The Nature Conservancy

Power of Place

National

EXECUTIVE SUMMARY

MAY 2023

Power of Place Principles

The following principles should guide energy planning and policy to achieve better outcomes for **climate, conservation, and communities**.

Better for Nature

Advance energy siting policies and solutions that limit negative impacts to natural areas and working lands.

Reliable

Ensure reliable clean energy for people.

Resilient

Plan for an energy system that can withstand the impacts of climate change by minimizing vulnerability to wildfires, flooding, and drought.

Affordable

Develop cost-effective clean energy pathways for consumers.

Equitable

Ensure frontline communities have a lead role in our clean energy future as beneficiaries and decision-makers.

Clean

Accelerate clean energy deployment to reduce emissions and pollution.

Block Island, Rhode Island | Dennis Schroeder, NREL

Introduction

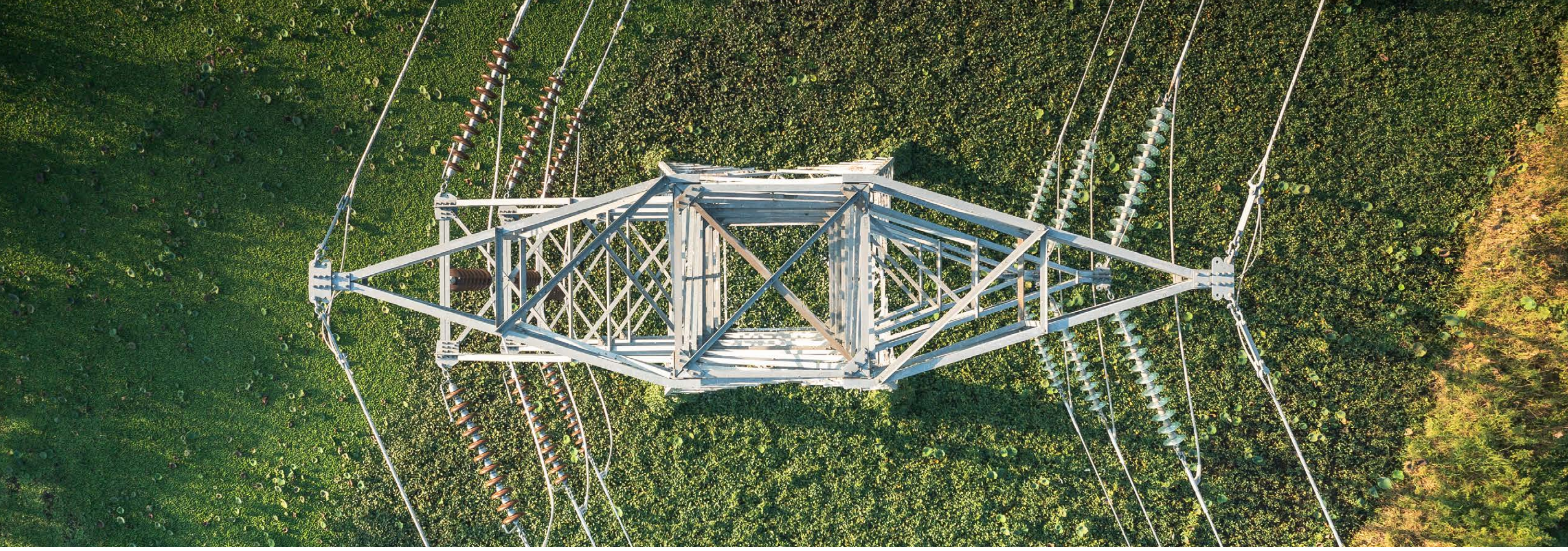
From solar farms in California's Central Valley to offshore wind installations that will soon rise in the waters off the Atlantic coast, momentum behind clean energy development across the U.S. has never been stronger. Recent investments by Congress will accelerate renewable energy expansion, support expanded transmission infrastructure, and encourage commercial deployment of other technologies important for reaching climate goals such as green hydrogen and carbon capture, utilization, and storage.

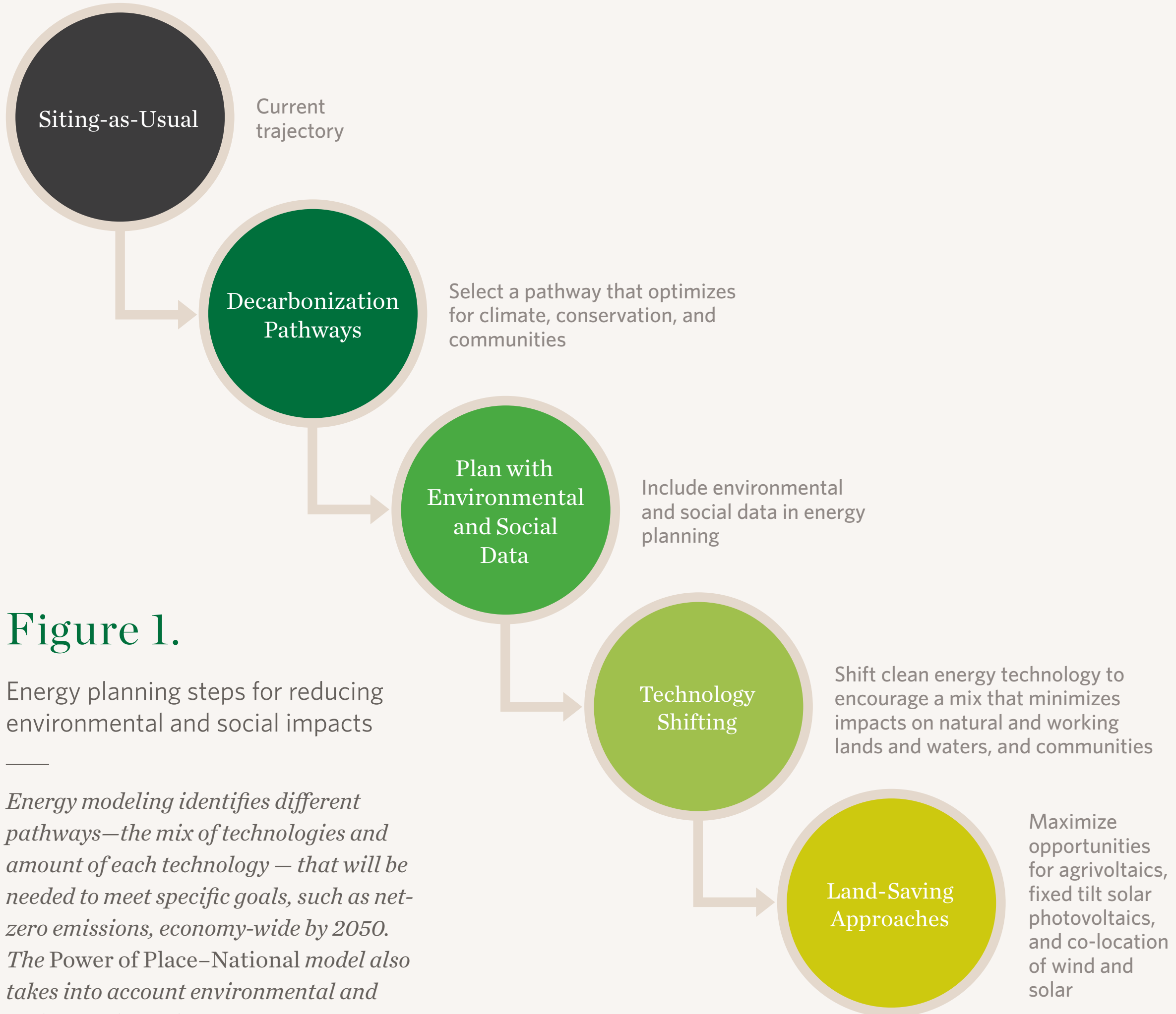
This momentum represents progress toward meeting the national goal of a net-zero carbon economy by 2050. However, the expanded spatial footprint and accelerated pace that is needed, along with current patterns of energy development, could adversely impact natural habitats, wildlife, working lands, and communities, and risk slowing down the transition.

