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Planning to Build Faster: A Solar Energy Case Study

Toward a Democratically Rooted, Nationwide Strategy to Accelerate Solar Deployment in the United States

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About Climate and Community Institute

The Climate & Community Institute (CCI) is a progressive climate and economy think tank. Its growing staff and network of over 60 academic and expert fellows create and mobilize cutting-edge research at the nexus of inequality and the climate crisis. CCI fights for a transformational agenda that will rapidly and equitably decarbonize the economy by focusing on material benefits for working people. CCI works with movements and progressive policymakers to pass new policy, effectively implement legislation, shift narratives, and deepen coalitions.

About the Roosevelt Institute

The Roosevelt Institute is a think tank, a student network, and the nonprofit partner to the Franklin D. Roosevelt Presidential Library and Museum that, together, are learning from the past and working to redefine the future of the American economy. Focusing on corporate and public power, labor and wages, and the economics of race and gender inequality, the Roosevelt Institute unifies experts, invests in young leaders, and advances progressive policies that bring the legacy of Franklin and Eleanor Roosevelt into the 21st century.

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Executive Summary

Energy analysts suggest that the United States will need to build millions of acres of solar capacity—totaling an area potentially as large as West Virginia—to reach 100 percent clean electricity by 2035. However, the speed of the energy transition remains incommensurate with the urgency of the challenge.

Energy analysts and policymakers have speculated widely about the factors slowing down renewable energy deployment. Using the build-out of solar energy as a case study, this report evaluates the factors that hinder—and help—the transition to renewable energy, with the aim of bringing nuance and empirical evidence to debates around permitting reform and political-economic strategies to hasten renewable energy deployment.

The transition to renewables will require a whole host of resources and technologies to ultimately transform built environments and energy landscapes. This report argues that the government should coordinate solar siting and development to both ensure rapid deployment and balance the impact of the new infrastructure. Leaving that task to a wide variety of private-sector actors is not conducive to swift—let alone equitable—deployment.

Effective solar deployment requires a nationwide planning and coordination effort. This paper outlines four key roles for the federal government to play in advancing solar:

1. **Conducting whole-of-government, nationwide, multi-scalar land-use and site planning** to identify high-benefit, low-harm solar sites across the country and organize deployment efficiently;
2. **Coordinating between federal, state, Tribal, and local governments** to ensure that national planning coheres with local priorities;
3. **Embedding community, worker, and environmental benefits** into solar deployment and development to build trust and support for the energy transition; and
4. **Creating and expanding support for public and nonprofit solar deployment companies,** unburdened by the duty of generating profits for shareholders.

Our preliminary analysis shows that there are nearly 226 million acres of high-benefit, low-harm area available for solar deployment; the US only needs between 3.5 million to 15 million to meet solar deployment targets (see Figure 1). We identify several categories of high-benefit, low-harm sites that meet environmental quality and social equity criteria and include everything from abandoned agricultural land to transportation rights-of-way (see Figure 2). **The area available for solar is 15 to 60 times what will be**

needed, suggesting that while land use and solar siting will present a challenge, it is ultimately a problem that can be resolved.

The "where" of solar deployment is important, but the "how" and "when" can be just as critical to its success. Connecting high-benefit, low-harm solar sites to the grid will require planning, policy, and investment in new transmission and distribution infrastructures. That is why we argue for community benefit, coordination across government scale, and public or nonprofit solar developers. Together, these measures can begin to align the US energy system with a progressive, post-neoliberal paradigm that recognizes the strategic nature of energy as a public good.

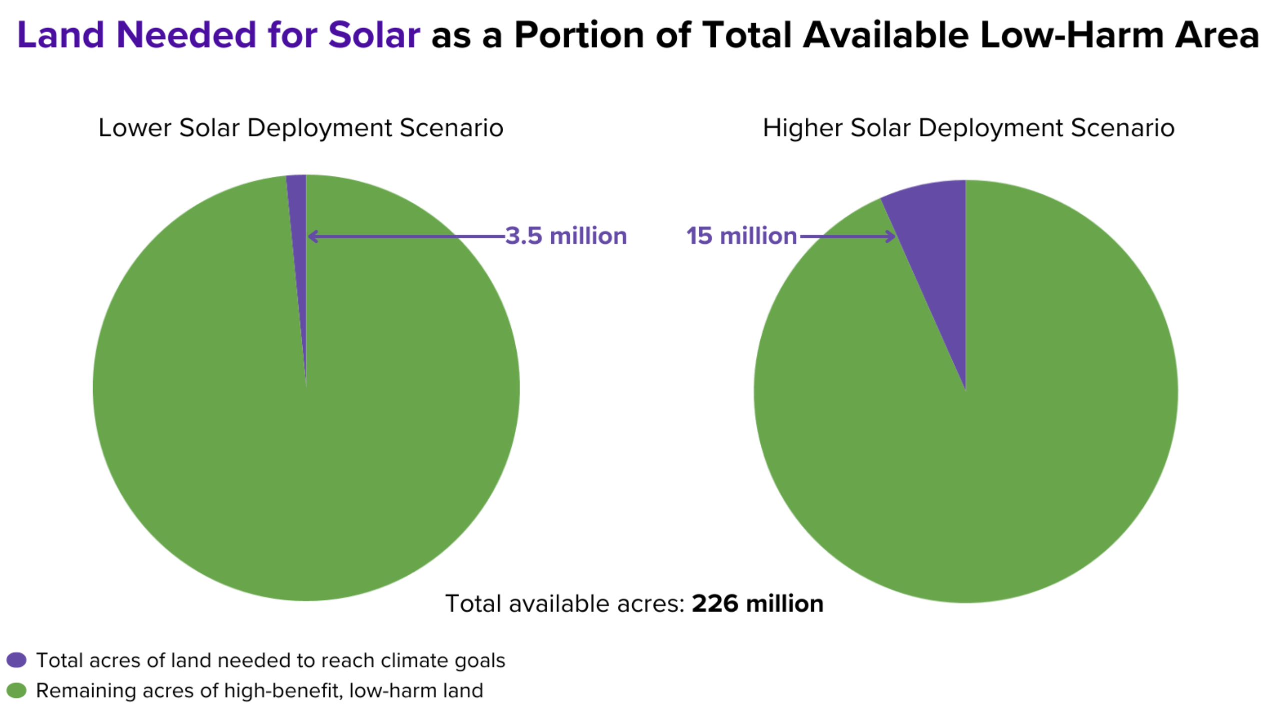

Figure 1. Area Needed to Meet 2050 Climate Action Targets Compared to Total Available Area of "High-Benefit, Low-Harm" Solar Sites. *This shows how much land is available in climate action scenarios that deploy more solar versus less solar based on our review of several leading estimates of how much solar power will be needed to meet 2050 targets. Lower solar deployment scenarios meet climate action targets with less reliance on solar capacity by using other energy sources, technologies, and resources to decarbonize, whereas higher solar deployment scenarios rely on more solar power.*

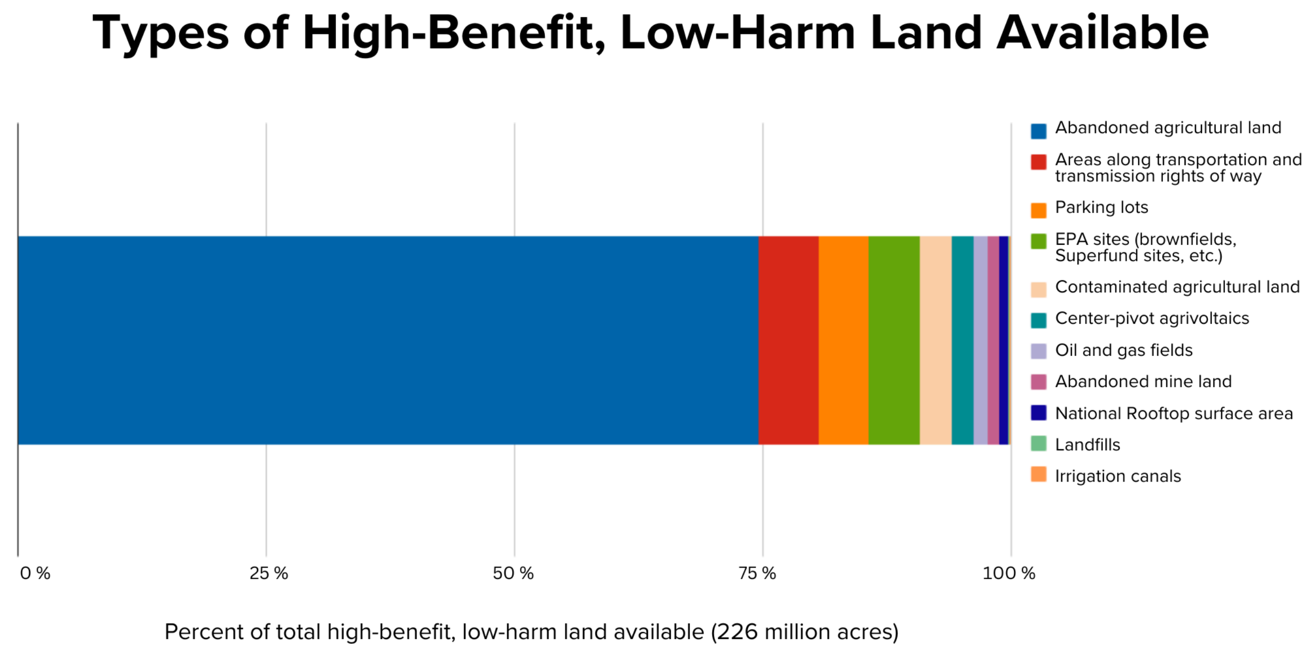

Figure 2. Types of Areas Available for High-Benefit, Low-Harm Solar Siting. *This figure shows the relative availability of different types of solar siting opportunities across 226 million acres of high-benefit, low-harm sites, including abandoned agricultural land, contaminated agricultural land, vacant areas around center-pivot agriculture, highway and transmission line rights-of-way, abandoned mines, oil and gas fields, brownfields and Superfund sites, parking lots, irrigation canals, landfills, and rooftops.*

Introduction: The Challenge of Solar Deployment

To meet climate objectives, the United States must rapidly transition to clean energy. The US Energy Information Administration (EIA) projects that power-sector carbon emissions will decrease up to 38 percent below 2005 levels by 2030—falling short of President Joe Biden's commitment to a 50 percent reduction by then (US EIA 2023a; White House 2021a). That commitment already failed to align with the scenarios set out by the special report of the Intergovernmental Panel on Climate Change (IPCC) (2022) on maintaining the Paris Agreement's 1.5°C target for a livable world. Clearly, the speed of the US energy transition remains incommensurate with the urgency and scale of the challenge.

Electricity from solar power will play a crucial role in replacing the fossil fuels used to generate electricity today. A range of different models project the future energy mix of the green electricity system, which include technologies such as carbon capture and advanced nuclear. Generally, solar and wind together are expected to make up somewhere between 60 to 80 percent of the mix by 2050, depending on assumptions and geography (Denholm et al. 2022; Larson et. al. 2021; Farnsworth and Gençer 2023).

This report uses solar energy deployment as a case study to explore the real-world dynamics at play in quickly developing clean energy. To meet the level of necessary utility-scale solar installations, the US will need to increase deployment by as much as 10 times by 2050. Different forecasts make different assumptions and projections about exactly how much solar the US will need (see Figure 3), but the **bottom line is that the US is not on pace to meet ambitious climate action goals. To do so, it will need to deploy many times over the current amount of solar installed—and this needs to happen much faster.**

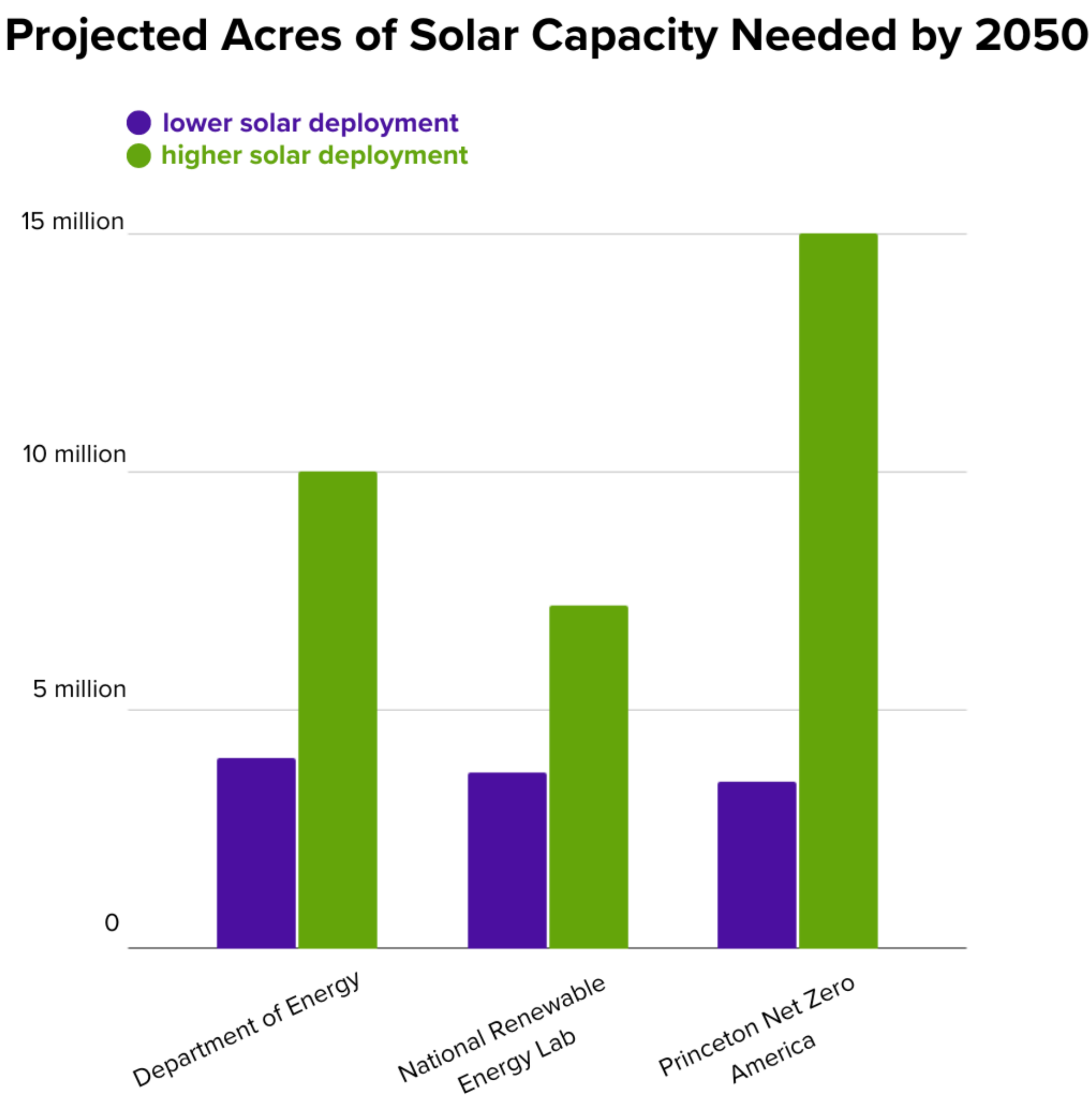

Figure 3. Acres of Solar Capacity Needed by 2050. *This figure shows model projections of how much solar capacity is needed by 2050 to meet climate action goals based on three studies (DOE 2021; NREL 2022; Princeton University 2021). We took each study's lower solar deployment scenario and higher solar deployment scenario to show the ranges in each study.*

In response to slow progress in displacing fossil fuels, a part of the US political zeitgeist has taken aim at environmental permitting as the specter responsible for slowing down solar and other technologies. Advocates of this view believe that the foundational reason that renewable technologies like solar are slow is because project developers in the US spend too much time in environmental review and are too often subject to National Environmental Policy Act (NEPA) litigation (Bennon and Wilson 2023), a finding directly contradicted by other studies (Adelman 2023; Dashiell, Buckley, and Mulvaney 2019). Research by analysts at Energy and Environmental Economics, Inc. (E3) found that "it is difficult to disentangle siting and permitting barriers and processes from other factors leading to renewable deployment and delays" (E3 2024). A Berkeley Lab survey of solar developers ranked local ordinances and zoning, interconnection queues, community opposition, and supply chain issues higher than environmental regulations, closely followed by lack of buyers for the project (Nilson and Stedman 2023). Thus, solar deployment raises many interlinked challenges that cannot be tackled solely via permitting reform.

