/j.jclepro.2020.120551.

[14] See https://www.nrel.gov/docs/fy22osti/80818.pdf

[15] Solar Trade Association (2019) Natural Capital Value of Solar, Eds N. Gall and E. Rosewarne. See https://solarenergyuk.org/resource/natural-capital/

[16] R.J. Randle-Boggis, P.C.L. White, J. Cruz, G. Parker, H. Montag, J.M.O. Scurlock, A. Armstrong, "Realising co-benefits for natural capital and ecosystem services from solar parks: A co-developed, evidence-based approach", Renewable and Sustainable Energy Reviews, Volume 125, 2020. See https://www.sciencedirect.com/science/article/pii/S136403212030071X

Permitting for large-scale solar projects is somewhat different depending on whether the project is built on private or public lands. Both processes, however, can be time consuming, involve multiple steps and levels of review, typically require an environmental impact review, and should involve public input.

a. Private Lands

Generally speaking, projects built on private land are subject to local government permitting jurisdiction, although there are exceptions, most notably in New York State which we discuss separately. It is important to keep in mind that with more than 90,000 local governments across the U.S. there is significant variation in permitting process and even some overlap with various levels of review. But we generalize the basic features of permitting in Table 1.

Typically, the project developer first undertakes a review of the proposed project footprint with respect to local zoning. If the project is consistent with local zoning, then the developer can move on to the next step or agree to certain conditions to bring the project into compliance. But if there are needed zoning changes, securing these changes can add a significant amount of time, and typically require action of the local zoning board. Relatedly, communities across the country also have "comprehensive plans" or land use plans that are put in place to help guide any proposed development in a community. Similar to zoning, and often instead of zoning, a solar project must demonstrate consistency with the comprehensive plan before seeking further local approval. In states with state-based environmental quality reviews led by a single agency, the local government itself requires the developer to analyze the environmental impacts of their projects and propose any remediation measures. Then, usually after taking public comment on the proposed project and holding a hearing on the potential impacts of the development, the local government grants or denies a permit for the project.

Table 1: Permitting Steps for Solar Projects on Private Land

Activity	Description
Zoning Compliance	Review to ensure the solar project is consistent with existing zoning ordinances
Comprehensive Plan Compliance	Review to ensure the solar project is consistent with the local government's development plan
Environmental Review	Review of potential environmental impacts from constructing and operating the project (*e.g.*, impact on wildlife, air quality, water quality)
Local Government Permit	Approval or rejection of conditional use permit typically following public comment and a hearing

b. Public Lands

There is significant development of solar projects on lands owned by federal and state governments as well, with solar development on federal land being more common. The Biden Administration has also set a national goal to authorize 25 GW of solar projects on America's federal public lands by 2025.

In some respects, the process of developing solar projects on federal public lands is similar to development on private land. The process begins with a federal agency, in most cases the U.S. Bureau of Land Management, holding competitive solicitations for solar project land leases. These leases are in pre-defined Solar Energy Zones and are governed by rules around competitive bidding. Upon selection as a lease winner, it is important to note that the solar project developer pays bonus bids and fees, benefiting taxpayers in the same way that a private landowner benefits from leasing their land to a solar developer.

Then the solar developer undertakes an environmental impact review as required by the National Environmental Policy Act. These reviews, which generally take between 8 and 12 months but can take much longer, assess the environmental impacts of the project, may propose mitigation measures, and are subject to public input. Upon completion of the review, the permitting agency accepts or denies a permit to build the project. Depending on the project configuration, other environmental permits from different state or federal agencies, such as a water quality certification, may be required as well.

IV. FOUNDATIONAL PRINCIPLES

It is helpful to keep in mind three foundational principles about solar development. These three underlying concepts inform our entire framework.