To reach net-zero emissions, stakeholders must undertake careful and coordinated planning to assess the tradeoffs of the clean energy transition and avoid achieving energy goals at the cost of healthy, productive lands and waters. *Power of Place* is The Nature Conservancy's approach to identifying pathways to a net-zero economy by 2050 while optimizing outcomes for climate, conservation, and communities. It lays out a methodology that energy system planners and decision-makers can use to create plans and develop policies that meet multiple societal goals.

Building on previous studies of California and the American West, this national study highlights the need for place-based planning across all levels of government if we are to accelerate decarbonization, limit environmental and social impacts, and minimize costs. **The study also finds that there is no one-size-fits-all national strategy for low-impact decarbonization due to regional differences in the quality of clean energy resources, wildlife and habitat values, land use patterns, and demographics.** A regional approach means that utilities, regional transmission organizations, state agencies, and local communities all have important roles in planning and governing our energy future.

The U.S. can build the clean energy infrastructure needed for economy-wide, net-zero emissions by 2050 while avoiding most impacts to sensitive natural and working lands.





Siting-as-Usual

Current trajectory

Decarbonization Pathways

Select a pathway that optimizes for climate, conservation, and communities

Plan with Environmental and Social Data

Include environmental and social data in energy planning

Technology Shifting

Shift clean energy technology to encourage a mix that minimizes impacts on natural and working lands and waters, and communities

Land-Saving Approaches

Maximize opportunities for agrivoltaics, fixed tilt solar photovoltaics, and co-location of wind and solar

Figure 1.

Energy planning steps for reducing environmental and social impacts

Energy modeling identifies different pathways—the mix of technologies and amount of each technology — that will be needed to meet specific goals, such as net-zero emissions, economy-wide by 2050. The Power of Place–National *model also takes into account environmental and social considerations.*

Previous *Power of Place* research found that the optimal pathway for balancing conservation and climate impacts is a “High Electrification” scenario (*see* Box 1). This pathway includes a range of commercially available technologies. For this study, researchers assumed that the High Electrification scenario would also be the best pathway for balancing cost, conservation, and expedience on a national scale. Additional place-based analysis will be necessary to determine optimal pathways to net zero where policy choices have defined earlier target dates or different technology mixes.

As with all transitions, the U.S. energy transition comes with opportunities and risks. Opportunities for economic development, energy independence, and revitalization of degraded lands counterbalances the risks of unnecessarily high costs due to inefficient technology deployment and loss of critical natural and working lands. The informed, well-planned, and collaborative development practices outlined in this report offer guidance on how decision-makers can take advantage of available opportunities while minimizing risks (*see* Figure 1).

The need to rapidly decarbonize our energy systems has never been more urgent. Getting it right won’t be easy, but failure to do so would have major impacts on nature and communities and could slow the clean energy transition.

BOX 1.

High Electrification Scenario

The Nature Conservancy’s 2022 study, *Power of Place–West*, modeled a variety of scenarios for meeting economy-wide net-zero emissions by 2050. The analysis includes the power, transportation, heating, and manufacturing sectors. The High Electrification scenario emerged as the leading decarbonization pathway for both climate and conservation. This scenario modeled all commercially available technologies, including onshore and offshore wind, solar, geothermal, biomass, hydrogen, some existing hydroelectric and nuclear, gas with carbon capture, direct air capture, and battery storage technologies. *See:* Power of Place–West.

Power of Place Background

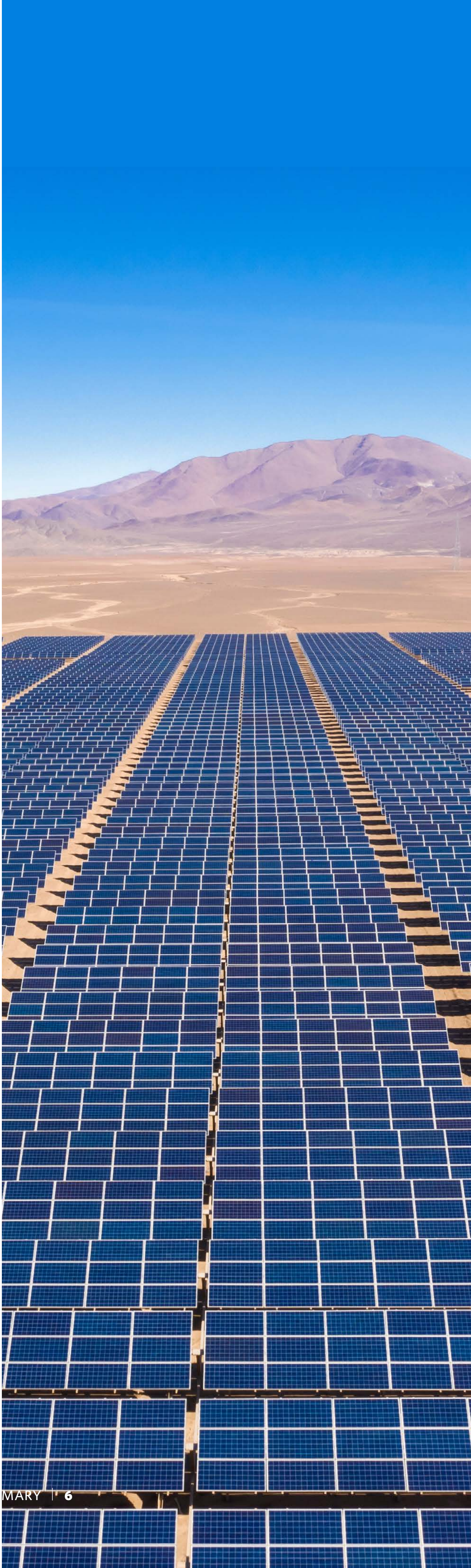
The Nature Conservancy has produced two regionally focused *Power of Place* studies. The first was released in 2019 and covered California; an expanded look at eleven western U.S. states followed in 2022. Collectively, these studies offer a compelling vision for how policy-makers, energy developers, utilities, and other stakeholders can expand clean energy and transmission infrastructure while maximizing benefits for people and nature.