The built environment will look very different when solar operates as a major electricity source, thus requiring a holistic understanding of interlinked deployment issues. Utilities historically built large-scale, centralized fossil power plants close to population centers. Many of these power plants are situated near communities of color or low-income populations, exposing them to hazardous air pollution and degrading local ecologies. Solar energy development, which ultimately has far fewer negative impacts, will help avoid many of these burdens (Fthenakis, Kim, and Alsema 2008). However, overall solar requires more space than conventional power sources that can create environmental pressures and land-use tensions. Utility-scale solar, in particular, is more often developed on rural, less expensive land further from population centers (Ong et al. 2013; IEA n.d.).[1] Decisions about how and where to build solar infrastructure will change the built environment—affecting land use, livelihoods, and local ecologies and biodiversity.

The purpose of this report is to explore those challenges and assess how solar can be deployed far more quickly while ensuring ecological conservation and protection, as well as the participation of communities in determining their best future in a clean energy transition.

We propose nationwide land-use and built environment planning to take solar from an emerging to a dominant technology in the energy landscape in a way that also supports workers, communities, and the environment, while preventing and minimizing harms. This paper outlines four key roles for the federal government to play in advancing solar:

[1] The intermittency of solar (inconsistent power generation due to fluctuations in weather and time of day) and low capacity factor of renewables (amount of power generated compared to the maximum amount possible) also requires the development and integration of more battery and energy storage.

1. **Conducting whole-of-government, nationwide, multi-scalar land-use and site planning** to identify high-benefit, low-harm sites across the country. This will require resourcing, expansion, and coordination of planning capabilities currently underfunded and scattered across federal agencies;
2. **Coordinating federal, state, Tribal, and local governments** to ensure national planning aligns national decarbonization priorities with local priorities;
3. **Embedding planned community, worker, and environmental benefits** into solar deployment and development to build trust and support for the energy transition; and
4. **Creating and expanding support for publicly owned, worker-owned, and nonprofit solar deployment companies,** unburdened by the duty of generating high profits for shareholders.

Together, these measures can begin to shift the US energy system toward a progressive, post-neoliberal paradigm that recognizes the strategic nature of energy as a public good—a standard approach in many other countries. The following sections of this report 1) identify the state of planning today and structural obstacles to solar deployment, 2) set out principles for solar deployment, and 3) outline recommendations.

This report is based on research interviews with agencies, policymakers, developers, and other organizations. Its objective is to understand and explain the barriers to solar energy deployment across multiple levels of government. The interviews were supplemented with a review of literature on factors known to hasten solar development, data on permitting timelines for solar projects sited under different planning regimes, and a geographic assessment of opportunities to build out solar in low-harm sites. We did not evaluate supply chain issues, but focused on land use and deployment.

Solar Industry Growth and Structural Hurdles

The State of Solar Deployment

Although the recent growth of solar has been impressive, it falls short of what's needed to replace the energy generated by fossil fuels. According to the US Department of Energy (DOE), there will be 266 GW of solar energy facilities in operation by the end of 2024, meaning that solar will contribute 6 percent of electricity in the US (US EIA 2024). In 2025, solar installations are expected to grow another 25 percent. Still, solar's strong growth over the past decade isn't keeping up with the pace needed to retire electricity generated by fossil fuels. New natural gas plants continue to be procured by electric utilities, and the lifetimes of fossil-fueled power plants slated to be shut down have been extended, while still others have no plans for retirement on the horizon. Strategically locating renewable energy and battery storage to replace fossil fuel generation could avoid the lock-in of additional future carbon emissions and help communities breathe cleaner air—for example, by retiring the most polluting peaker power plants (PSE 2019).

States leading in utility-scale solar development include Texas, which will have 25 GW installed by the end of 2024, followed by California (20 GW), Florida (17 GW), North Carolina (7 GW), and Nevada (6 GW). While much of early solar adoption was driven by state renewable energy portfolio standards—state laws that require electric utilities to procure increasing amounts of renewable electricity at specific mileposts—more recently, solar developments have also been driven by corporations through power purchase agreements between utilities and solar developers (Nilson, Hoen, and Rand 2024).

As solar growth continues, innovative ideas like agrivoltaics—where photovoltaics are integrated with agricultural activities, apiaries, or rangelands—are increasingly being deployed in the US, with the National Renewable Energy Lab (NREL) reporting over 10 GW installed and an enormous potential given the extensive agricultural area of the US (Bullock-Sieger 2024). Other novel concepts, like floating solar—solar panel structures that float on a body of water instead of on land—are also on the rise and have already been deployed in countries like Japan. A recent study by NREL found that installing floating solar on 24,000 human-made US reservoirs could generate 10 percent of annual electricity production (NREL 2018).

Photovoltaics installed as distributed energy resources (DERs) through net metering and other arrangements continue to grow in the US as well. The year 2023 was the fifth in a row of record distributed solar in the US, with 7 GW of installations (SEIA 2024). However, some sunny states like California and Arizona are making cuts to incentives for distributed solar (California Solar & Storage Association 2023). These shifts in rate design have largely disregarded the non-energy benefits of rooftop solar and other DERs, such as increased reliability and resilience as well as avoided transmission infrastructure and fuels. The cost of distributed solar is also considerably more expensive across the US than in places like Europe (Barbose et al. 2023). Increasingly large portions of the costs of distributed solar installations go to marketing and customer acquisition costs. Energy analysts at Wood MacKenzie noted that $0.85 per watt of distributed solar is spent on acquisition (the cost of acquiring a rooftop solar customer)—far higher than the $0.49 per watt for photovoltaic modules (McGarvey 2023). The costs of local permitting and inspections for distributed solar add another $1.00 per watt (Barbose et al. 2023).

Does Environmental Review Slow Solar Deployment?

Some renewable energy advocates often claim that environmental review of utility-scale solar projects is one reason that solar deployment is slow.[2] A recent paper repeats this assertion, using data from the Council on Environmental Quality (CEQ) on 23 utility-scale solar projects sited between 2009 and 2014 to find that solar projects take, on average, 2.4 years to complete the NEPA process (Bennon and Wilson 2023).[3] Figure 4 shows how in recent years, utility-scale solar projects have begun to move much more swiftly through environmental review. Solar projects sited on public lands proposed between 2021 and 2024—during the Biden administration under Interior Secretary Deb Haaland— took an average of 0.49 years and a median of 0.37 years to be approved.[4] On private land in California's Westlands Water District in Kings County, where a programmatic environmental review was completed to expedite solar siting on land retired from agriculture (see Figure 4), projects were permitted in 0.15 years on average. In contrast, the time these projects spent in interconnection queues—the waitlist of solar projects with outstanding requests to connect to the electricity grid—averaged 2.1 years (Rand et al. 2024).

This data suggests that permitting is not the most significant factor slowing down solar deployment. Instead, it is a complex system of interlocking issues, including federal agency coordination, transmission and interconnection planning, and poor stakeholder management. In the next section, we outline in more detail some of the reasons that solar has not been deployed faster.

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[2] Environmental review is a public disclosure process in which an environmental impact statement (or report), environmental assessment, or exemption is prepared under the National Environmental Policy Act (NEPA) or a similar state-level process. An organization proposes a project to the public, describes its impacts and alternatives in a formal document, and collects stakeholder or Tribal input. With a few exceptions, the project is then approved (US EPA n.d.).

[3] Twenty-two of the 23 are on public lands managed by the Bureau of Land Management (BLM). Among other challenges with the dataset are that numerous projects use technologies deemed nonviable (e.g., stirling engines, power towers, or amorphous silicon photovoltaic [SPV]) or where companies suffered from numerous bankruptcies or sales/property turnovers that caused delays while under environmental review. The authors did not report the median time frame from this CEQ dataset, so we analyzed the sample and found that the median is 1.7 years, suggesting that a few long projects in the sample skew the data.

[4] The CEQ dataset used in Bennon and Wilson (2023) contained 20 projects on public lands and 2 on private lands, so those data are best compared to timelines for review of projects on public lands.

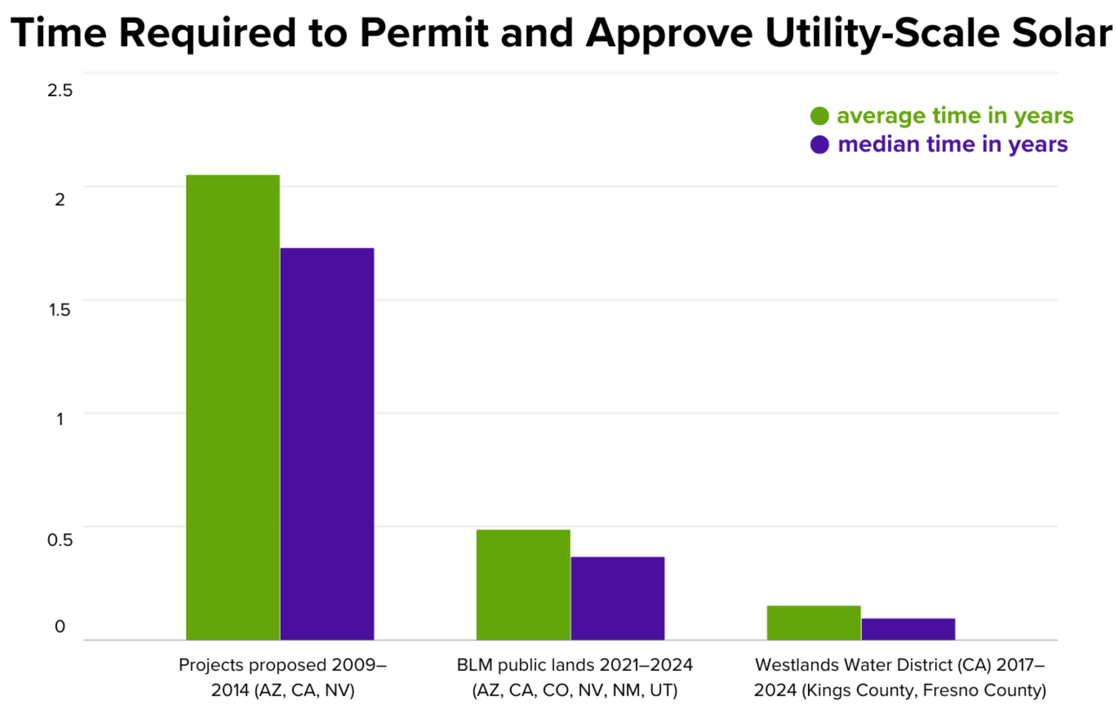

Figure 4. Time to complete environmental review. *This chart depicts the average and median times required for projects proposed from 2009 to 2014 to complete environmental review, based on data collected from the CEQ, compared to approval timelines for solar projects proposed on public lands from 2021 to 2024 and in the Westlands Water District Solar Park in California. Note that the rapid timelines for approvals in the Westlands case are because the water district underwent a master planning process to identify which of the agricultural lands would be retired because of declining water availability and salt-contaminated soils.*

Obstacles to Swift Solar Deployment and the Critical Challenge of Private-Sector Primacy

The key reasons for solar slowdowns include conflicts of over land use, poorly orchestrated interregional transmission, opaque interconnection processes, and rent-seeking behavior of utilities. The good news is that in 2023, solar developers reported fewer delays across all areas that have been plaguing the industry, from supply chains to trade restrictions. Only 19 percent of solar developers experienced some kind of delay in 2023 (US EIA 2024).

Lack of Effective Siting and Land-Use Management

Competing Land Uses: Siting new projects can be a challenge due to poor management of conflicts over competing land uses. Renewable energy infrastructure will require siting new utility-scale solar across a range of landscapes, impacting agriculture, rural areas, wildlife habitat, and places of cultural importance (Hernandez et al. 2015; Levin et al. 2023). This can raise local concerns about environmental degradation, lower property values, lost access to leisure spaces, or damage to cultural resources—the types of land-use conflicts that provoke tensions with local communities (Susskind et al. 2022).[5] Early efforts to plan for renewable energy development can mediate many of these concerns. However, deployment and land-use decisions are heavily fractured between different federal agencies, states, Tribal governments, and local jurisdictions. Cooperation and coordination can facilitate effective siting and land-use management (Schelly et al. 2019; Cameron et al. 2017).

Local, State, and Tribal Pushback: Local and state pushback have emerged in reaction to solar development across the country. These frustrations are often fomented by "astroturf" campaigns and fossil-fuel advocates who whip up opposition with misformation and by feeding on residents' lack of control over past projects coming into their region (Eisenson 2023; Green, Copley, and Kellman 2023). NREL researchers have collected information about ordinances in several states and assessed how land-use restrictions, such as setbacks (the required minimum amount of land between a structure and the edge of its property), reduce the available land for solar energy development (Lopez et al. 2023). One community in Mohave County, Arizona, is even pursuing a natural gas power plant while it has a moratorium on renewable energy projects (Meiners 2024). A significant portion (28 percent) of community opposition to renewable projects stems from mistrust of the engagement process itself, specifically the fact that community concerns are only solicited once final plans are already drawn and financed (Susskind et al. 2022). Additionally, opposition has grown within some Tribal governments to utility-scale solar projects sited on public lands that are within the traditional lands of Indigenous nations, threatening to disrupt and destroy their sacred sites and cultural resources (Mulvaney 2017; Grodsky and Hernandez 2020).[6] The potential for these conflicts is aggravated by the lack of planning.

Obstacles to Distributed Energy Resources (DERs): Residential rooftop solar, batteries, demand-responsive devices, smart grids, and virtual power plants could all help alleviate land-use problems by both lowering the demand for electricity and co-locating solar with demand. However, DER deployment still faces significant obstacles to implementation, such as slow interconnection, inspection, and the process of obtaining local electrical and building code permits, which vary by local jurisdiction and utility (O'Shaughnessy et al. 2022). Utilities are often not keen on DERs because they make more money when people use more electricity. This creates misaligned incentives between the utility, customer, and climate. Additionally, there is often not

[5] Furthermore, intergovernmental jurisdictions including zoning or other local regulation may come into conflict with state siting laws, creating complex dynamics between government entities and possibly slowing down projects. In many of these cases, especially on private land, most of the approvals that slow down renewable energy projects are at the state and local level where zoning or land-use ordinances could be used to block proposed development (Lopez et al. 2023). It is possible that some ordinances may facilitate deployment by prescreening sites and identifying and pre-approving mitigations to lessen impacts for development early in the review process.