1. **Rely on Existing Law.** There is an extensive body of existing federal and state law that already protects and prohibits development on sensitive ecosystems such as wetlands, protects habitat and species of concern, encourages community outreach, and requires developers to consider a project's impact on Tribal sites and other historical resources. In short, decision-makers should not "reinvent the wheel" or layer on new restrictions based on the existence of this already robust set of protections. For decades, project developers seeking federal, state, and local approvals have been required to assess the environmental impact of their proposed projects, consider alternatives that address environmental concerns, and avoid, minimize, and/or mitigate those impacts through various mechanisms.
2. **The States Should Help Their Local Governmental Partners.** State regulators should develop frameworks and tools for use by local governments in making permitting decisions. Local governments are often understaffed and could benefit from having tools developed by expert state regulators to aid them in making decisions. Policy makers should have up-to-date, publicly accessible land use mapping tools available to help drive responsible siting decisions.[17]
3. **Solar Development and Environmental Conservation Are Not at Odds**. Finally, solar development can be compatible with conservation and preservation of community character provided the practices outlined in this paper for development are followed. And new research is beginning to show that more environmental benefits can flow from solar projects, beyond the injection of carbon free electricity into the grid, that should be accounted for during environmental impact review and factored in during permitting.

[17] What data you use matters. Publicly available GIS data such as Massachusetts is preferred. Data layers and exercises developed by private parties and interest groups should be avoided.

a. Large-Scale Solar Siting Framework: Design for Ecosystem Services; Avoid, Minimize, and Mitigate Potential Negative Impacts

Our framework starts with a careful, science-based assessment of the land on which the project will be built. This assessment involves analysis of available geographic information system (GIS) data, on-the-ground review of the conditions of the property in part to ensure the accuracy of the mapping data, and an analysis of any special project circumstances.

Although GIS data should be part of the analysis, GIS data should not be determinative. In other words, GIS data that was collected for different environmental objectives, such as habitat and species mapping, should not be used to drive regulatory decisions. Furthermore, despite regulators' best efforts, GIS data is often incomplete or out of date, and therefore must be accompanied by on-the ground verification of its accuracy to be used in case-by-case siting decisions.

In designing a facility, the project developer, to the best of their ability, should first work to identify ways in which the project can be designed to provide ecosystem service benefits over the time of its operation. They should then work to determine how the project's design and operation could avoid environmental impacts such as unnecessary soil disturbance, tree cutting, and sedimentation and

[18] This approach built on a similar one-stop shopping process designed for other major electrical generation projects that was originally enacted into law in the early 1990s.

water runoff. To the extent that these impacts cannot be avoided, the project designers would do their best to minimize impacts, such as installing erosion control barriers, selectively cutting trees where possible, or adding setbacks and buffers to appropriately manage the neighboring community's view and minimize changes in community character.

For some projects, additional mitigation steps could include executing a protection agreement for an equivalent resource, such as agreeing to fund an agricultural easement on certain lands, paying into a fund for preservation work, or integrating, for example, a dual-use agriculture/solar protocol to preserve the resource.

Throughout the entire design process, the project developer should be in regular contact with representatives from the community and should be taking community feedback into consideration. In many instances, regular engagement with neighborhood groups can result in better project design, or the installation of plants and trees that can preserve local views.

The following table explains this simplified approach, and each term and response is described in more detail below.

Table 2. Framework for Large-Scale Solar Siting

Category	**Required Actions**
Design:	Design the solar project operation to encourage habitat/biodiversity, dual-use and add elements that can provide additional ecosystem services.
Avoid:	Select the least damaging alternative for the resource, involves consideration of multiple alternatives and project configurations with the goal of avoiding environmental impacts.
Minimize:	For impacts that cannot be avoided, projects should employ measures to minimize the environmental impact such as installing erosion control barriers, buffers or setbacks from sensitive resources.
Mitigate:	For environmental impacts beyond avoidance for certain projects, a) engage in agreements for protection of an equivalent resource, or b) integrate dual use agriculture protocols or other compatibility measures or c) pay into a fund or fee for restoration or preservation work.

1. Design for Ecosystem Service Benefits

Land use change for solar is increasingly being recognized as distinct from other forms of development given its temporary, reversable nature, the minimal human disturbance of the ground and small infrastructure footprint. Incremental design and operation in the form of habitat/biodiversity, dual-use or other elements can provide additional ecosystem services and should be incorporated into project design. State regulators should also encourage design that results in ecosystem services or increased agricultural output by initially deploying incentives to encourage their development, and then taking these benefits into account when considering long-term solar project compensation.