This study builds on the first two and uses a first-of-its-kind combination of analytical approaches to identify low-impact pathways to net-zero, economy-wide decarbonization for the entire continental United States. Additional research would be needed to provide detailed analysis at the subregional or state level. Authors of this report addressed, at a national scale, three questions that have been central to the *Power of Place* approach:

- How much clean energy will be needed to achieve economy-wide net-zero emissions by 2050?
- How much land area will be needed for the clean energy transition?
- How do shifts in clean energy technologies affect costs and impacts on natural areas and working lands?

For this study, researchers also considered two new questions:

- What role could land-saving renewable energy approaches play in the scale of the buildout?
- How much renewable energy will be built in the “energy communities” that will receive tax incentives from the Inflation Reduction Act, and how many people live in these communities (*see* Box 2)?



BOX 2.

Definition of Energy Communities Used in This Study

The Inflation Reduction Act (IRA) of 2022 provides a 10% tax credit for clean energy development built in "energy communities." Several types of lands fall into the definition of an energy community and are eligible for this incentive, including brownfield sites. For the purposes of this study, however, researchers only modeled areas associated with historic fossil fuel industries, specifically the following two categories:

- A metropolitan statistical area or non-metropolitan statistical area which has (or, at any time during the period beginning after December 31, 2009, had) 0.17% or greater direct employment or 25% or greater local tax revenues related to the extraction, processing, transport, or storage of coal, oil, or natural gas (as determined by the Secretary), and has an unemployment rate at or above the national average unemployment rate for the previous year (as determined by the Secretary).
- A census tract in which after December 31, 1999, a coal mine has closed, or after December 31, 2009, a coal-fired electric generating unit has been retired, or which is directly adjoining to any census tract described [above].

See: Public Law No: 117-169.

This study uses a novel *dynamic impact avoidance* scoring system to build development scenarios. Each scenario reduces environmental and social impacts in 10% increments, beginning with the siting-as-usual case, in which impacts are not avoided (*see* Methods). Unlike previous decarbonization studies that exclude certain areas when evaluating siting decisions, this analysis uses a weighted impact score to evaluate approaches to the clean energy buildout along a continuum. The continuum begins with "no avoidance" of sensitive natural and working lands and waters (except areas with existing legal protection or restrictions) and ranges to the opposite extreme of "strict avoidance." This methodology creates a gradation of impacts that allows different tradeoffs to be weighed (*see* Methods).

Key Results

Power of Place–National identifies scenarios for rapid, efficient clean energy deployment with varying degrees of landscape and social impacts. For illustrative purposes, the following key results are based on the scenario of a 70% reduction of environmental and social impacts as compared to siting-as-usual. We highlight this scenario because it represents a balanced combination of low-cost, clean energy technologies and minimal negative impacts on people and natural and working lands. Key results of this study include:

1

When environmental and social factors are considered in energy planning and deployment, planners, regulators, and developers can significantly reduce negative environmental and community impacts of development projects

The scale of clean energy development needed to reach net zero by 2050 is massive: between 3,100 and 3,500 gigawatts (GW) of wind and solar generation capacity (*see* Figure 2). Planners, developers, and regulators can reduce the impacts of that new generation capacity, including on intact landscapes, croplands, wildlife species, and communities by shifting current and planned deployment toward technologies and approaches that reduce spatial requirements and avoid sensitive areas (*see* Figures 1, 2, and 3). Under status quo development practices, the deployment of wind and solar would require over 250,000 square miles, an area larger than Texas. Under the 70% impact reduction scenario, we can avoid impacts to 115,000 square miles, an area the size of Arizona (*see* Figure 2).

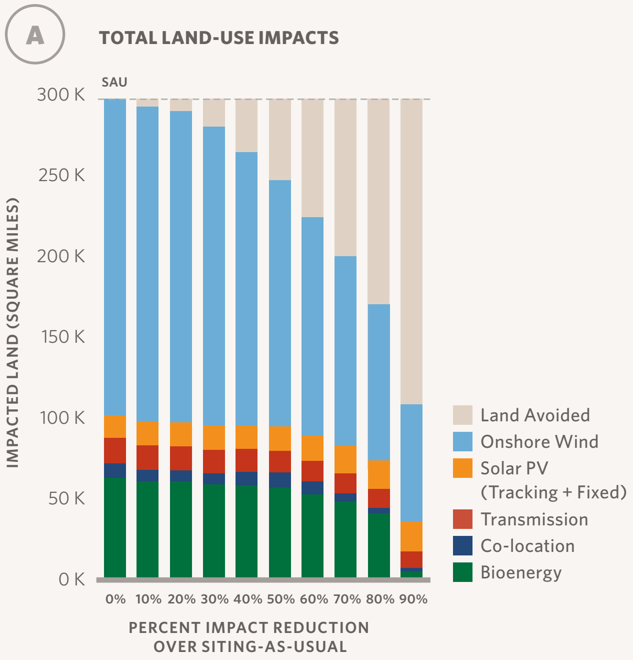
Recognizing the large number of renewable energy projects needed to reach net-zero emissions, researchers considered whether broader use of certain land-saving approaches could reduce land impacts. Researchers considered three such approaches in this study, all of which are effective ways to reduce environmental and social impacts where they can be deployed: 1) the co-location of wind and solar; 2) agrivoltaics (siting fixed photovoltaics (PV) panels on agricultural land); and 3) fixed tilt PV (*see* Box 4). The opportunity for co-location is most prominent in the southern Great Plains. Development of agrivoltaics is well-suited to vegetable and fruit growing areas in various parts of the country. Currently, the use of agrivoltaics is an uncommon practice that is gaining traction and is likely to grow as innovations advance and incentives offset additional costs.