[6] For instance, the Confederated Tribes of the Colville Reservation and the Confederated Tribes and Bands of the Yakama Nation opposed an Avangrid solar project on Badger Mountain in Washington state that was planned to be sited on the tribes' important cultural lands (Oaster 2024).

effective policy to make the financials work for homeowners—especially for Black and economically disadvantaged households (Brockway, Conde, and Callaway 2021).

Transmission and Interconnection Quarrels

Lack of Transmission Planning and Right of First Refusal: A lack of comprehensive planning slows transmission, especially when lines must cross multiple utility service areas or navigate cross sections of both federal and private lands. Since solar requires certain conditions to optimize operations that may be different from those of load centers, this makes interregional transmission development particularly important. Local utilities are usually eager to build transmission within their service territory, but building interregional lines requires development across multiple service territories and therefore invokes competition between utilities that typically have monopoly power. Some utilities have supported state "right of first refusal" laws so that developers of multistate transmission lines hoping to build into or across some states can be blocked or subjected to special permissions from the state—under the pretense of protecting the state's own energy utilities—slowing down and complicating the process (Gearino 2023; Bozuwa and Mulvaney 2023).

Overloaded Interconnection Queues: Grid operators generally evaluate interconnection requests project by project, assessing and determining the cost of interconnection for each applicant. In response, applicants submit speculative projects because they are unsure of the cost or timeline of interconnection. As a result, developers submit more projects than they intend to build, and thus most applications for interconnection are withdrawn. As some states commit to new power capacity, applications to connect utility-scale renewable energy projects to transmission systems throughout the US have soared—so much so that in 2022, two major grid operators, the regional transmission operator (RTO) Pennsylvania-New Jersey-Maryland (PJM) and California Independent System Operator (CAISO) requested a pause on new applications while they clear the backlog. The Federal Energy Regulatory Commission (FERC) approved a pause in 2023 for PJM that will last through 2026 (FERC 2022; Howland 2023), and a pause for CAISO in April 2024 (Fordney 2024). In fact, there are more renewable energy projects awaiting interconnection studies (around 2 terawatts) than the generation capacity of the entire electricity system in the US today (approximately 1.4 terawatts) (Rand et al. 2024).

Incumbent Utilities, Deregulated Electricity Markets, and Unambitious Renewable Portfolio Targets: Electric utilities too often lobby against the public interest, including against laws and regulations that would result in more renewable energy. Vertically integrated utilities shield their power plants from competition and their transmission systems from interregional markets. Places where electricity grids separate responsibilities for power generation from transmission and distribution—i.e., deregulated as opposed to vertically integrated utilities—also pose a challenge to planning and investment. Electricity transmission and distribution utilities in deregulated arrangements have little control over where generators will be sited, making it more difficult to align power generation with transmission and distribution needs. Furthermore, this arrangement often puts shareholders into conflict with ratepayers and customers, as utilities tend to put new transmission in places where they can find the most profitable projects instead of those that help ratepayers. These deregulated electricity markets result in laissez-faire power contracting that does not result in targeted renewable deployment to shut down fossil generators. Instead, deregulated markets result in site selection based on the most profitable locations for renewables developers to build projects and sell electricity to utilities, which often means they are in rural areas far from other fossil fuel power plants that may be in urban areas. These electricity generators also lobby against policy efforts to increase or implement renewable portfolio standards. Research on renewable portfolio standards shows that utilities are on track to meet their obligations, but those will not be met until 2060 (Kroeger and Burgess 2024). More ambitious renewable portfolio standards will speed up solar energy deployment.

Short Termism and Misaligned Incentives

Profitability: Emphasis on financial return and short-term profitability in industrial investment has hindered renewable build-out for decades. The first attempt to build a domestic solar manufacturing industry crumbled following a shift toward shareholder primacy and stock returns in the 1980s that pushed major energy conglomerates to shed their nascent, less profitable photovoltaic technology divisions (Jerneck 2017). Now that federal funding has finally been allocated via the Inflation Reduction Act (IRA) to build out renewable energy sources, profit motives threaten to delay build-out at the project-siting level. As Christophers (2022) and others have noted, solar and wind projects have low barriers to entry, require high up-front capital investments with very long payback periods, and offer rates of return ranging from 4 to 8 percent—an unattractive proposition for would-be investors who have the option of chasing 15 percent returns in oil and gas projects. With thin profit margins, developers have to do everything within their power to lower costs, which can—paradoxically—put their solar projects in danger of facing issues like community opposition and therefore slow down the project and incur additional costs.

Value Mismatch for Communities: Whereas some communities are eligible for revenue sharing from oil and gas operations located within their boundaries, no such revenue-sharing facilities exist for utility-scale renewable energy facilities. In the absence of that major incentive, communities may often be driven to keep polluting facilities that are detrimental to their health or to seek other kinds of investments (e.g., manufacturing) that are more likely to yield long-term economic development benefits than renewables facilities.

The solutions to this set of obstacles are manifold, but two immediately actionable challenges stand out. First, many of these problems can only be solved by bolstering planning and coordination at the nationwide level and across different levels of government. Second, we need to move toward a renewable deployment paradigm less dominated by the profit motive, which calls for a larger role for the public sector, unburdened by the need to generate financial returns.

Renewable deployment that aligns with local community values cannot be ensured by disparate private actors scattered across the country. It can only be provided through the leadership of a federal government with the mandate to both pursue national goals and ensure accountability to local communities. In the sections that follow, we examine how strengthening planning capabilities can begin to tackle these challenges, with particular focus on solar deployment.

The State of Planning Capabilities for Solar Deployment Today

Planning for solar deployment in the US is taking place in a piecemeal fashion, distributed across agencies within and across multiple levels of government. At the federal level, in the absence of an overarching body charged with articulating and coordinating a government-wide plan for deployment of renewables, planning is left to each agency. Furthermore, much of the solar development planning occurs at the city or county level, often excluding state involvement and with little support from the federal government. Agencies, in turn, conduct planning within the bounds of their statutory authorities, with different levels of ambition. We see a strong need to design a "whole-of-government approach" to bring together the power of multiple agencies and levels of government to achieve a common goal. Below we evaluate the state of planning within some key agencies: the Department of Agriculture (USDA), Environmental Protection Agency (EPA), Bureau of Land Management (BLM), and the national labs. We then also review existing planning proposals put forward by civil society.

The American Farmland Trust expects that up to 83 percent of solar installations will occur on agricultural lands (Beck et al. 2022). The USDA could engage in land-use or site planning to identify agricultural land that could be well-suited for solar development or agrivoltaics (integration of solar on agricultural land). The USDA already has programs to enable farmers to seize solar installation opportunities, including the Rural Energy for America Program, which provides loans and grants for solar in rural communities (USDA n.d.). The federal government could utilize legislation that is periodically reauthorized, like the farm bill, to attach statutes that define and fund agrivoltaic research, prioritize development grants, and coordinate the patchwork of state regulations and policy on agrivoltaics. Some proposed legislation would require USDA grants to prioritize support for projects that promote agrivoltaics or pollinator habitats.[7] Other planning capabilities include the Department of Energy's distributed

[7] S.1555 - Pollinator Power Act of 2023

data collection system to crowdsource data on existing agrivoltaics sites, and an extensive research program at the NREL (InSPIRE n.d.; NREL n.d.).

The EPA has developed a database of potential solar sites through its RE-Powering America's Lands Initiative. The program tracks lands that are former industrial sites, brownfields, Superfund sites, landfills, and abandoned mines that are viable for renewable energy development. The program has seen the development of 494 solar projects with a capacity of 1.826 GW, with 83 percent of projects at almost 1 GW sited on landfills (US EPA 2023). Some states have developed incentives to attract solar developers to contaminated properties. The Illinois Climate and Equitable Jobs Act requires that some portion of the state's renewable energy is sited on previously developed sites. In addition to preventing the destruction of intact wilderness areas and other important locations, siting solar projects on previously disturbed lands allays the desecration of Indigenous preserved sacred sites and landscapes, a goal important to Tribal governments.

When it comes to federal lands, on which the government can take direct action, the BLM and public research centers—such as the Argonne National Laboratory and the National Renewable Energy Laboratory—have engaged in proactive land-use planning. The West-wide Energy Corridors program, initiated by Congress, which designated transmission corridors across western federal lands, is an important example of interagency collaboration and coordination across multiple scales of government.[8] The effort was limited to transmission planning across federal lands all within the Western Electricity Coordinating Council, the organization responsible for bulk power reliability for the western portion of the grid that powers North America from Canada to Mexico, including 13 western states. While still limited by the patchwork of public land, this shows that there is power for agencies to set agendas, conduct deep analysis, and deploy strategy with private actors.

The BLM also leads the Western Solar Plan (also called the Solar Programmatic Environmental Impact Statement), which is the most comprehensive multi-state planning framework to identify lower conflict areas for solar development in the US across 22 million acres of federally managed public lands. The federal solar leasing program has approved over 25 GW of utility-scale solar on public lands since 2010 (US DOI 2024). The plan manages land use by identifying lower-conflict "solar energy zones" or "designated leasing areas" that receive expedited environmental review because they are prescreened for resource impacts. This approach helps keep solar development off the most important conservation lands, while allowing expeditious solar development.[9]

[8] The West-wide energy corridors program was in response to Section 368(a) of the Energy Policy Act of 2005.
[9] This can, however, have unintended consequences such as habitat loss or groundwater depletion when lands are greenfield developments on relatively undisturbed habitat. For more on this, see the example of Chuckwalla Valley, discussed below.

The Western Solar Plan update finalized by the Biden administration in August 2024 expands the solar leasing program to 11 western states and changes how the BLM identifies priority development areas. Changes include a focus on solar development within 10 miles of existing or planned transmission infrastructure, preventative design measures to mitigate impacts, and exclusion criteria to eliminate areas that are too complicated to host solar arrays or are habitat for important species like sage grouse. However, it does not prioritize building on areas prescreened for cultural or natural resource conflicts—despite the success of this model of rapid solar development for public lands in California (see Box 1). Environmental organizations and Tribal governments, as well as coalitions of solar developers, requested BLM address weaknesses in the proposed Western Solar Plan update, including improving inconsistent exclusion criteria; implementing better design criteria and mitigations to offset ecosystem or protected species impacts, such as avoiding desert tortoise habitat; and using “smart from the start” approaches that screen for resource conflict (Sierra Club 2024; Axelrod 2024; Davis 2024; Western Watersheds Project 2024). Unfortunately, these considerations went unheard in the final plan, which will open 31 million acres of public lands to solar development even though the agency admits it only needs 700,000 acres. A better approach is to prescreen for resource conflicts, which allows for greater public participation and engagement and helps officials make decisions with the best information available.

Civil society groups are also developing land-use planning capabilities. The Nature Conservancy's *Site Renewables Right* map (2022), for example, identifies sites in the central US where renewables can be developed while still conserving important wildlife habitats and natural areas. Analysis from The Nature Conservancy shows that land-use change could be reduced by 70 percent through strategies like co-locating wind and solar, employing agrivoltaics, and using solar tracking technology to increase the capacity of panels (The Nature Conservancy 2023). An expansion of the *Site Renewables Right* map to the rest of the country could greatly improve the knowledge base for smart nationwide deployment planning.

In the realm of physical infrastructure, site planning for solar deployment is slowly emerging. State-level transportation departments across the country—from California and Oregon to Massachusetts—are experimenting with the incorporation of solar into roadside rights-of-way and other transportation infrastructure (Hodges and Plovnick 2019). Studies on the potential of co-location are promising: In California, an analysis of three counties identifies enough solar potential to power over 270,000 homes annually (King and Peters 2023). At the federal level, however, the Department of Transportation has not undertaken studies to identify high-potential sites across the country alongside transportation infrastructure. Similarly, the EPA has not undertaken the task of developing a knowledge base of brownfield sites that could be well suited for renewable deployment (see Appendix I for more detail).

In short, the US currently lacks a whole-of-government approach to land-use and site planning for renewables deployment, perhaps in part because no entity currently has the authority—and therefore the mandate—to develop a vision that cuts across the jurisdictional boundaries of the many agencies that manage relevant sectors: public lands, agricultural lands, transportation and other physical infrastructure (rooftops, roads, etc.), and brownfields. In the sections that follow, we will outline principles and policy proposals that can facilitate this kind of comprehensive, democratic planning and accelerate solar deployment.

Box 1. Community and Environmental Accountability in California's Chuckwalla Valley

California has cumulatively installed over 37 GW of utility-scale and rooftop solar as of summer 2024, leading the US in solar deployment. Learning lessons from California's early rapid build-out of solar can be instructive for understanding environmental impacts and how to better garner community support (Parker, Cohen, and Moore 2018). California has aggressively pursued decarbonization policies such as the electrification of transportation, homes, and buildings, coupled with widespread deployment of both utility-scale and rooftop solar electricity. Federal, state, and local agencies have been coordinating land-use planning for solar deployment for almost two decades now. This coordination is crucial for California to reach its climate action goals while also aiming to conserve 30 percent of its land and coastal waters by 2030 (California Natural Resources Agency n.d.). Below, we provide two different examples of planning in California that have had different levels of success.

Land-use planning requires anticipating future land-use patterns and understanding the impacts of different scenarios. California's Desert Renewable Energy Conservation Plan (DRECP) is an example planning framework that has prioritized solar development and land conservation. The DRECP is the California version of the Western Solar Plan, which prescreened California's deserts and identified areas to focus solar development and areas for conservation. This planning effort provided more certainty to the conservation community and to solar developers, by identifying development focus areas and making other areas off limits to development (Duane and McIntyre 2011). The policy's success can be measured by the fact that it has not seen any litigation since implemented in 2016—during which time California has built over 20 GW of utility-scale solar.

Other experiments with planning have been less effective. Deserts are refuges for important flora and fauna—not just dead or empty wasteland—and are important to the global carbon cycle and can help avoid greenhouse gas emissions (Allen et al. 2024). California did not fully consider the ecological and carbon impacts of such deserts in the Riverside East Solar Energy Zone (SEZ) between Desert Center and Blythe, California. Riverside East SEZ "fast-tracked" several projects through environmental review that had significant impacts to wildlife and cultural resources (Agha et al. 2020; Mulvaney 2017). This not only compromised the desert's ecological value but also the pace of development, raising questions about the adequacy of Tribal consultation and efforts to protect cultural resource values (Bathke 2014; Mulvaney 2019). Since the projects have been built, the region has encountered groundwater challenges because of the heavy use of water in construction (Myskow 2023). The Riverside East SEZ could have better avoided impacts to ecosystems, water, and cultural resources with additional up-front evaluation and consultation.