2. Avoid

Avoiding adverse environmental impacts when considering a proposed project is already a bedrock principle in environmental law. Flowing from this category of actions is analyzing alternatives in the large-scale solar project configuration to select the least damaging alternative. For example, projects should be carefully designed to avoid Native American sites of significance, and other resources that may have special meaning to the host community.

3. Minimize

To the extent that these impacts cannot be avoided, project designers do their best to minimize impacts, such as installing erosion control barriers, or adding setbacks and buffers to appropriately manage view sheds and changes in community character.

4. Mitigate

If avoiding negative environmental impacts are impossible, the federal government and most states allow for mitigation payments to offset those impacts. For example, to offset impacts a firm could execute an agreement to protect another parcel of nearby land that has conservation value or make payments to an established trust fund or state-run program to encourage the protection of agricultural or forested land. By entering into mitigation agreements, a state or region can continue to make progress toward its long-term conservation objectives as well as make progress toward its clean energy goals.

V. ADDITIONAL CONSIDERATIONS

This section of the paper describes a few additional considerations that should be taken into account when making siting decisions. These are broken down between agricultural, and wildlife resources.

a. Agricultural Resources

As state regulators work to put together guidance for local governments, it is essential that state departments of agriculture and the energy regulatory agencies work together to ensure consistent policy implementation. Although these regulatory agencies generally have very different missions and statutory authority, the agencies must be on the same page with respect to project siting.

One way to encourage cooperation is the development of dual use agriculture and solar guidelines. Beyond having sheep to keep vegetation at bay at a large-scale solar project, projects can be designed to allow for both crop and clean energy production. Dual use solar projects can be designed to maximize crop production from the farm, or the total value of the agricultural goods, as well as for clean energy production. Increasing the height of panels, increasing spacing between panel rows and other techniques, where feasible, could be used more effectively in designing a dual use program.

Furthermore, dual use agriculture and solar could be integrated on projects where a certain percentage of prime farmland is affected by the construction of a solar farm. Any solar incentive program should be designed to cover any additional cost associated with configuring a project to accommodate dual use.

b. Protection of Wildlife

A robust suite of federal and state laws protect wildlife, including threatened and endangered species, from the potential impacts of solar development. At the federal level, the Endangered Species Act prohibits the taking of over 2,000 individual threatened and endangered species and encourages the conservation of species that may potentially be designated as threatened or endangered in the future as well as critical species habitats across the country. Other federal laws provide specific protections for marine mammals, migratory birds, and certain species of eagles. And many states have enacted their own versions of these laws to protect local species of concern.

While the best available science regarding potential impacts of solar development on wildlife continues to evolve, the industry also employs best management practices to create habitat as well as avoid or minimize potential impacts. For example, many developers conduct pre- and post-construction wildlife surveys, often in coordination with state or federal agencies; deploy measures such as downward-facing lights and anti-perch equipment to protect birds and bats; and install special fencing that allows wildlife to safely cross solar facility footprints. Industry also works closely with government and private research institutions to advance understanding of potential impacts and effective mitigation measures.

VI. INNOVATION

As regulators wrestle with the land use impacts of large-scale solar siting, they should also keep in mind that tomorrow's large-scale solar projects may look significantly different than today. For example, panel efficiency continues to improve. Increasingly, trackers are allowing solar to pivot with the angle of the sun further increasing efficiency and electricity project output.

As improvements to solar technology continue, the acreage needed to build large-scale solar projects is likely to decrease. This is not to say that states should delay siting facilities until a later date. With the impacts of the climate crisis manifesting themselves in new more dangerous ways every day, the transition to renewable energy must take place as soon as possible. The point is simple: tomorrow's siting framework may be different than today's, and regulators should keep in mind that land use solutions appropriate now may need a second look based on the pace of technical innovation.

VII. RECAP/CONCLUSIONS

A vast amount of additional renewable energy must be developed in order to enable decarbonization. While many land use concerns are legitimate, solutions are needed to find an appropriate balance that enables a sufficient pace of renewable energy deployment to avoid the worst consequences of climate change. To find that appropriate balance, policy makers should avoid the temptation to reinvent the wheel when making decisions about solar and land use.

A well-established body of law can be used to help guide the sensible development of renewable energy projects. A fact-based approach should consider the overall need for renewable energy and the ecosystem benefits of solar installations alongside the potential impacts and aesthetic concerns.