Decisions on which energy technologies and land-saving approaches to deploy should be based on regional factors (*see* Result 6). However, the incorporation of ecological considerations in energy planning and utilizing a diverse portfolio of clean energy technologies are important starting points for reducing impacts in every region of the U.S. For example, the effects of development on tallgrass prairie remnants of the Great Plains and the corridors that connect them can be nearly eliminated when they are considered in energy planning. For threatened and endangered species that depend on small areas of suitable habitat, such as whooping cranes and grouse, avoiding further habitat loss from energy development is critical (*see* Figure 3).

Figure 2.

Reducing impacts shifts clean energy portfolios

(A) Total (direct and indirect) land use impacts (see Methods for definition) of the 2050 net-zero emissions reduction energy system under a siting-as-usual scenario (0% reduction threshold) and in 10% increments of increasing environmental and social impact reductions. By shifting technologies, land use impacts are reduced. "Bioenergy" refers to land used for biomass.



(B) Electric supply portfolios of the energy system under the different impact reduction scenarios. As impacts are reduced, the energy portfolio shifts to less onshore wind and more offshore wind, solar, storage, and nuclear. "Co-location" refers to the deployment of wind and solar in the same project area. "Agrivoltaics" refers to co-production of food and solar electricity via tracking PV on agricultural lands. "Electricity Storage" includes utility scale battery systems and pumped storage hydropower. "Other Renewables" includes geothermal and hydroelectricity. "Other Thermal" includes existing coal, existing natural gas, new natural gas with carbon capture, existing petroleum, biomass, landfill gas, and municipal waste, all of which are abated.

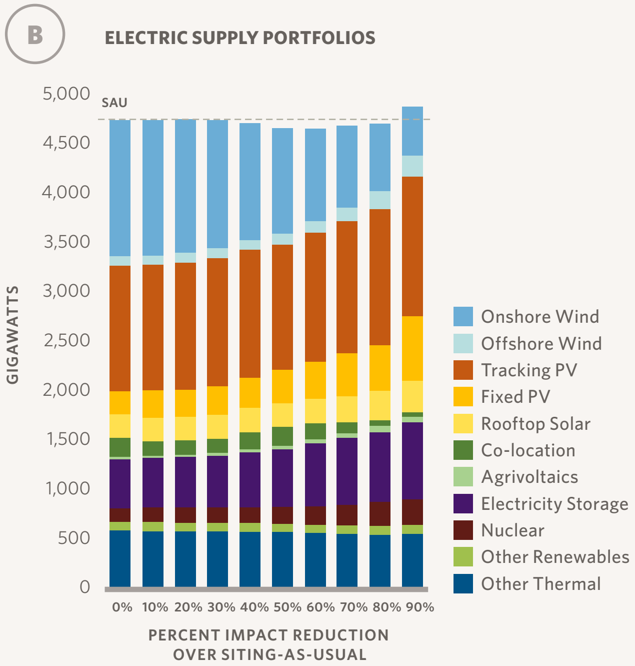
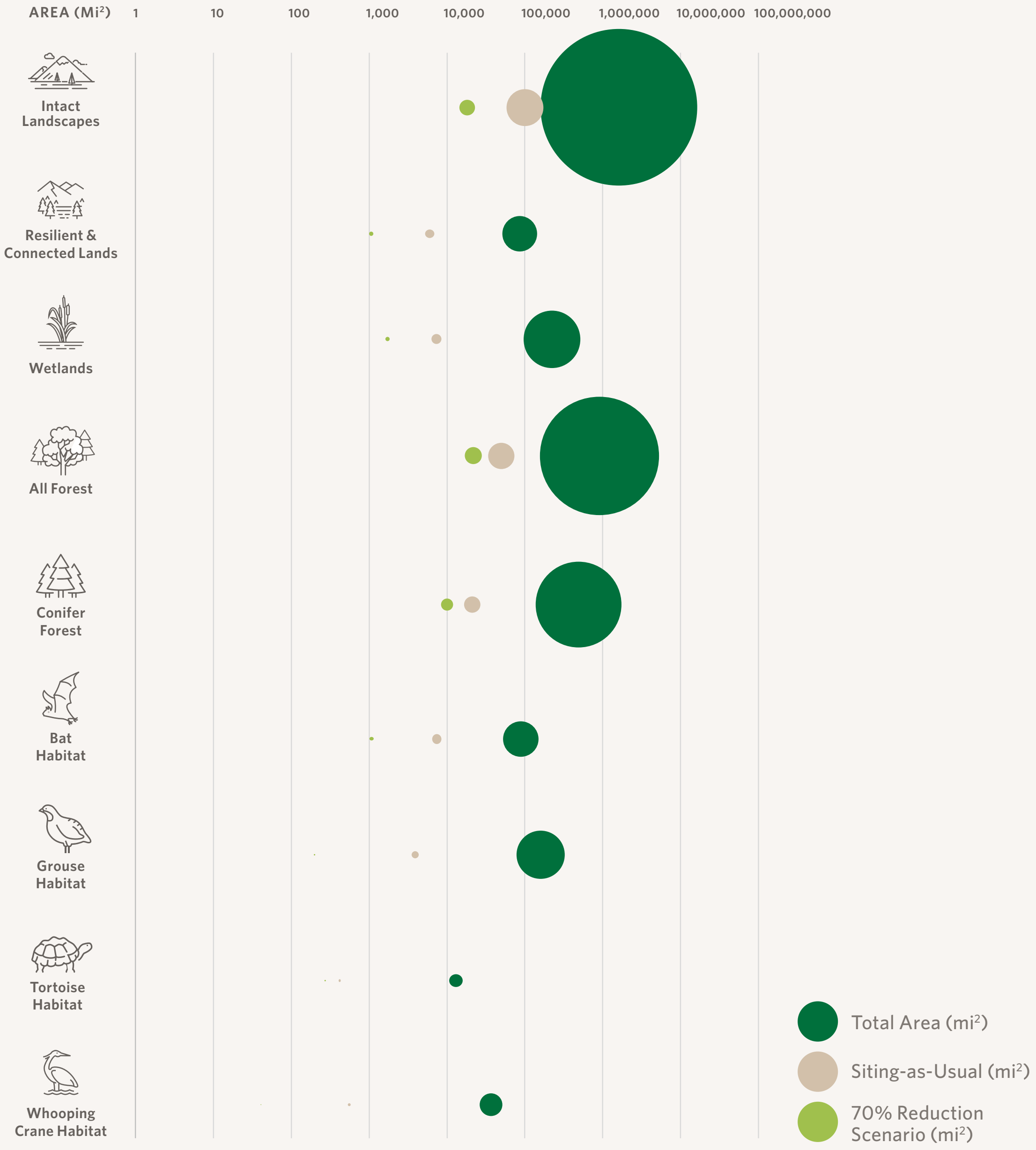


Figure 3.