Principles for National Planning of Democratically Rooted Solar Development

In our 2023 report, *A Progressive Take on Permitting Reform: Principles and Policies to Unleash a Faster, More Equitable Green Transition*, we outlined three broad principles to guide policy design for a just transition: (1) design with communities in mind, (2) strengthen environmental protections, and (3) align with Paris Agreement climate action goals. As we focus on the specific case of solar deployment in the United States, we reinforce and expand on these principles to include more detailed guidelines, drawing lessons from relevant historical experiences (see, for example, Malhotra 2024). We do this to guide a whole-of-government approach toward the collective mission of public interest–driven deployment that harmonizes national climate and deployment targets with local and environmental priorities. A progressive, democratic process for fast solar deployment should uphold the following principles:

1. **Invest in Constructive Reparations.**
   The history of land-use planning in the US is riddled with harmful and racist zoning decisions that have deeply impacted the health and well-being of millions. In the United States, Indigenous peoples have been dispossessed of 99 percent of their land over 300 years of colonization (Farrell et al. 2021). We have the opportunity to break with that history by crafting an energy transition that acknowledges and repairs past harms (Bozuwa and Mulvaney 2023; Táíwò 2022). A constructive reparations approach means that investments should disproportionately benefit people who have been subjugated by the current political-economic system.

2. **Distribute Benefits—and Inevitable Harms—Fairly.**
   Democratically rooted solar deployment should limit the harm of new infrastructure as much as possible. A coherent approach to planning requires

facing the tensions and trade-offs between the goal of fast solar deployment and other societal objectives head on. Sometimes it's possible to find creative solutions to siting that resolve tensions and avoid new human and environmental harms such as destruction of biodiversity, ecosystems, leisure spaces, and/or Indigenous cultural resources.

3. **Engage in Democratic Accountability and Meaningful Community Consultation.**
   Solar siting and permitting processes should ensure that communities are engaged in consent-based consultation processes. Community members deserve an opportunity to weigh in at a time when their suggestions and concerns can be incorporated in the final siting decision and design of the project. In particular, the Tribal sovereignty of Indigenous communities should be respected, and they should be given Free Prior and Informed Consent (FPIC).

4. **Make Financial Returns Subordinate to Social and Environmental Returns.**
   Solar development has potential to provide multiple environmental benefits via emission reductions and potential habitat restoration or other ecosystem services (Hernandez et al. 2019). Capturing both benefits requires attention to more marginal sites that may escape a profit-oriented lens. An effective solar build-out relies on reconceiving "return on investment" as including social "returns" (lowered bills, project revenue, cultural benefits) as well as decarbonization and environmental protection "returns."

5. **Find Synergies and Multi-Solving Opportunities.**
   Wherever possible, coordinated solar development should aim to solve complementary challenges to maximize the social and environmental "return" on federal investments and make the most efficient use of low-conflict land. For example, according to a recent study by The Nature Conservancy, the US could limit land-use change by 70 percent through strategies like co-locating wind and solar or employing agrivoltaics—which brings the added benefit of providing shade to agricultural workers (The Nature Conservancy 2023).

6. **Build Sustainably.**
   Sustainability in this context entails building energy infrastructure that embodies an energy *and* material consumption pattern that's consistent with the long-term livability of the planet. Solar development contributes to energy sustainability but doesn't necessarily contribute to material sustainability. Thus, we should prioritize building with materials, products, and system designs that minimize full life-cycle climate and environmental impacts and their consequences for human well-being (Estevez and Schollmeyer 2023).

Recommendations for Policy and Planning

Begin Whole-of-Government, Nationwide Land-Use and Site Planning: Systematically Identify High-Benefit, Low-Harm Sites to Accelerate Deployment

The current scattering of deployment planning capabilities across agencies and levels of government means that no entity has a clear mandate to answer two questions central to a coherent planning process: (1) How much surface area do we need across the country to meet renewable, and specifically solar, targets? And (2) how can we meet that demand by systematically identifying appropriate sites (from public lands to rooftops) and driving resources to deployment on such sites?

Since the answers to those questions cut across jurisdictions, it is not clear where this mandate should sit. The US has no national planning authority or council. Entities that have government-wide authority, like the White House's Domestic Climate Office, the National Economic Council, or the Office of Science and Technology Policy have limited staff, but could potentially resource and coordinate across agencies and national laboratories to build the knowledge base for whole-of-government planning by answering the above questions. Funding sufficient staff at an entity within the White House to coordinate deployment across agencies would be a straightforward first step toward whole-of-government planning.

No matter where a planning authority sits, the task for the national government remains the same: coordinating agencies and between federal, state, Tribal, and local governments to ensure that planning for solar deployment is holistic, coherent, and guided by a clear public-interest mandate that keeps private interests in check.

As we describe in detail in Appendix I, one of the first steps in that process is developing a systematic nationwide mapping of **high-benefit, low-harm[10] sites** for solar deployment. The federal government is particularly well-suited for identifying high-benefit, low-harm sites, because it is an entity committed to public benefit above financial returns. Siting renewables on certain brownfields or degraded land might not be the cheapest option, but we argue that there is a public interest in siting solar in these places and limiting expansion onto greenfield or ecologically important lands.

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[10] Harms that communities often identify as concerns in solar deployment include the following:

1. **Ecological loss:** Loss of biodiversity, habitat fragmentation, and ecosystem degradation (e.g., by cutting down forests to build solar [Manion et al. 2023]).
2. **Cultural loss:** Destruction of leisure and recreational spaces and access to cultural resources (Grodsky and Hernandez 2020).
3. **Economic loss:** Negative impacts on tourism revenues arising from loss of natural spaces and opportunity costs of allocating land to solar capacity compared to more economically advantageous land-use opportunities.

This could also limit community controversy over siting, making such an approach not just desirable as a matter of principle but also essential for accelerating the energy transition.

To illustrate what a democratically rooted approach to solar planning could look like, we have outlined and begun to operationalize a methodology that breaks down the planning process step by step (see Appendix I for more detail on the methodology and for underlying assumptions):

1. **Estimate the size of the national solar infrastructure gap**. We use the estimates provided by the National Renewable Energy Laboratory, Department of Energy, and Princeton University, which suggest that reaching 100 percent clean electricity by 2050 would require 3.5 million to 15 millions acres of land (see Figure 1).

2. **Identify sites for DERs and non-wires alternatives.** In accordance with the "do no additional harm" principle, non-wires alternatives—investments like energy efficiency or DERs that limit the need for new transmission buildout—are the first order in the hierarchy of deployment because they can reduce the overall system power demands, delivery needs, and system costs. Some electricity grid investments and projects use nontraditional transmission and distribution devices, including DERs, energy storage, demand response, energy efficiency, microgrids, or software controls. Use of non-wires alternatives can delay or completely defer the need to expand transmission, distribution, substations, and utility-scale solar by integrating local solar and storage solutions (García-Santacruz, Marano-Marcolini, and Martínez-Ramos 2024). Rooftop solar and storage potential alone would fit nearly one-third of the total space required for solar (see Appendix I). For context, California currently gets half of its solar power from rooftop solar. DERs could yield significant potential co-benefits for energy-burdened families by reducing the cost of electricity directly or through grid operating cost savings; one study found grid system operating cost savings of 40 percent from expanded pursuit of DERs (Laws, Webber, and Chen 2024).

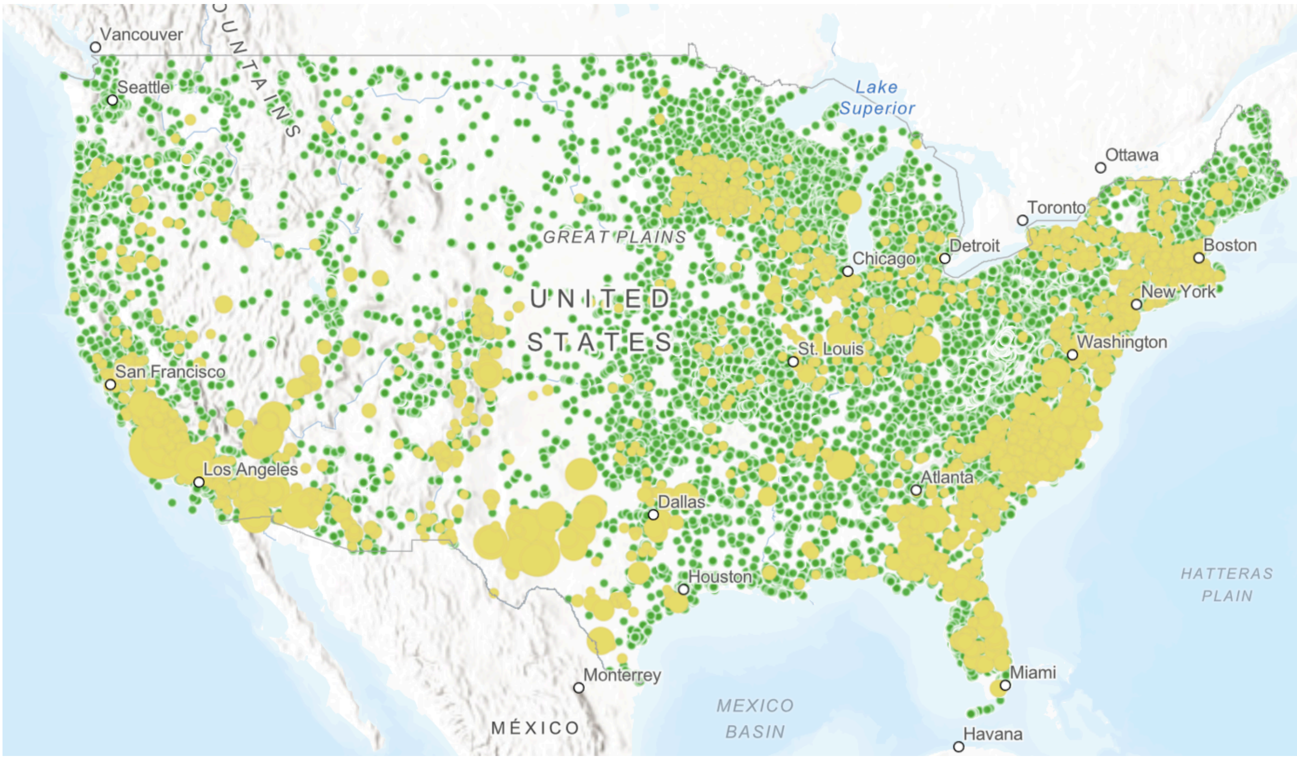
3. **Identify other no-harm/low-harm sites**. To fill the rest of the solar capacity gap—and continuing to follow the "do no additional harm" principle—we propose identifying additional no-harm/low-harm sites. The appendix (Table 1) includes a list of sites that are likely to meet the low-/no-harm criteria and an estimate of their corresponding surface area. Our analysis suggests that there is a major surplus of acreage with solar potential that could meet the no-/low-harm criterion: 226 million acres are available. Building solar capacity *exclusively* on existing solar-appropriate infrastructure (rooftops, roads, railways, and canals) would be more than sufficient to meet solar deployment targets: There are 19 million acres of solar potential on existing infrastructure (Wu et al. 2019; Hernandez et al. 2019; Hoffacker, Allen, and Hernandez 2017). There is significant

additional acreage in brownfields, Superfund and other degraded lands, as well as abandoned, marginal, and salt-contaminated agricultural lands that could be used for solar deployment.

4. **Identify high-benefit and low-harm sites**. After applying the low-/no-harm filter, following the primacy of the "do no additional harm" principle, we next propose identifying sites that are likely to also provide high co-benefits, such as the opportunity to repair environmental injustice in historically harmed communities (constructive reparations) and the potential to increase energy resilience for isolated rural communities.

5. **Select sites as candidates for categorical exemptions and other solar deployment fast-tracks**. There are many ways to use the above methodology and data to expedite and improve the quality of solar deployment. For example, ensuring transparent and centralized access to visualized data displaying high-benefit, low-harm sites for every neighborhood, region, and landscape across the country would allow communities, governments, and solar developers to more quickly identify opportunities for solar deployment. We have begun to illustrate how this could look in **this interactive map tool** (see Map 1). Another way to use the above data to expedite solar deployment is to inform a framework for categorical exclusions from NEPA review. Site types that qualify for the high-benefit, low-harm category could be automatically granted a categorical exclusion from NEPA. A rule adopted by the DOE in 2023 already grants categorical exclusions to solar built on degraded land (Dabbs 2023). Similarly, expedited permitting and priority access to public funds could be offered to a special class of high-benefit, low-harm site types.

6. **Conduct community-based verification.** The estimates and analysis in our methodology are, of course, only preliminary, as would be any high-benefit, low-harm designations. The federal government can support democratically rooted planning efforts at different levels of government by producing more refined data and resourcing state, Tribal, and local actors to verify whether the types of sites identified above are in fact high-benefit, low-harm sites in their particular contexts. State, Tribal, and local governments can also produce this kind of data and engage stakeholders directly in the verification process. Community members and organizations can also use this data and **interactive map tool** (see Map 1) to demand action from policymakers and to take action themselves as economic agents. In the next sections, we will outline mechanisms to participate in this sort of community-based engagement.



Map 1. [**Map of Indicators for Equitable Solar Deployment**]. *The map shown displays existing large-scale photovoltaic installations (yellow circles) and existing brownfield sites that are suitable for solar development (green dots). The full, interactive online version includes additional indicators related to solar deployment such as transmission lines, areas carrying an existing pollution burden, Tribal lands, and critical habitat for endangered species.*

An important takeaway from this preliminary analysis is that taking a systematic, nationwide, whole-of-government approach to analyzing the problem of deploying solar and other renewables can yield insights that improve the quality of deployment: its speed as well as its ability to generate high "returns on investment" that appropriately prioritize public benefit. Our analysis also suggests that concerns about land-use conflicts slowing deployment could become a nonissue if site and land-use planning is coherently implemented to target high-benefit, low-harm sites. Operationalizing this kind of planning, however, requires complementary policy interventions.

Case Studies

In the following section, we show how layering the interactive map data with sociopolitical dynamics can help evaluate how solar can be deployed in a range of contexts. The case studies below show the need for both top-down and bottom-up planning to achieve the highest-value solar build-out across the country. Case Study 1 looks at agrivoltaics in the Salinas Valley in California, and Case Study 2 looks at replacing peaker plants with DERs in New York City.

