# Pathways to deep decarbonization must consider land-use impacts

Ecological impacts from solar and wind are significant, but can be avoided to achieve California's goal of 100% renewable, zero-carbon electricity by 2050.

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Based on **Grace C. Wu, Emily Leslie, Oluwafemi Sawyerr, D. Richard Cameron, Erica Brand, Brian Cohen, Douglas Allen, Marcela Ochoa and Arne Olson. 2020. "Low-impact land use pathways to deep decarbonization of electricity."** *Environmental Research Letters*.

## The Policy Problem

The costs of renewable energy technology are rapidly declining. At the same time, governments across the globe are mandating significant GHG reductions and setting targets for zero-carbon electricity. These forces are accelerating the clean energy transition. Yet few studies have accounted for the natural and agricultural land impacts of renewable energy development, or how environmental siting constraints affect electricity costs and technology choices. We address these gaps by developing an approach to support policy and regulatory design that achieves multiple objectives—protection of natural and working (agricultural and rangelands) lands and renewable energy development, using the state of California as a case study.

## Key findings and proposed solutions

- Impacts may be avoided if developers use integrated planning and effective screening tools early in the project development cycle. For California, access to regional renewable resources can achieve lower impacts at lower costs.
- Working lands impacts are significant in all scenarios, however, agrivoltaics and wind-friendly farming and ranching have the potential to both reduce conflicts and promote synergistic, higher land-use efficiency landscapes.
- Developers can adopt this framework and policymakers can use regulatory mechanisms such as land use policy or zoning changes to prioritize low-impact electricity development.

## What We Found

Using California as a case study, we examined the land use trade-offs of renewable energy development required to achieve ambitious clean energy goals. We used California's capacity expansion model, RESOLVE, to create optimal portfolios of onshore wind, solar photovoltaic, and geothermal resources to meet the state's 2050 GHG reduction and zero-carbon electricity goals. We modeled the spatial build-out of power plants and transmission corridors for 61 scenarios for 2050 and estimated the area of impacted natural and working lands under four levels of siting protections.

Results suggest that enough low-impact onshore wind and solar resources are available to meet increased clean energy demand in Western states. Developers may face siting challenges because a large percentage of desirable sites have environmental and social value. Additionally, without land protections, new solar and wind projects are likely to have sizable impacts on natural lands outside legally protected areas. Local, state, and federal policymakers can use multiple mechanisms to achieve lower-impact electrification pathways. Regulatory mechanisms could include a combination of land use policy or zoning changes. Non-regulatory mechanisms can include adopting this framework—incorporating environmental spatial data into long-term energy and transmission planning to send market signals to prioritize low-impact development.

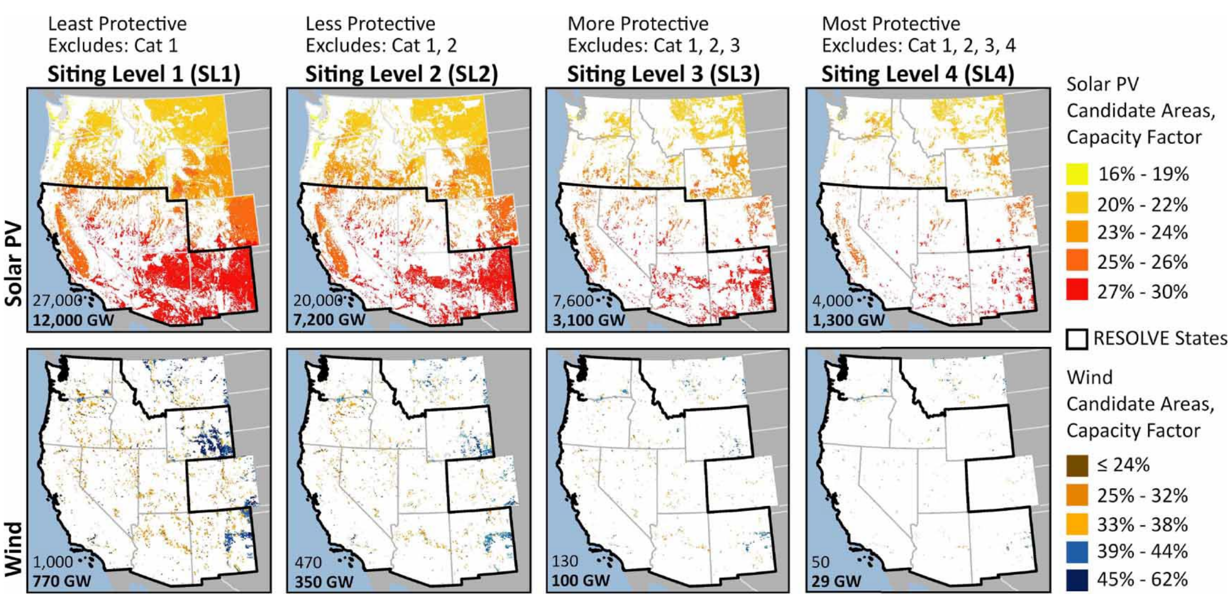


**Figure 1. Renewable resource availability maps showing candidate project areas of solar PV and wind for Siting Levels 1 through 4.** Total resource potential in gigawatts (GW) is labeled within each subfigure; the top value is the total resource potential across all states; the bottom value in bold is the resource potential within RESOLVE states (within black outlines). Cat 1–4 excluded from each Siting Level refer to Environmental Exclusion Category 1 ('Legally Protected'), Category 2 ('Administratively Protected'), Category 3 ('High Conservation Value'), and Category 4 ('Landscape Intactness').