Natural resource impacts avoided, as a function of impact reduction

In the 70% impact reduction scenario, less than 2% of the total resource area for each natural resource is affected by new renewable energy infrastructure. Total area of habitats, compared to 70% impact reduction scenario, and siting-as-usual (see Methods).



2

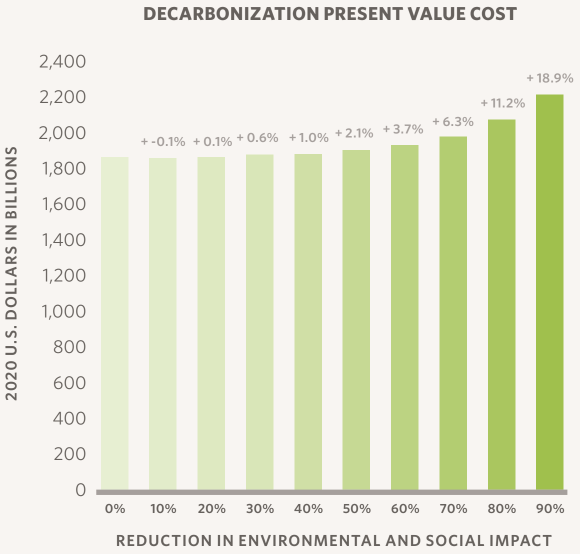
Reducing impacts on natural and working lands and waters can be achieved at a modest cost

Under the 70% impact reduction scenario, environmental impacts can be achieved at a 6.3% cost increase over the current trajectory (*see* Figure 4). This may be an overestimate since avoiding environmentally sensitive areas may reduce cancellation rates, permitting delays, and increased mitigation, monitoring, and design costs compared to projects in less sensitive areas. These factors are likely to affect overall project costs, giving energy planners and developers an added incentive to avoid siting projects on sensitive lands.

Figure 4.

Incremental cost of achieving net-zero emissions under different impact reduction scenarios

The Siting-as-Usual scenario assumes the cost of achieving net-zero emissions is $1.87 trillion, based on the Annual Decarbonization Perspective (ADP). Incremental present value cost increases per reduction of environmental and social impacts. Costs shown include all energy system and technology costs (excluding CO_2 abatement) needed to reach net-zero emissions by 2050.



3

We can reduce impacts on croplands and generate co-benefits for landowners

Agricultural lands will play a vital role in any scenario to reach net-zero goals in the United States. U.S. cropland is highly productive globally, and with the anticipated increase in global food needs in 2050, avoiding land-use changes associated with food production is a major social priority. If we continue siting-as-usual energy development practices, direct impacts to general croplands — farmland under cultivation — would total 13,000 square miles (2% of all croplands in the country). As we reduce impacts to habitats and species, we also reduce impacts to general croplands by nearly 25% to 10,000 square miles. This occurs as the energy mix shifts from wind (much of which is deployed on croplands in higher-impact scenarios) to solar and other technologies that are less prevalent on croplands. It is important to note that some croplands serve as important habitat and foraging areas for migratory birds, such as whooping crane. As a result, croplands near migratory stopover sites are avoided for development as environmental and social impacts are reduced. Impacts to "highly productive croplands” (*see* Box 3) follow a similar pattern. Under current practices, approximately 6,000 square miles of highly productive croplands would be converted to renewable energy use enroute to net zero. This declines by 33% to approximately 4,000 square miles in the 70% impact reduction scenario (*see* Figure 5).

Shifting away from wind and toward more solar development reduces impacts to both general croplands and highly productive croplands. Employing land-saving approaches–including the co-location of wind and solar energy on agricultural lands and agrivoltaics on croplands (*see* Box 4) — can help further reduce impacts. While this may mean less wind on agricultural lands, landowners can still benefit from revenue streams from co-location and agrivoltaics.

BOX 3.

Defining Highly Productive Croplands

American Farmland Trust (AFT) scores agricultural lands according to three factors –soil suitability, crop type and growing season length, and land cover/use type. The resulting “PVR” (productivity, versatility, resilience) scale ranges from 0 to 1.0 with higher scores indicating higher value. AFT recommends avoiding conversion of or impacts to higher value PVR lands unless the sites are compatible with land-saving approaches, such as agrivoltaics. For this study, The Nature Conservancy used a threshold of 0.53 to indicate highly productive cropland.

See: Farms Under Threat 2040: Choosing an Abundant Future, Farms Under Threat: The State of the States Productivity, Versatility, and Resiliency (PVR) Analysis, and Smart Solar on Farmland and Ranchland.

BOX 4.

Co-location of Wind and Solar

Co-location is a land-saving approach where wind and solar are deployed in the same project areas. In contrast to agrivoltaics, co-location decreases land use from 9,467 square miles under current practices, to 5,200 square miles in the 70% impact reduction scenario. This occurs because there is less wind deployment in lower impact scenarios, which reduces co-location opportunities.

Agrivoltaics

Agrivoltaics is an important and promising strategy for producing food and generating solar energy on the same land. Some crops are more compatible with agrivoltaics than others, including certain types of vegetables and fruit. The solar panels not only provide favorable conditions for the crops, but also provide shade for farm workers. Study authors estimate that the land used for agrivoltaics could grow from 216 square miles to a modest 600 square miles (but an increase of almost 300%) as we reduce impacts to natural and working lands and waters under the 70% impact reduction scenario.

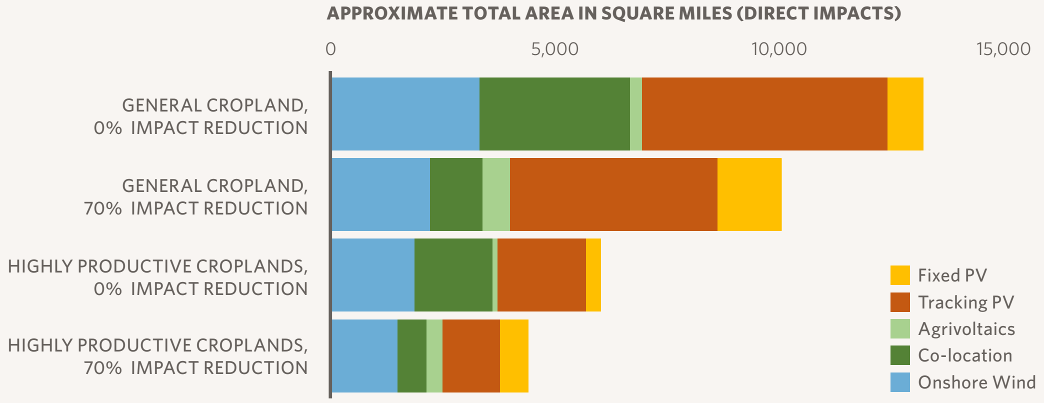
Fixed Tilt Solar Photovoltaics

Fixed-tilt configurations for ground-mounted solar PV allow for 46% higher power density, on average, than single-axis tracking systems. Single-axis systems typically leave a larger space between rows to avoid shading. While capacity factors are lower for fixed tilt systems, the performance advantage of single axis tracking is smallest at high latitudes (northern states). For these reasons, places with smaller average project sizes or high land cost, such as in the Northeast, already favor fixed tilt systems. With increasing land protection, fixed tilt systems can become a good land-saving option in areas of the Midwest and Mid-Atlantic regions.