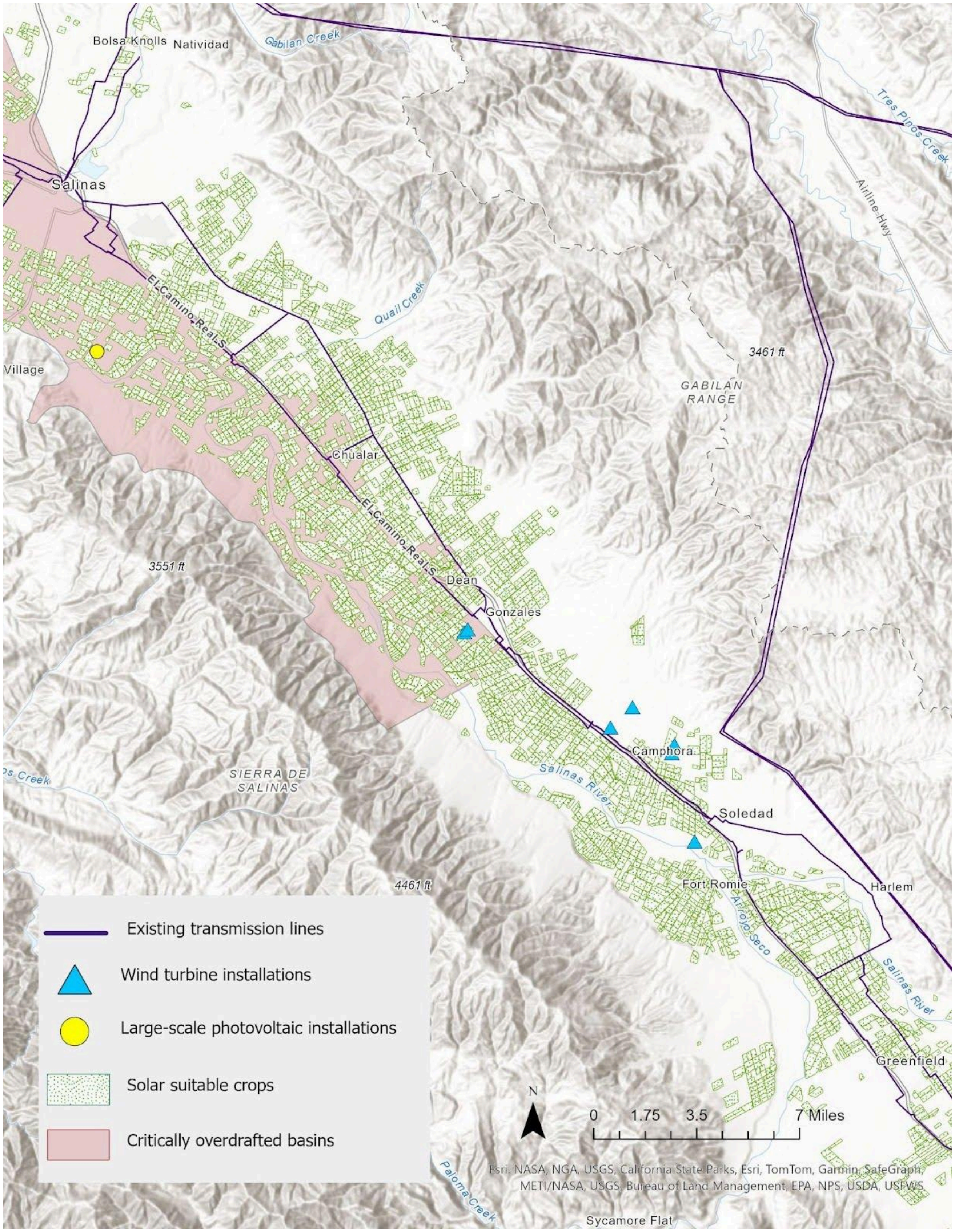
CASE STUDY 1:
Restoring Groundwater with Agrivoltaics in the Salinas Valley

This case looks at how agrivoltaics could be deployed at a regional scale and the planning considerations that are key to identifying suitable areas for them. Agrivoltaics are photovoltaic installations that integrate agriculture, livestock, or apiaries and photovoltaic power systems. Variations of the concept include range voltaics using mostly sheep or sometimes other grazing animals, integrating apiaries for honeybees, or restoring lands around and under solar farms with native pollinators. The purposes of these installations range from simply using animals to manage weeds and grass to extensively developing agricultural operations. Research on agrivoltaics finds that the shading aspects offer multiple synergies for food-energy-water systems (Barron-Gafford et al. 2019). Some crops are more suitable than others for agrivoltaics. For example, crops like grains that require large farm equipment like harvesters are less suitable than crops that are harvested by hand. The partial shade from agrivoltaics can potentially diminish productivity for crops that require direct sun, so these installations are typically best suited for leafy greens and other non-fruiting crops. Crops grown in the scattered shade of agrivoltaics could also offer respite from the heat and sun for farmworkers and improve working conditions. The microclimate created by respiring plants act to cool photovoltaics as well as helping them operate more efficiently. Given the extensive land-use pressures from solar development, it is possible that agrivoltaics could be more widely accepted by rural communities, especially as they would conform to rules and regulations intended to keep land in agricultural production.

The Salinas Valley, known today as the lettuce bowl of the world, is one of the world's most productive agricultural areas. The valley is in Monterey County, which ranks as the third- or fourth-largest agricultural county in the United States, as measured by farm revenue. John Steinbeck wrote about the extensive presence of industrial agriculture in the valley during the Great Depression, and today it remains largely rural with a significant farmworker population. The productivity of these lands means that growers can make many times more revenue growing crops (even with all the associated costs) instead of developing and selling solar energy. In this part of California, which still relies to a significant degree on natural gas, bringing power closer to the state's coastal cities is a decarbonization imperative. Agrivoltaics may be one way to bring more solar energy to agricultural areas like the Salinas Valley, where farmland is valuable, protected, or potentially nearing compulsory retirement to comply with the state's new groundwater regulation. Some countries like France and Italy have gone so far as to ban solar on prime farmland, unless it is an agrivoltaic project that maintains agricultural production. NREL estimates that there are 10 GW of agrivoltaics installed in the US.

One hundred and fifty years of intensive agriculture in the Salinas Valley has left a toll on the valley's groundwater. The overpumping of groundwater for agriculture along with two upstream dams that have reduced aquifer recharge are causing saltwater intrusion and decreased groundwater supplies. In 2014, California passed the Sustainable Groundwater Management Act, requiring local governments in overdrafted water basins to plan to bring groundwater use into balance. The Salinas Valley will need to significantly reduce groundwater use. Research by The Nature Conservancy has looked at how agrivoltaics could be deployed in areas with agricultural production to reduce groundwater use. The particular case they looked at involved the retirement of groundwater rights, but there are other applications. In California, the first regulation of groundwater started in the past decade through the Sustainable Groundwater Management Act. The combination of less agricultural water use and increased water use efficiency from shading in agrivoltaic systems can result in significant water savings.

Where transmission access might be difficult, agrivoltaic systems can be integrated into power delivery systems for powering the many food processing facilities and irrigation pumps in the valley. The Salinas Valley still depends on diesel fuel pumps for irrigation, and solarizing water pumps could help avoid particulate matter and ozone pollution. One advantage of the valley's location is that it is close to developed transmission along the highway 101 corridor, which runs all the way through San José into the rest of the San Francisco Bay Area. A new state law in California incentivizes transmission and solar along highways, and there are incentives to build these infrastructures in the Inflation Reduction Act. Finally, the Salinas River terminates not far from Moss Landing, the site of a combined cycle natural gas power plant and the largest collection of batteries in the US connected to the Central Valley via a separate transmission corridor. Strategic development of agrivoltaics could help retire fossil-fueled power plants, restore groundwater levels, charge grid-scale batteries, clean the air, and lower the carbon footprint of agrifood systems.



Map 2. Potential for Agrivoltaic Deployment in California's Salinas Valley

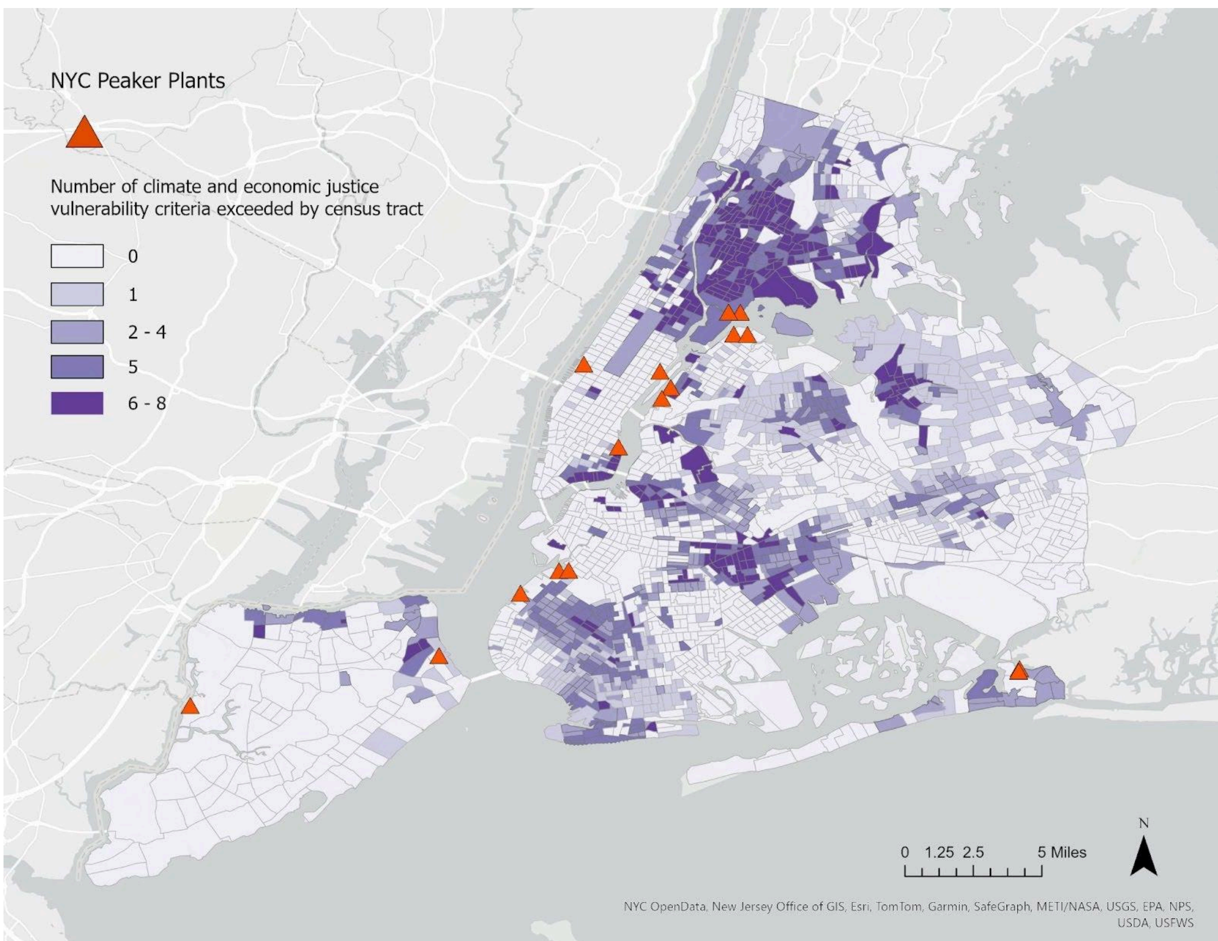
CASE STUDY 2:
Leveraging Distributed Solar to Offset Peaker Plants

New York City has 17 active peaker plants—old oil and gas plants that come online at peak times of the year, such as when New Yorkers are cranking their air conditioning units or heating their homes during a cold snap. While these power plants are only used a few times a year, they have to be maintained. Because of their age, peaker plants are some of the most polluting and harmful forms of energy in a region. Old, inefficient, and sometimes using particularly dirty fuel, peaker plants can emit 2 times as much carbon dioxide and 20 times as much nitrogen dioxide as newer plants (Knoblauch 2023). The neighborhoods of Hunts Point and Mott Haven in the South Bronx are in close proximity to not only highways but also to these peaker plants, increasing the risk of asthma from air pollution for those living nearby. These neighborhoods are among the lowest-income areas of the city and have the highest rates of childhood asthma (Gonzalez, Lankar, and Hangun-Balkir 2021). Map 3 shows peaker plants in close proximity to neighborhoods with high climate and environmental justice vulnerability indicators.

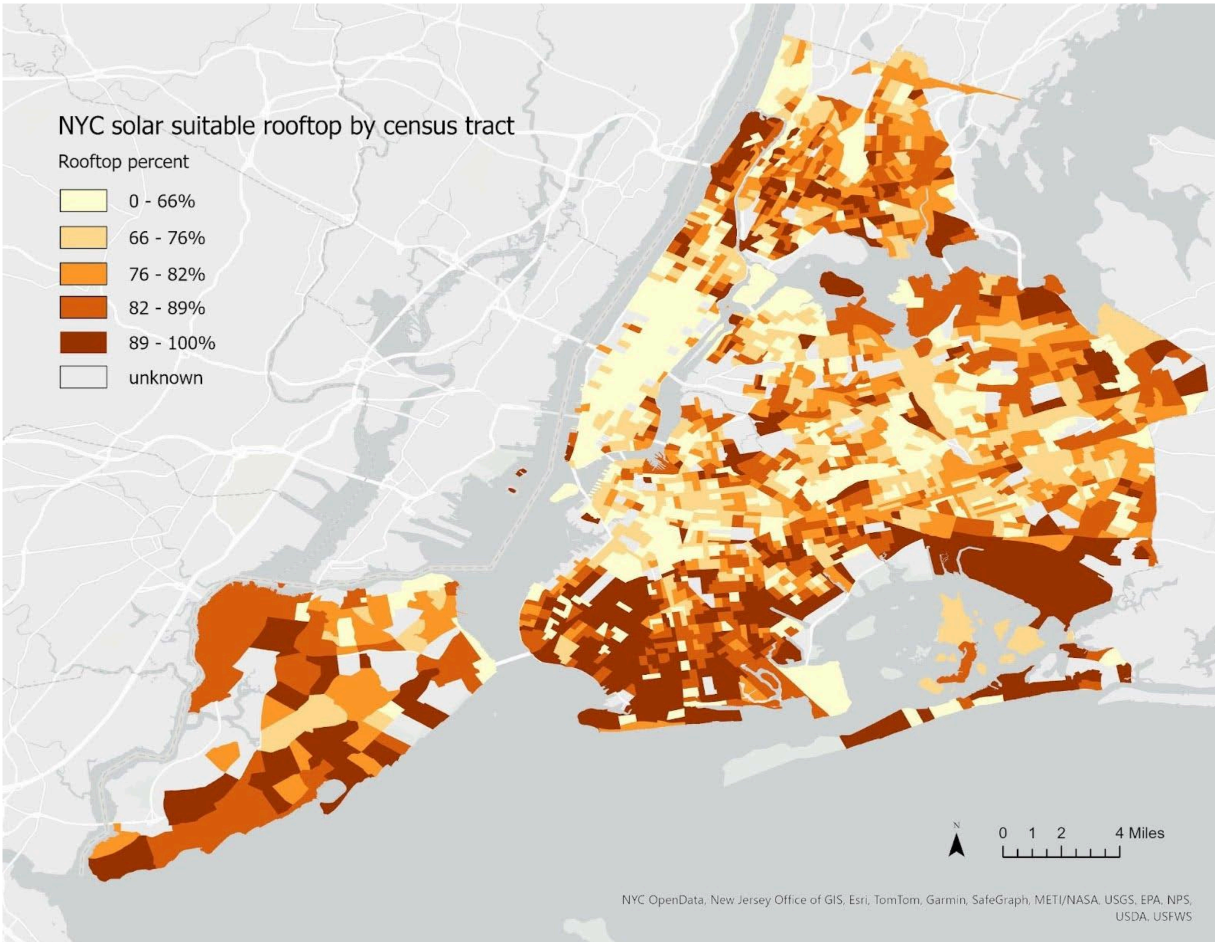
Community groups and environmental justice organizers have banded together to fight any additional fossil fuel plant expansion in the area, as well as to advocate for an official wind-down of peaker plants. Through these groups' pressure, New York now has plans to shut down its peaker plants, but increasing energy needs have meant that the New York Independent Service Operator (NYISO), the state's wholesale market manager, is requiring the peaker plants to stay online past their promised end date to maintain reliability (Kinniburgh 2023). The main environmental justice coalition involved in advocacy around the plants, the PEAK coalition, has called for the state, utilities, and NYISO to rapidly deploy renewables, transmission, and demand response technologies instead of extending peaker plant lives. The utility has pushed back, saying that it can't deploy transmission fast enough to achieve those goals (Walton 2023).