Figure 5.

Renewable energy declines on croplands as environmental impacts are reduced

Development of solar, onshore wind, and co-located wind and solar on general and highly productive croplands declines as environmental impacts are reduced under the 70% impact reduction scenario.



The following table shows the changes in direct land area in square miles for agrivoltaics and co-location under the siting-as-usual (SAU) and the 70% impact reduction scenario.

	SAU *(mi²)*	**70% REDUCTION** *(mi²)*
Agrivoltaics	216	600
Co-location	9,467	5,200

4 The Inflation Reduction Act directs more clean energy development to “energy communities”

The Inflation Reduction Act includes tax credits for developing clean energy in “energy communities” that historically or currently host fossil fuel extraction, processing, and generation facilities (*see* Box 2). These communities are widely distributed and found in every state. The impact avoidance scoring system gave a preference to these areas to reflect the new incentives for deployment on these lands (*see* Methods). Encouraging clean energy deployment in energy communities is compatible with the 70% impact reduction scenario.

Under the siting-as-usual scenario, researchers estimate new clean energy infrastructure in energy communities will be approximately 1.4 terawatts (TW), or 1,400 GW, as compared to 1.5 TW in the 70% impact reduction scenario, an increase of 7%. Under the 70% impact reduction scenario, about 32% of the 2050 energy portfolio occurs in energy communities and energy communities hosting clean energy include 23 million people, compared to 21 million people in the siting-as-usual scenario. Deployment in these areas may also offer opportunities for repurposing existing infrastructure — such as transmission and roads.

5

All scenarios require major expansion of inter-regional transmission capacity, but lower-impact scenarios require less investment in new infrastructure

Transmission is widely recognized as a significant barrier to the deployment of clean energy: there's not enough capacity to carry all of the clean energy to where it is needed. Under all scenarios considered, a significant expansion of inter-regional transmission will be needed to reach net-zero emissions by 2050 — 2.5x at the low end and 3.5x at the high end. Inter-regional transmission is that infrastructure — the wires and towers — that brings power across electricity market boundaries.

However, as researchers reduced environmental and social impacts, the model showed less inter-regional transition is needed (*see* Figure 6). Under the 70% impact reduction scenario, we also see a switch to more solar and less wind. This switch means less new inter-regional transmission is needed because solar is built closer to densely populated areas, requiring less infrastructure expansion.

Inter-regional transmission capacity needs drop by almost 30% between the 70% impact reduction scenario and siting-as-usual. The 70% scenario also reduces the required amount of generation interties (gen-tie) — the short-distance wires needed to bring electricity generation projects to the grid–by almost 20%.

Jack's Solar Garden, Longmont | Joe DelNero, NREL

Figure 6.

GW-miles of additional inter-regional transmission and gen-ties needed under each impact reduction scenario.

GW-miles of additional inter-regional transmission infrastructure required under each impact reduction scenario, and GW-miles of gen-tie distribution infrastructure needed under each impact reduction scenario.

REDUCTION IN ENVIRONMENTAL IMPACT	**GW-MILES** *inter-regional transmission*	**GW-MILES** *gen-tie transmission*
0%	283,000	27,000
10%	279,000	27,000
20%	272,000	26,000
30%	264,000	26,000
40%	248,000	25,000
50%	233,000	24,000
60%	219,000	23,000
70%	202,000	22,000
80%	191,000	21,000
90%	144,000	22,000

Previous studies, such as *Power of Place–West*, have shown that we can also significantly reduce the amount of new transmission needed through grid upgrades and co-locating additional capacity within existing electrical utility rights-of-way. Reconductoring, the practice of replacing old transmission cables with bigger, modernized cables on existing towers, is a good example of a grid upgrade that requires no additional land.

6

Ideal impact reduction strategies and the technologies to achieve them will vary by region

Ecosystems, wildlife, land use, demographics, and energy resource potential vary widely across the United States, changing significantly from one region to the next. In addition, states and regions may favor different technologies and timelines to reach emissions reduction goals, focus on different impact reduction scenarios, or emphasize different resource tradeoffs. As a result, approaches to reducing impacts from clean energy deployment vary considerably across the six regions analyzed (*see* Figure 7). In each region, researchers identified the renewable supply portfolio, residual impacts to species and habitats, and the population in energy communities that host renewable energy projects under the 70% impact reduction scenario. It should be noted that even within regions there can be considerable diversity in the potential of specific technologies and land-saving solutions.