While deploying underground transmission infrastructure may be a big lift in a short time frame for the utility, there is significant untapped distributed renewable potential. Map 4 shows the rooftop solar suitability in the city, indicating a substantial amount of potential distributed solar capacity that could be deployed and interconnected (in conjunction with demand response and localized battery storage) to both create more resilience in the face of extreme weather as well as fill the need for more energy capacity that could displace peaker plants on a quicker timeline, if incentivized. Rooftop solar does not require high-voltage transmission infrastructure, though it may require some upgrades to the transmission and distribution grid to allow new levels of energy to course through the lines (Dutzik, Ham, and Neumann 2024). The maps provided here provide visual context for strategies to decarbonize quickly in ways that could increase equity.

Advancing a distributed solar strategy to eliminate peaker plants will require city and state coordination. In particular, increasing the equity of the project requires evaluating the up-front cost of rooftop solar. Often, rooftop solar is prohibitive to renters and low-income homeowners because it requires high credit and up-front investment, even if it can lower energy costs in the long run (Heeter et al. 2021). Furthermore, rooftop solar is often an opt-in strategy with some incentives to increase uptake, not a coordinated strategy that can scale quickly enough to displace peaker plants. This demonstrates the need for democratically rooted planning—if the city and state coordinate with an array of stakeholders to come up with a plan to deploy the necessary amount of solar, it could achieve the goals of displacing peaker plants, lowering costs for consumers, and ensuring that low-income households reap the benefits. New York City has already set up a range of incentives for rooftop solar that can be built upon. In particular, the city is rolling out a new public rooftop solar program that could be instrumental as both a financing program and as a program to coordinate deployment equitably and quickly, if empowered to do so (Foster and Lander 2023). The city has also mandated solar on its roof systems, which could help accelerate updates to large-scale buildings (Amarnath 2024).



Map 3. New York City Peaker Plants and Neighborhood Vulnerability. *This map indicates the location of peaker plants in New York City in relation to the number of exceeded climate and economic justice vulnerability thresholds by each census tract.*



Map 4. New York City Peaker Plants and Solar-Suitable Rooftops. *This map indicates the location of peaker plants in New York City in relation to the concentration of rooftops per census tract that are suitable for distributed solar.*

Enhance Coordination Between Federal, State, Tribal, and Local Governments

In the US, public control over land use is given to individual states by the 10th Amendment. This means that states, often delegating to local governments, have zoning power and are able to regulate private activities on land in their jurisdiction. But the federal government can play a critical role in building coherence between "top-down" and "bottom-up" priorities. This sort of coordination work is critical to avoid the many pitfalls of multi-scalar planning processes such as technical knowledge gaps, competing interests, and difficulty adhering to complicated regulatory regimes. The challenges of coordinating organizations and governments that operate at different scales and may have competing priorities manifest in several ways that can be addressed to ensure solar projects do not face obstacles or delays. To ensure national planning coheres with local priorities, the federal government could help expedite permitting and approval burdens on already overextended local, state, and federal government staff. Key areas where enhanced coordination across multiple levels of government would help accelerate solar energy deployment include the following:

Coordinate transmission and proactive land-use planning. In the spring of 2024, Texas surpassed California as the leader in installed capacity of utility-scale solar. Much of the state's rapid development was enabled by a process initiated in 2005 that led to the creation of Competitive Renewable Energy Zones (CREZ). The idea was to build out transmission to connect population centers in Texas to the renewable energy resources in the western part of the state. The state Public Utilities Commission created these zones proactively, as opposed to reactively, as much transmission planning is done. Not only did it help Texas connect over 20 GW of wind power, but the CREZ process also had the unexpected outcome of facilitating the most rapid utility-scale solar deployment in US history. This Texas case is often held up as a model that FERC could implement across other RTOs/ISOs, by requiring forward-looking proactive planning, acknowledging the benefits of transmission, and developing rules for how to pay for it. FERC Order 1920 begins to enhance some of these collaborative efforts to build interregional transmission (Lawton 2024). In 2024, DOE finalized a new rule that is supposed to cut the permitting timelines for transmission in half (Lawton 2024). Early Tribal consultation, stakeholder outreach, and environmental screening for low-impact routes can help ensure transmission gets built with support of Tribal, community, and environmental groups.

Create consistent protocols for renewable energy interconnection to transmission and distribution systems. The rules and standards that govern how projects are connected to the electricity grid have led to a severe backlog of renewable energy and storage projects (Rand et al. 2024). These delays are compounded by developers seeking multiple applications and speculation on the value of multiple interconnection sites. FERC Order 2023 made some changes to help clear the backlog by requiring shorter review timelines and imposing penalties (Walton 2024). However, FERC and the RTO/ISOs it oversees should take further action to systematize interconnection and incentivize a more coordinated plan for utility-scale solar interconnection. This can be done by mandating more interregional planning and development between states, as well as Tribal governments, so that transmission needs for clean energy development are far clearer; sorting out the mired cost allocation problem by distributing the cost of transmission build-out across developers; and aggressively enhancing transparency of interconnection queues to stop the speculative nature of solar project interconnection applications. The DOE has already put forward a robust interconnection roadmap that integrates many of these concerns and should be followed up with actionable FERC orders (Gorman et al. 2024).

Create comprehensive DER incentives at all scales of government. DERs face other challenges, including long wait times for building permits from local governments, or with slow interconnection and inspection processes with electric utilities, as well as the erosion of policies that incentivize DERs (McAllister 2019). They are also inadequately valued by utilities, which offer low prices to rooftop customers that want to sell power to the grid. What is needed is a more accurate valuation of the many benefits DERs provide, including local power, grid resiliency, and avoided costs of infrastructures and equipment. For example, the state of Minnesota initiated a "value of solar" tariff proceeding at their utilities commission to estimate the fair price that rooftop customers should be compensated at. There are also investments needed in local distribution networks. Some states have conducted hosting capacity analyses so that they can expedite interconnection and inform distribution system planning (McAllister 2019). In the hopes of reducing the installed cost of rooftop solar, California requires new home and building construction to be equipped with photovoltaics (California Energy Commission n.d.). A combination of solar-powered net-zero homes and buildings requirements, fair compensation and strong incentives for low-income residents, and increased investments in the distribution grid could help counteract the restrictive impact of utility policies that undermine the value of distributed solar. Where rooftop solar is not available to homeowners or tenants, creating opportunities for these ratepayers to buy into community solar could offer alternatives (O'Shaughnessy et al. 2024).

Support capacity-building for local and state zoning regulations. While numerous local and state governments have developed policies to encourage solar development, others have passed restrictions and ordinances that could have the effect of blocking solar projects (Eisenson 2023; Lopez et al. 2023). Where development pressures are significant, local and state regulators can be overwhelmed by the number of applications to consider. In some cases, there has been tension between state and local level zoning, with some states developing preemption laws to bypass local government regulations stopping renewables, including Florida, California, and Michigan (Cart 2022; Mauger 2023). The federal government should support state and local capacity building for solar development planning because solar does not often fit neatly into existing land-use classifications and may require rezoning to obtain approvals (US DOE 2023). Agencies can work with state and local zoning and permitting authorities to develop frameworks for understanding how to manage new project development in their regions, as well as provide capacity building for community input processes that limit the potential for political capture. Building capacity for deliberative and fair decision-making is one way to get more local acceptance of renewable energy projects (Wolsink 2024). Capacity for county and regional planning efforts like programmatic environmental reviews (which would include Tribal considerations), general or specific plan updates, and providing resources for stakeholder participation can help communities prepare for and get the most benefits from solar deployment.

Build Tribal capacity for engagement. With more than 5 percent of US solar power potential on Tribal lands, meaningful nation-to-nation engagements could help Indigenous communities develop jobs and clean energy (Beshilas et al. 2022). Research by NREL has shown several key barriers to Tribal nations seeking solar deployment in their communities, including a lack of Tribal representation in regulatory and utility decision-making processes, a lack of Tribal technical capacity, a lack of net metering policies and unclear interconnection rules, being served by multiple utilities, and inability to take advantage of tax equity policies (Beshilas et al. 2022). Capacity for Tribal governments and communities to engage with projects on public lands within the traditional lands of affected Indigenous nations is particularly lacking, not just in terms of meaningful consultation but also in authority to limit or prohibit development around sites deemed sacred or important and in need of preservation. Support for meaningful engagement and research for Tribes could be usefully integrated into programmatic planning processes to identify areas of agreement to support solar development and cultural preservation. The federal government could also offer public lands back to Tribes to manage or comanage the solar leasing program, which would empower Tribes in the prioritization of where and when to protect sites or develop for solar.

Harmonize and improve data used to inform land-use decisions. Successful planning and deployment will require coordinated data collection, transparency, and data sharing, as well as a well-maintained, centralized repository of planning tools and other data management infrastructure (from shared spatial data to legal and community organizing information). The federal government currently maintains a spatial database of existing renewable projects as part of its Energy Atlas, which documents the presence and capacity of solar projects. Accelerating equitable solar deployment however, will require consistent availability of much more detailed data on suitability and community factors. With the inclusion of more data at the local scale, NREL's SLOPE (State and Local Planning for Energy) has the potential to serve as a comprehensive planning tool, but would be most effective if further harmonized with other DOE efforts as well as data sources maintained by counties and local governments. Currently, the most detailed data for solar planning is either paywalled or operating on proprietary platforms; thus, developing and consolidating open-access data on social, economic, and land-based factors for solar deployment is an urgent imperative that will require public investment.

Embed Planned Community, Worker, and Environmental Benefit

There are tensions between building solar fast and building solar equitably with robust community engagement. Some advocates for permitting reform argue that, because the climate emergency is so dire, measures need to be taken to eliminate regulatory barriers—even including some of the very environmental protections that have been instrumental tools for advocates in limiting the impact of industries on communities and ecologies (Mintzes 2023; Pleune 2022). While permitting delays are a threat to timely solar deployment, piecemeal permitting mandates are not an adequate substitute for comprehensive land-use policy and should not be an excuse for steamrolling communities. The process of moving solar projects forward without robust community engagement, consent, and benefit could reinforce narratives that vilify the green transition within regions and ossify resistance to solar projects (Susskind et al. 2022). Indeed, the push for solar without consultation continues to feed right-wing campaigns and reactive responses to solar development that have bubbled up across the US to immobilize proposed projects (Eisenson 2023).

Conducting whole-of-government national planning in combination with implementing consent-based frameworks can blend top-down and bottom-up processes, feeding into decision-making processes that create buy-in for solar early (Stober et al. 2021). By integrating consent into project planning early, projects can be effectively aborted or redirected quickly instead of through long, drawn-out litigation fights or other forms of resistance.

This is why national and regional planning become important: When projects are deployed on a project-by-project basis without analysis of why a project or piece of infrastructure is best suited for that area, communities can feel frustration about why the project is in their backyard instead of somewhere else. It also means that failed projects have to go back to the drawing board without an assessment of alternative placement at a more coordinated level. Integrating localized project benefits in conversation with local actors can also increase the potential for project consent. Utilizing several of these strategies increases the likelihood of projects moving forward and ensuring that they provide local benefit and address historic harms:

Free, Prior, and Informed Consent. The UN Declaration on the Rights of Indigenous Peoples (UNDRIP), to which the United States is a signatory, requires member nations to consult and cooperate with Indigenous Peoples on legislation, administration, or projects that may affect them under the principle of Free, Prior, and Informed Consent (FPIC). This means that for "any project affecting their lands or territories and other resources, particularly in connection with the development, utilization or exploitation of mineral, water or other resources" (United Nations Declaration on the Rights of Indigenous Peoples 2007), states should seek free (not under threat or coercion), prior (early) and informed (including with adequate information in local languages) consent before approving projects. Considering the history of settler colonialism in the US and the impact of historic and current infrastructure, embedding FPIC into solar development is an important step to begin to reconcile the US relationship to Indigenous lands and advancing a reparative approach to energy transition. Tribes are not merely stakeholders but rather sovereign nations. Formal nation-to-nation consultation on impacts from solar projects slated for development on public lands happens through Section 106 of the National Historic Preservation Act, and other federal and state laws intended to protect cultural resources. Impacts of consideration extends to resources that Indigenous communities might deem culturally or spiritually significant. This is especially vital in solar projects planned for development on public lands that are outside the reservation jurisdiction of a Tribal government but still within their traditional lands.

If a solar project is slated to be built within a reservation, then the Tribal government should have either shared its consent or have the authority to deny such a project. However, Tribes don't currently have such influence on projects proposed for public lands. As part of Section 106 consultation, Tribes can nominate traditional cultural properties to offer them greater protections from development. However, many observers to this process note that development is usually a foregone conclusion, and that federal government consultation is failing Tribal governments and their spiritual landscapes (Bathke 2014). In January 2021, President Biden signed a memorandum to enhance "regular, meaningful, and robust" consultation with Tribal Nations (White House 2021b). As part of that consultation, Tribes noted that other executive orders such as "streamlining national environmental policy act reviews" were unhelpful in achieving these objectives, stating that most federal policy around consultation falls short of international standards, including FPIC (US DOI 2021), and that ultimately, Tribal consultation as it currently exists can do little to prevent solar projects from being approved once they are already in the approval process. Embedding FPIC and the Right to Say No into solar development and planning is a baseline (and ongoing) component to equitable and democratically rooted deployment.

There is also a significant education burden placed on community members, which leaves the door open for powerful interest groups to spread incomplete information or misinformation on projects. A Tribe, for example, may have to review multiple major infrastructure projects in their ancestral territories at the same time but might lack the staff or expertise to do so meaningfully. Public agencies should take an active role in providing the public with educational materials and planning guidance to support the democratic engagement process, as well as provide mechanisms of accountability throughout the process. First Peoples' Worldwide created an FPIC due diligence questionnaire for investors that is a useful guide to considering how FPIC processes could be implemented more systematically in nationally coordinated solar development. The US Interagency Working Group on Mining Laws, Regulations, and Permitting, tasked with identifying legislative and regulatory recommendations to increase timeliness of development of critical minerals, also has specific recommendations for how to incorporate FPIC into project planning and resource review processes (US DOI 2023).

Community-first planning. National, whole-of-government planning should be coordinated with more bottom-up, community-based planning that directly addresses systematic and institutional injustices. While Indigenous communities in the US deserve to be able to give explicit consent, as put forward in UNDRIP and considering the nuances of Tribal sovereignty and historic genocide, other communities have also experienced historic disenfranchisement. Histories of racist or classist planning by either companies or government have disproportionately placed polluting infrastructure like coal-fired power plants or refineries in Black or low-income communities of color (Bullard 1998).

Providing opportunities for communities to play a central role in planning for solar deployment within their local context can build a sense of ownership and buy-in for solar projects. Community members at the local and regional levels could provide vital local information that adds additional context to development strategies that may not be as clear at the zoomed-out national level. For instance, they may be able to provide insights into weather patterns, sites of cultural importance or norms, pollution centers, and local power dynamics. Some planners or developers may be hesitant to engage in community-based planning because of fear of losing control, but limiting community engagement in planning could create a feeling of "us-versus-them" that could breed community anger or, at worst, protest (Al-Kodmany 2001). In comparison, involving communities in the process can shift perspectives and emphasize comanagement and agency in the process of solar development (Pearce et al. 2016). Communities often have particular conceptions of place and space, and being able to navigate the dynamics of a changing landscape with solar deployment—particularly utility-scale solar—can therefore be challenging (O'Neil 2021).

At the same time, the concept of community should not be fetishized. A community is not homogenous. Communities have embedded structural inequities and contain certain vested interests (Nilson and Stedman 2023; Spangler et al. 2024; Lane and McDonald 2004). If a planning process considers communities without distinction, it can entrench elites, platform astroturf groups, and facilitate unjust outcomes. Instead of smoothing over differences in community-based planning, planning officials must be prepared to undo structural asymmetries of knowledge and power in processes in order to maximize benefits. This may mean providing support to underserved community voices. Some state public utility or service commissions provide intervenor funding to support local community groups in engaging in the regulatory process. Similar funding could be provided at multiple scales of solar planning—from local to federal. Another important intervention would be to equip planners at multiple scales with training and staff capacity on community-based planning so that they have the tools to navigate the complex socio-technical dynamics of solar deployment.

Community Benefits Agreements. Community Benefits Agreements (CBAs) are legally binding agreements between a developer and a community detailing commitments that may include direct payments, local hiring requirements, neighborhood services, revenue-sharing or ownership stakes, and decommissioning, among other things (Trandafir et al. 2023). In a CBA's ideal form, it offers a "win-win approach to development" that increases public support and offers meaningful benefits (Partnership for Working Families 2016). In its worst form, the developer factionalizes the community to manufacture project consent with little to no real community or economic benefits by picking off a small or unrepresentative group as CBA signatories in an exclusive process, or offers only voluntary commitments. As Powerswitch Action details, there are four principles of effective CBAs: (1) community interests are well represented; (2) the process is transparent, inclusive, and accessible; (3) the process provides concrete, meaningful benefits; and (4) the process has clearly defined enforcement mechanisms (Partnership for Working Families 2016).

The government could play a substantive role in CBA development. In most instances, the ultimate signatories of a CBA are a developer and a coalition of community groups across multiple levels of government engagement (Been 2010). But there is an inherent power mismatch in CBAs—it is a negotiation between developers with resources and a suite of lawyers versus, quite often, marginalized communities that often do not have the time, capacity, or expertise for meaningful negotiation. The government—be it federal, state, Tribal, or local—can be an important stakeholder that can shift this power imbalance. It can condition CBAs for permits or funding, provide resources for communities in negotiations, and create systems of enforceability. California's opt-in program to expedite solar projects within 270 days and New York State's Accelerated Renewable Energy Growth and Community Benefit Act are two examples of state programs that have made CBAs core to policy for expedited development for solar energy.

Project labor agreements, sectoral bargaining, and equitable work opportunities. Project Labor Agreements (PLAs) have been used for generations to negotiate employment conditions for both union and nonunion workers on a construction project (AFL-CIO n.d.). They are generally pre-hire agreements that provide a secure and trained workforce for the developer, and job stability, strong wages and benefits, onramps for local labor, and minority-based hiring for workers. PLAs have been commonplace in the fossil fuel industry for decades and are a major source of security for union workers who have seen years of union erosion (Nieves 2023). In comparison, utility-scale solar construction has largely consisted of nonunion, low-paying, often temporary jobs with workers traveling long distances to get to sites (Harris 2022; Luke 2023). Labor and pay equity issues will be critically important to address as the solar industry attempts to attract more diversity in the workplace (IREC 2022).

The DOE Solar Energy Technologies Office estimates that the solar workforce will need to grow as much as sixfold by 2035 to match solar deployment goals (US DOE n.d.c.). The IRA and the Infrastructure Investment and Jobs Act (IIJA) both include sweeteners for clean energy projects that pay prevailing wages and meet certain apprenticeship requirements, a major step forward in workforce development and "high-road" solar job stability. Prospects for job growth have also opened up additional space for sectoral bargaining in the solar industry—the International Brotherhood of Electrical Workers, International Union of Operating Engineers, and Laborers' International Union of North America recently signed a historic solar agreement that indicates the role of each union on a utility-scale solar job site (Harris 2023). This is a positive step forward, but these are only three of many unions that may be involved in solar deployment, and this agreement does not take on more distributed-scale renewables. Federal, state, and local governments should support the trades in this sort of sectoral bargaining to alleviate friction both between unions and developers as well as among unions themselves so as to move projects along at faster rates. The IRA and IIJA have incentives for prevailing wage in tax incentives and priority given to projects that have Community Benefit Plans (CBPs) or Project Labor Agreements for competitive grants or loans—good steps forward. The federal government should support local and state governments, as well as solar deployment companies, in implementing high-road labor standards. Furthermore, it should proactively support unionization in the sector, such as through the National Labor Relations Board as well as by enforcing labor peace agreements.

Benefit sharing. While CBAs and CBPs are useful tools for managing development when put in place systematically, the government could play an important role in ensuring long-term structural benefit sharing of solar. Importantly, governments should not use these agreements and programs to manage development within their regions and rely on private industry to provide affordable housing or greenspace, but should systematically incorporate these benefits into the regulation and policy of their communities. A baseline example of this sort of regulatory intervention is revenue-sharing or tax-basing infrastructure, where communities share benefits or taxpayers collectively make investments. The BLM has different policies for oil and gas development versus solar development on public lands: Oil and gas lease revenues are shared with communities, but solar lease revenues are delivered only to the federal agency budget. In California, solar projects do not have to pay property taxes and therefore do not contribute to the tax base of the municipality or county (Empson-Rudolph and Loesel 2023). Some counties have responded by requiring CBAs or similar impact fees to make up for lost or forgone revenues for community and public services.

Ensuring that local communities receive revenue is important. When municipalities or counties are determining what types of development projects to prioritize, they may feel disincentivized to pursue or zone for solar projects if the land could instead be used to help build up the local tax base. A new California Energy Commission process allows developers the option to have the commission review projects instead of the county, provided they have in place a CBA. Solar development is an immense opportunity to ensure revenue and other benefits accrue to county and local governments instead of companies and financiers. Federal, state, and local governments have different levers at their disposal—taxes, royalties, or regulatory oversight that can all ensure a more equitable distribution of benefit (see the Roosevelt Institute brief "Multi-Solving, Trade-Offs, and Conditionalities in Industrial Policy" [Estevez 2023] for an overview of an industrial policy toolkit). While Community Benefits Agreements between a community and developer provide avenues to benefit sharing, a coordinated strategy for national benefit sharing can create more durable mechanisms for shared benefit.

Create and Expand Support for Public Deployment Enterprises

Sometimes, deploying renewables—particularly in an equitable way—just isn't profitable. In his book *The Price is Wrong* (2024), Brett Christophers writes about the profit bind that much of the renewable energy industry finds itself in. The majority of utility-scale renewable energy expense is up-front construction, requiring big investments from financial backers so that developers can buy or lease land, source materials, hire workers, get necessary approvals, and make it through the interconnection process so that the energy can get online. With such high up-front costs, project financiers want both big profit margins and high investment security. However, solar's thin margins in US wholesale electricity markets doesn't bode well in the current market design. With profit margins low, solar developers need to do everything in their power to keep their costs low to maximize potential profit.

Public enterprises could be key actors to help fix this market failure and quickly deploy solar in coherent, ecologically safe, and socially useful places. Unburdened by the duty of generating high profits for shareholders, these enterprises can deploy solar in places with high environmental and social returns. They are also well-suited to act as the executor of plans devised by local, state, and federal government entities, instead of those entities laying a complex system of carrots and sticks for private developers. In fact, having in-house expertise on developing solar projects could increase the viability of planned solar deployment when put into conversation with urban planners, ecologists, and the like—facilitating multi-solving. Lastly, as enterprises are rooted in place and without financiers eyeing the bottom line, avoiding obligations to shareholder profits could ground investments in the local economy and give any profits, if made, back to the community. There are a range of scales and permutations that public enterprises can take, but one example is community choice aggregators, which buy electricity on behalf of utilities and purport to offer a greener alternative. Below, we offer a few recommendations.

Create federally coordinated regional power authorities. Since the New Deal, the federal government has created a number of regional power authorities, including the Tennessee Valley Administration (TVA) in the South and the Bonneville Power Administration (BPA) in the Pacific Northwest, to coordinate electricity production, embark on large-scale power projects (largely hydroelectric dams), and provide regional economic development. While these authorities have a checkered past of racism and ecological mismanagement, there is an opportunity to build a new wave of regional power authorities in the era of renewable power. These regional entities could act as important planning bodies that consider a range of different energy infrastructure investments—planning across multifaceted needs to optimize resilience, justice, environmental impact, and rapid deployment. In a recent Climate and Community Institute report, we describe how these regional power authorities could operate (Bozuwa et al. 2023). Not only could the US create new regional power authorities in areas of the US not currently supported by existing entities, it could also more heavily intervene in the authorities like BPA, TVA, and the three additional, though less expansive, Power Marketing Administrations (US DOE n.d.a.). Right now, the federal government has taken a hands-off approach to these administrations and largely not modernized them for the renewable era.

Embolden existing publicly owned utilities and cooperatives. There are already over 2,000 publicly owned utilities and rural electric cooperatives operating in the US that could be major actors in developing and deploying solar far faster. Some of these utilities have already taken up the opportunity, like Ouachita Electric Cooperative in Arkansas, which has used renewable energy deployment as a way to lower electricity bills for its member-owners (Hayle 2018). As of 2020, five utility companies had achieved 100 percent renewables—all of them municipal utilities (Adesanya, Sidortsov, and Schelly 2020). Another study found that "in general, communities with electricity supplied by an investor-owned utility (65 percent in the larger data set) may find it more difficult to switch to 100 percent renewable electricity than those with alternative organizations such as local public power, a locally controlled electricity cooperative, or community choice aggregation" (Hess and Gentry 2019). However, the majority of the subsidizations for renewable development did not apply to public entities until the passage of the Inflation Reduction Act (Thomas 2023). Providing support to and emboldening existing public entities and cooperatives to deploy solar could increase the viability of projects and facilitate higher levels of buy-in to the projects.

Develop state-level solar developers. In addition to regional power authorities managed at the federal level, there is also the opportunity to develop new state-level public solar developers or power authorities that can support coordinated land-use planning with states and localities and then support in executing the plan. The Build Public Renewables Act passed in New York State could offer an interesting example. New York has an existing publicly owned utility, the New York Power Authority (NYPA), that operates both generation (largely from hydroelectric) and transmission—among other projects. The recent bill passed in New York required NYPA to invest in more renewable development projects with high labor standards and particular attention paid to lowering bill costs for low income residents (Uteuova 2023). New York City has also rolled out a new public rooftop solar developer program, Public Solar NYC, to finance and expedite rooftop solar proliferation in the city (New York City Comptroller Brad Lander n.d.) Such public entities could also help deploy Virtual Power Plants, which are aggregations of DERs. The IRA's passage of direct pay standards to level the playing field for renewable subsidies for public entities was a major contributor to both state and city initiatives. States across the country could heed this major win and create their own new solar developers or power authorities that could help accelerate solar deployment in their region in coordination with state commitments.

Nationalize resource planning and transmission infrastructure. Solving the solar deployment crisis requires more than just creating public solar developers. In fact, one of the most impactful things that the federal government could do is nationalize high-voltage transmission infrastructure to rebuild a broken transmission system—one that is owned by hundreds of disparate actors and managed by Regional Transmission Operators or Independent Service Operators, private organizations that largely operate the market systems in a black box. By both stitching back together a patchwork of poorly coordinated grids across the country and then placing the high-voltage transmission system in public ownership, the federal government could impose far-reaching reforms that could massively facilitate solar deployment. It would allow for coherent transmission infrastructure planning coordinated within and across cabinet-level positions at the Department of the Interior (DOI), Department of Transportation (DOT), and DOE. This could also better allow coordinated investments in "non-wires alternatives" to avoid unnecessary transmission development.

Better resource planning could also lower the hurdles to interconnection for solar developers. In fact, a nationalized high-voltage transmission system could be a boon for private solar developers looking for dependability for their project development and, importantly, limit the amount of speculation in the solar industry. Not only that, but with control over the wholesale marketers, markets could be redesigned to optimize for solar and other clean energy infrastructure instead of fossil fuels. While on its face, nationalizing the transmission grid may seem like a big ask, many countries in western Europe operate on a public ownership model (Florio and Florio 2013).

Avenues for Future Research

Nationwide identification of high-benefit, low-harm sites. In the Appendix, we outline and begin to implement a methodology to identify high-benefit, low-harm sites. However, as we note, there are many knowledge gaps that need to be filled to complete this research exercise and to move from estimates to hard data, ranging from a nationwide map of lands with high agrivoltaic potential, to mapping parking lot surface area, to an evaluation of renewables potential on oil, gas, and coal sites. This kind of systematic nationwide mapping effort requires a scale of research capabilities that are best developed within the federal government, in coordination with state and local governments and stakeholders. While such mapping can encourage participation from Tribal governments and Indigenous communities, their participation may be more confidential, as the disclosure of some specific cultural resources can be sensitive and guarded. Similarly, while our map tool helps illustrate the potential for visualizing high-benefit, low-harm areas, it does not not pinpoint those areas in ways that are immediately actionable at the local level. Further research to develop a granular map would yield an invaluable tool for both bottom-up and top-down solar planning. For example, producing better quality data and visualizations of high-benefit, low-harm sites for every neighborhood and county across the country would allow communities, governments, and solar developers to more quickly identify opportunities for solar deployment. It can serve to further motivate community members to take advantage of public resources, such as direct pay (CPCC and LPIL 2024), to purchase solar capacity for their homes, schools, and houses of worship, or even to create new, community-based solar development firms.

Mapping projected transmission and build-out of renewables and energy storage. One of the best ways to accelerate deployment of renewables and make transmission more efficient is, of course, to plan transmission and distribution in tandem with the development of renewable energy infrastructure. This requires simultaneous, coordinated, and iterative mapping of projected and desirable transmission lines, renewables sites (for solar, wind, geothermal, and hydroelectric), *and* storage facilities following the high-benefit, low-harm democratically rooted framework—based on real power needs. There are also multi-solving opportunities to support (particularly rural) communities through broadband deployment coordination.

Deeper analysis of the impact of a public, nationalized grid. This report has lightly touched upon the idea that a more coherent, public high-voltage transmission system could be a transformative way to accelerate solar deployment. While the benefits of a national grid have been discussed, the possibilities of better RTO and ISO integration as a public agency have yet to be fully evaluated.

Manufacturing, mining, and recycling planning. Our study only contemplates the siting of renewables. However, manufacturing and mining are just as important for the deployment of renewables, and these domains raise manifold human and environmental health challenges. Pioneering research is needed to extend a democratic planning and constructive reparations framework to the production of renewables along the supply chain. This could include, for example, prospecting research that follows the high-benefit, low-harm framework; avoiding extraction in Indigenous and other overburdened communities; and applied research to accelerate the build-out of mineral recycling capabilities.