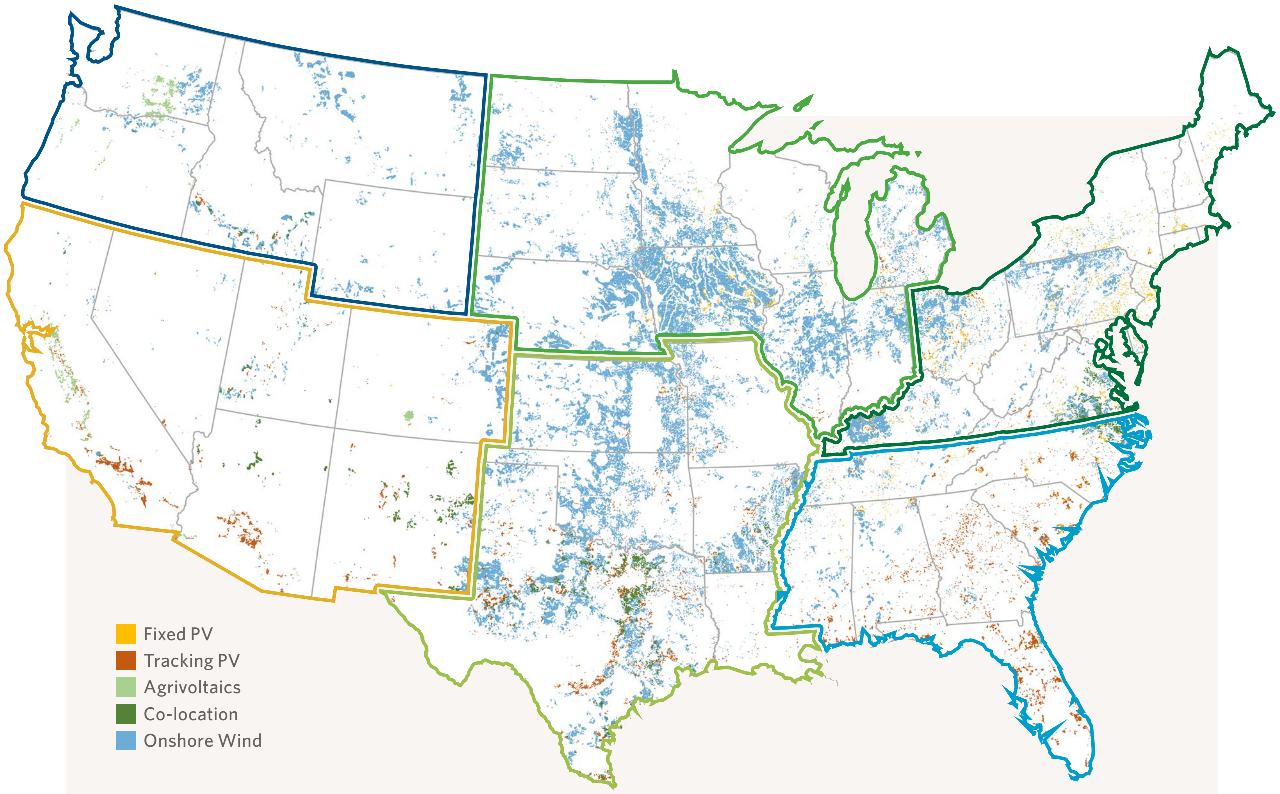


Figure 7.

Renewable energy distribution under 70% impact reduction scenario

Under the 70% impact reduction scenario, renewable technologies will be widely distributed across all six regions of the United States.

KEY VARIABLES IN REGIONAL ANALYSES

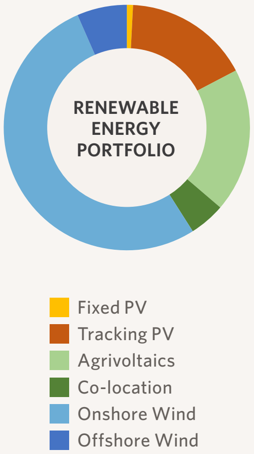
Renewable Energy Portfolios. *Under the 70% impact reduction scenario, the portfolio of renewable energy technologies (including onshore wind, offshore wind, solar tracking and fixed photovoltaics) and land-saving approaches (co-location of wind and solar, agivoltaics, and fixed tilt PV) vary by region. Most regions are dominated either by solar (Southeast, Mid-Continent South, Southwest) or onshore wind (Mid-Continent North, Northwest). The Northeast has the largest contribution from offshore wind energy.*

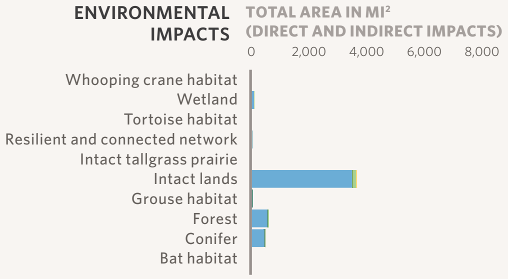
Environmental Impacts to Species and Habitat. *Researchers evaluated total impacts (see Methods) to habitats and species most sensitive to wind and solar development under the 70% impact reduction scenario. The habitat types include wetlands, tallgrass prairie, all forest, conifer forest, intact lands, and lands in The Nature Conservancy's Resilient and Connected Network. Species included whooping cranes, gopher and desert tortoise, grassland grouse, and bats. While the study considered the best available environmental data for each of these species, not all habitat types are present in some regions due to data limitations and species ranges.*

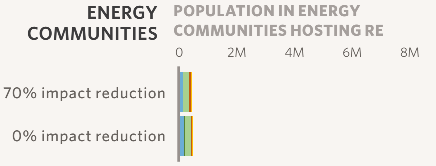
Energy Communities. *The Inflation Reduction Act provides incentives for deploying clean energy in "energy communities" (see Box 2). Researchers evaluated the number of people in energy communities under the 70% impact reduction scenario. Regions with the most people in energy communities under this scenario are in the Mid-Continent and Northeast.*