Identification of systemic interventions to reduce energy and materials demand, such as public transport and building efficiency development. One of the advantages of a whole-of-government, economywide approach to planning is that it opens up opportunities to identify system-level changes that can yield far greater impact than piecemeal interventions. For example, as recent research from the Climate and Community Institute (2023) shows, lithium demand can be reduced by up to 92 percent in 2050 in comparison to lithium-intensive scenarios by decreasing car dependency in favor of mass transit, right-sizing EV batteries, and strengthening recycling systems. Building on this research to map opportunities for high-benefit, low-harm construction of mass transit across the nation (and beyond) is a critical next step. This can also be applied to building and industrial system efficiency. By conducting coordinated deep efficiency programming, the US can dramatically reduce its power needs, helping to relieve some of the pressure for transmission and renewable development.

Conclusion

Deploying solar quickly in the US will be instrumental to achieving the nation's climate goals and keeping the planet livable. In this report, we have explored how the uncoordinated, largely privately driven approach to solar development and deployment is not moving fast enough. While some advocates believe the answer is eliminating regulatory red tape, namely weakening environmental review, we develop more compelling explanations for why solar energy deployment still lags behind climate action ambitions. We inspect the intersections of the socio-technical and political-economic dynamics at play and propose an alternative: a democratically rooted national plan for solar deployment that allows for building out solar infrastructure rapidly while also proceeding at the speed of consent and care.

A multi-solving, whole-of-government approach to planning and coordination could help the US identify high-benefit, low-harm sites for deployment, alleviating potential conflict and ensuring a strong, biodiverse ecology and the preservation of cultural resources for decades to come. Our approach to looking for land-sparing opportunities draws from research on techno-ecological synergies, offering opportunities to multi-solve across ecological and technological domains to avoid trade-offs and instead embrace multifunctional landscapes. We have found that there is more than enough land and surface area on transportation corridors, Superfund sites, and other degraded lands to host solar without having to cut down ecologically significant forests or degrade arid landscapes by preparing land with agricultural and road grading equipment. We identify ways to balance top-down and bottom-up planning mechanisms and project design elements to ensure equitable and ecologically synergistic outcomes to simultaneously streamline approvals, improve land stewardship, and augment community benefits from solar deployment.

We also show how consent-based frameworks and community benefit can actually accelerate solar deployment and provide avenues for more coordinated engagement and benefits-based infrastructure. Accelerating solar as a means to achieve climate goals may mean disregarding the profit motive as the primary driver of economic decision-making, particularly while balancing societal and ecological needs, and we put forward key points of intervention for the public to play a larger role in managing and deploying solar.

The proposal for democratically rooted, nationally coordinated solar deployment we sketch here may feel ambitious. However, much of what we propose is not new policy, but draws from historical precedents, best practices from the literature, and community demands. The state is well-positioned to take up this coordination problem and advance a more comprehensive solar deployment strategy, and there is opportunity for states or regions to take up these recommendations and lead the way by operating as a test kitchen for ultimate federal action.

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Appendix I: A Methodology for Democratically Rooted Solar Planning: Identifying High-Benefit, Low-Harm Sites

In line with the preceding principles and analysis, we propose that nationwide land-use and site planning for solar deployment in the US should be composed of five basic steps.

Step 1. Defining the Mission: Determining the Size of the National Solar Infrastructure Gap

Planning for solar deployment is fundamentally about filling an infrastructure gap in solar energy generation capacity. The most foundational part of the planning process is understanding the size and nature of that gap. That begins with: (i) identifying the appropriate climate targets to serve as the north star or "core mission" for solar deployment; and (ii) calculating the overall solar energy generation capacity and physical space needed to meet those climate targets.

In this working methodology, we use placeholder estimates from Denholm et al. (2022) and the National Renewable Energy Laboratory, which suggest that reaching 100 percent clean electricity by 2035 under a "no CCS" scenario will require building **25,000 km^2** of solar capacity (Denholm et al. 2022). That's 6.2 million acres—4.7 million football fields, or an area slightly larger than the size of New Hampshire (24,216 km^2). Figure 1 shows alternative estimates of solar acreage required to meet climate targets ranging from under 3.5 million to 15 million acres.

Solar power requires 5 to 10 acres per megawatt (MW). The reason for the variation is that not only do different places have different solar resources, landscape-level spacing requirements, and idiosyncrasies, but solar power plants may have many more photovoltaic modules than their rated capacity. A solar project with 100 MW of capacity might have 120 MW worth of photovoltaic modules. Many research papers on land use and utility-scale solar development use 30 MW/km^2 (equivalent to 8.23 acres/MW) to estimate the amount of solar power per unit of land. Our estimates do not take into account what space may be needed for other kinds of renewables (wind, geothermal, etc.). They also do not aim to estimate reductions in land use arising from increasing efficiency of solar panels as technologies improve.

With the infrastructure gap defined, the next step in the planning process is to identify sites that are suitable for building solar capacity to fill that gap, in accordance with the principles outlined in this report. The guiding question in the next step is: "Can we build the solar capacity we need without unwanted side effects?"

Step 2. Identifying No-Harm/Low-Harm Sites

Locations that do not create additional harms should, in principle, be ideal candidates for solar siting. If no additional harms are likely to arise from the construction of solar capacity on a given site, resistance to construction is likely to be low. Harms that communities often identify as concerns in solar deployment are the following:

1. **Ecological loss:** Biodiversity erosion, habitat fragmentation, and ecosystem degradation;
2. **Cultural loss:** Destruction of cultural resources and access to leisure and recreational spaces; and
3. **Economic loss:** Negative impacts on tourism revenues arising from loss of natural spaces and opportunity costs of allocating land to solar capacity vs. more economically advantageous land-use opportunities.

Based on our preliminary analysis, grounded on desk research and interviews with a diversity of stakeholders, the following types of sites outlined in Table A1 may *potentially* meet the "do no additional harm" principle. Further research and consultation at the state and local level is needed to develop more reliable estimates that take into account context-specific variables.

Table A1. Sites That Potentially Meet the "Do No Additional Harm" Principle

		Potential available acreage *	Potential solar capacity (GW) *
Abandoned agricultural land	Hernandez et al. (2019) estimate that there are 682,579 km^2 of abandoned agricultural land in the US. **Co-benefit:** Repair, restore, and revitalize land.	168,665,271 acres	20,494 GW
Rights-of-way (along roads, rail, transmission)	Milbrandt et al. (2014) estimate that there are 55,935 km^2 of rights-of-way—land along transportation and distribution infrastructure, such as roads, rail, and transmission. **Co-benefit:** Co-site infrastructure like broadband internet and transmission.	13,821,539 acres	1,679 GW
Brownfields, former industrial areas, Superfund sites, etc.	Milbrandt et al. (2014) estimate that there are 47,070 km^2 of EPA-managed sites, including brownfields and Superfund sites (areas previously used for industrial purposes) across 450,000–1 million sites. **Co-benefit:** Restore and revitalize land and community.	11,630,997 acres	1,413 GW

Parking lots for solar canopies, distributed and community solar[11]	The US Geological Survey estimates parking lot coverage change by watershed over the last four decades, finding that parking lots cover 35,685 km2, or 0.47 percent of the total contiguous land area in the US (Nugent 2022). Fifty percent of parking lot area would provide almost 18,000 km2 of high-benefit, low-harm solar. **Co-benefit**: Reduced heat island effect and local power bill reductions for energy-burdened households.	11,419,200 acres	1,388 GW
Nationwide rooftop surface area for distributed solar	According to a 2016 National Renewable Energy Laboratory (NREL) analysis, there are over 8,000 km^2 of rooftops on which solar panels could be installed in the United States, representing over 1 terawatt of potential solar capacity. These non-wires alternatives can avoid the need for transmission, and can be aggregated as virtual power plants to displace fossil-fueled power plants. **Co-benefit:** Avoided land use; non-wires alternative; grid resilience.	1,976,841 acres	1,118 GW
Contaminated agricultural land	Hernandez et al. (2019) estimate that there are 28,960 km^2 of land contaminated from cropland and grazing practices (such as metal, saline-sodic, and fertilizer contamination). **Co-benefit**: Opportunity to repair and revitalize land.	7,156,016 acres	870 GW
Center-pivot agrivoltaics	Many agricultural lands are irrigated by center-pivot agriculture, which at a landscape level leaves the edges of field circles absent from crops. **Co-benefit:** Energy resilience for rural communities, which are often subjected to lengthy waits when power lines are damaged; shade for farm workers.	5,189,100 acres	631 GW
Abandoned oil and gas fields	According to the EPA (2018), researchers estimate that there are between 2 to 3 million abandoned oil and gas wells in the United States. Around 123,318 are "orphaned"[12] (uncapped, unproductive, and with no responsible party identified to manage leakage or pollution risks). Around 912,962 oil and gas wells are active. Solar suitability at these sites likely varies. We assume an average of 1 acre per site. **Co-benefit**: Rehabilitation and potential to create jobs where jobs are being lost.	3,000,000 acres	365 GW

[11] An example policy can be found in France, where law requires photovoltaic canopies over parking lots.
[12] Estimates drawn from Environmental Defense Fund's map of orphan wells and the US Energy Atlas.

Abandoned mines	Hernandez et al. (2019) estimate that there are 11,380 km^2 of abandoned mine land. **Co-benefit**: Opportunity to repair and revitalize land.	2,811,998 acres	342 GW
Landfills	Hernandez et al. (2019) estimate there are 1,637 to 6,592 km^2 of landfills in the US. We use the more conservative estimate of 1,637 km^2. Landfills are used for disposal of waste beneath solid surface, and they release leachate and landfill gas. **Co-benefit**: Opportunity to repair and revitalize sites.	404,503 acres	49 GW
Irrigation canals	The US alone has 12,875 km of federally owned canals, which are estimated to have a solar energy generation potential of 25 GW. Some states have enormous potential: California has 6,437 km of water canals, which could generate about half the new capacity needed by 2030 to meet the state's decarbonization goals (McKuin et al. 2021). **Co-benefit**: Water conservation from reduced evaporation; solarizing irrigation pump power; lower air pollution by retiring diesel pumps.	193,047 acres	25 GW
TOTAL HIGH-BENEFIT, LOW-HARM SOLAR ACREAGE AND POTENTIAL POWER CAPACITY		226,268,511 acres	28,372 GW
SOLAR ACREAGE AND POWER CAPACITY NEEDED TO MEET CLIMATE ACTION TARGETS		3,500,000–15,000,000 acres	630–2,750 GW

This analysis shows that the US has more than enough acres of potentially high-benefit, low-harm sites to meet solar deployment targets. Notably:

1. There are over 226 million acres of high-benefit, low-harm potential sites for solar to fit the estimated range of 3.5 million to 15 million acres of solar power needed.
2. There are 19 million acres of solar potential on existing infrastructure. Building solar capacity *exclusively* on existing solar-appropriate infrastructure would be more than sufficient to meet even the highest estimates of solar deployment targets.
3. Rooftop solar potential alone (1.9 million acres) could meet nearly one-third of future solar needed to achieve climate action goals.
4. There is significant additional acreage in brownfields and other degraded lands, as well as agricultural lands, that could be used for solar deployment, thereby decreasing the need to use less-efficient energy technologies like wind, which require as much as 10 times more land than solar to produce the same amount of energy (Wu et al. 2019).

Step 3. Identifying High-Benefit, Low-Harm Sites

The site types identified above were selected following the "do no additional harm" principle. Of those site types, seven stand out for their high potential to create co-benefits. In accordance with constructive reparations and a multi-solving framework, these co-benefits should be taken into account to direct resources to and prioritize permitting for high-benefit, low-harm projects.

1. Irrigation canals (**co-benefit**: water conservation);
2. Brownfields (**co-benefit:** opportunity to repair and revitalize);
3. Degraded lands (**co-benefit:** opportunity to repair and revitalize);
4. Superfund sites (**co-benefit**: opportunity to repair and revitalize);
5. Oil and gas fields (**co-benefit:** potential to create jobs where jobs are being lost);
6. Abandoned agricultural land (**co-benefit**: opportunity to repair and revitalize); and
7. Agrivoltaics (**co-benefit:** energy resilience for rural communities, which are often subjected to lengthy waits when power lines are damaged).

Step 4. Selecting Sites as Candidates for Categorical Exemptions and Other Solar Deployment Fast-Tracks

The above methodology could be harnessed to expedite and improve the quality of solar deployment. Producing more certain data and visualizations of high-benefit, low-harm sites for every neighborhood across the country would allow communities, governments, and solar developers to more quickly identify opportunities for solar deployment. We have begun to illustrate how this could look in this interactive map tool. Developing and socializing these tools could motivate community members to take advantage of public resources, such as direct pay (CPCC and LPIL 2024), to purchase solar capacity for their homes, schools, and houses of worship, or to create new, community-based solar development firms.

The table above could inform efforts to expedite solar deployment by establishing what is eligible for categorical exemptions from National Environmental Policy Act review. While much of land-use planning responsibility falls to states and local governments because of the 10th Amendment, federal controls are limited to federal lands and waters. However, the federal government could still play an important role in the coordination of planning and investment across and between states and local governments.

In California, many large solar projects are permitted in rapid time under the California Environmental Quality Act. Projects that undergo some prior planning via a programmatic environmental impact report receive an expedited form of permitting called a **mitigated negative declaration**.

Similarly expedited permitting could be offered to a special class of **high-benefit, low-harm** site types that meet the following requirements:

1. Belongs to a low-harm site category (additional priority for high benefits); and
2. Is already connected to a transmission line. This saves resources and time and prevents new potential conflicts around land use.

Step 5. Community-Based Verification

All of the above estimates are, of course, only preliminary, as would be any high-benefit, low-harm designations. The federal government can support democratically rooted planning efforts at different levels of government by producing more refined data and resourcing state, Tribal, and local actors to verify whether the types of sites identified above are in fact high-benefit, low-harm sites in their particular contexts. State, Tribal, and local governments can also produce this kind of data and engage stakeholders directly in the verification process. Community members and organizations can also use this data and map tool to demand action from policymakers and to take action themselves as economic agents.

Appendix II. Table A2

Table A2. US Solar Deployment Projections Compared to Land Area and Transmission Needed to Meet Climate Action Deployment Targets

	Solar deployment projection (GW)	Area for solar needed by 2035/2050	Transmission needed by 2035/2050	Target and timeframe
Department of Energy - Solar Futures Study (lower 48 US)	**2035:** 540 GW to 1,000 GW overall; **2050:** 1,050 to 1,600 GW	4,000,000 acres to 10,000,000 acres		100% Clean Energy by 2050
National Renewable Energy Lab - Supply-Side Clean Energy Options (lower 48 US)	540 to 1,000 GW overall, 190 GW DER	3,700,000 acres to 7,200,000 acres (15,000–29,000 km2)	13,000 to 91,000 miles or 1,400 to 10,100 miles per year.	100% Clean Energy by 2035
Princeton Net Zero 2050 (lower 48 US)	630 GW to 2,750 GW USSE; 163 GW DER	3,500,000 acres to 15,000,000 acres (14,200–61,200 km2)	306,000 GW-km to 1,309,000 GW-km	Net-Zero by 2050