A

Northwest

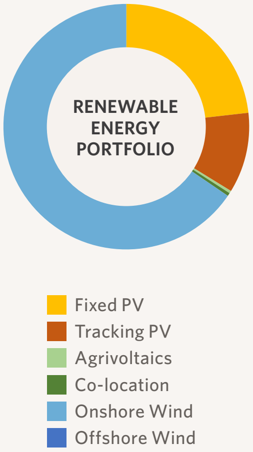


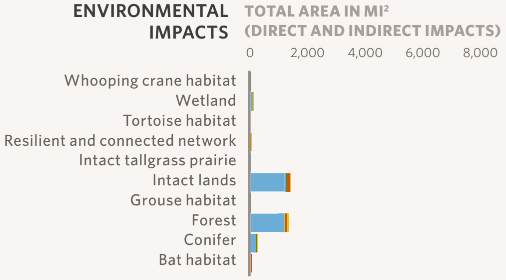


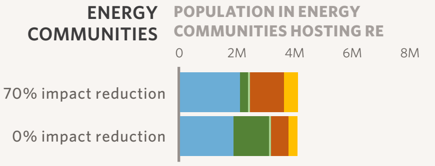


B

Mid-continent North

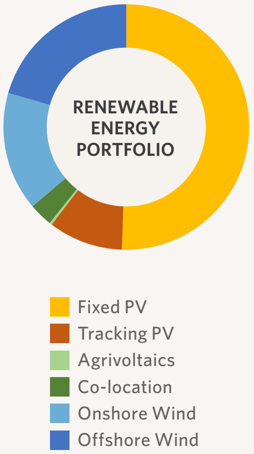


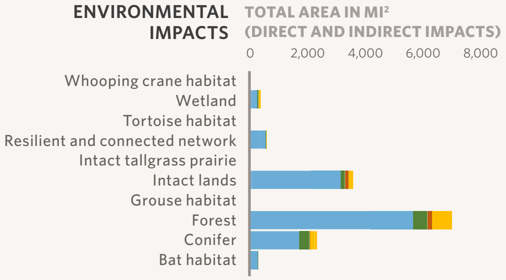


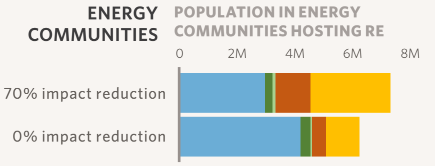


C

Northeast

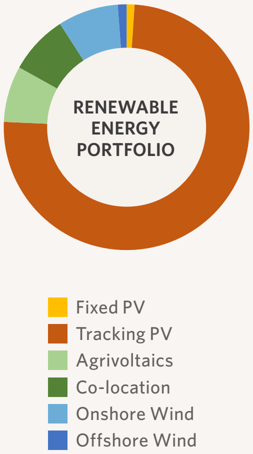


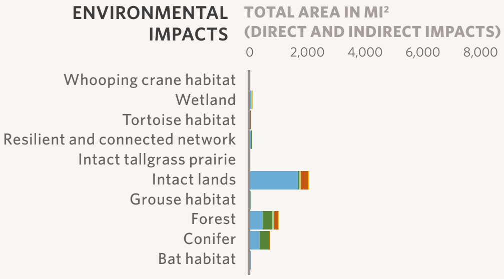


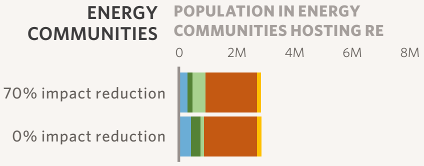


D

Southwest

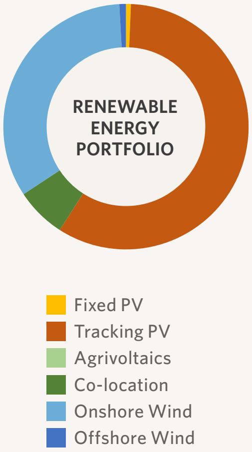


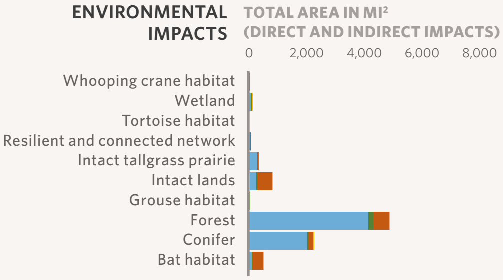


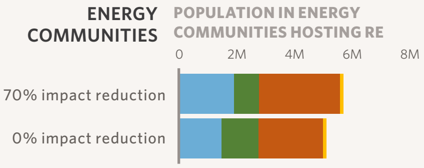


E

Mid-continent South

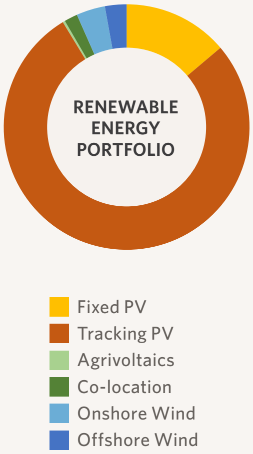


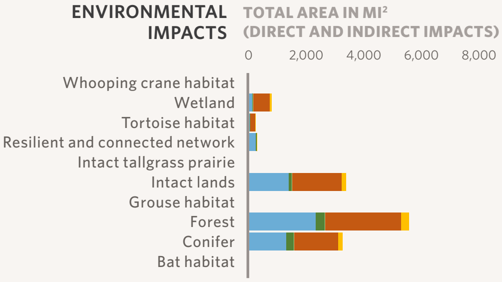


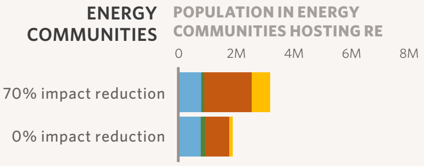


F

Southeast







Policy Recommendations

The *Power of Place–National* study finds there are and will continue to be difficult tradeoffs between minimizing disruption to communities, protecting important natural areas, maintaining highly productive croplands, and deploying responsible, equitable clean energy infrastructure. Many impacts, however, can be avoided through long-term energy planning that incorporates environmental and social data and policies that incentivize clean energy deployment in low-impact areas. The following policy recommendations provide a framework for designing and implementing the policies and practices needed to accelerate clean energy while maximizing positive outcomes for climate, conservation, and communities.

1

Plan for nature and people at all levels

The *Power of Place–National* methodology demonstrates that by utilizing high-resolution conservation, land use, and demographic data, we can optimize benefits and minimize unnecessary tradeoffs on the path to decarbonization. Environmentally and socially informed planning is needed at all levels: national, regional, state, and local. In addition, different planning opportunities are available on public and private lands, as well as offshore.

Much planning has been done and must continue to happen as energy development activity ramps up. The clean energy transition will take time, and we need a long-term vision for how we complete it.

Because most energy siting decisions are made at the state and local levels, decision-makers at both levels need roadmaps that lay out the long-term vision for decarbonization, including the mix of technologies that will be required, the most effective land-saving strategies, and the amount and type of transmission investments. Transmission planning is especially important because it sets the stage for future clean energy investments and can help unlock low-impact areas for development. Having these plans in place empowers state and local policy-makers to envision their role in decarbonization, proactively adopt the incentives and other mechanisms needed to avoid unnecessary conflict, protect natural and working lands and waters, and maximize localized co-benefits.

The data on which *Power of Place–National* is based can be a starting point for undertaking this planning. However, regions, states, and localities may want to include other conservation and community data, as well as clean energy targets and timelines, that reflect their unique values, priorities, and geographic particularities.

Finally, but just as importantly, process matters. Inclusive, participatory planning processes are needed to ensure that economic and environmental benefits and burdens from decarbonization are shared equitably. Indigenous and frontline communities must be included in clean energy infrastructure planning and decision-making. There are significant, existing, and well-supported guidelines and best practices that should be used (*see* Box 5). These resources highlight how to enhance and support public involvement and the engagement of environmental justice communities, including communities of color and low-income communities already overburdened by cumulative environmental impacts and those historically marginalized in public decision-making.

BOX 5.

Sample of Additional Resources on Participatory Planning and Engagement

Resources on Tribal Engagement

- Voices from the West – A companion document to *Power of Place–West* that summarizes interviews with leaders in Indigenous organizations serving Tribes on energy-related issues, and Tribal utility managers who have first-hand knowledge of energy infrastructure that provides a perspective on the importance of including Tribal voices in energy and infrastructure planning, permitting, and development from the start.

Resources on Community-Driven Engagement Processes

- Community-Driven Engagement Processes – A toolkit developed by the Georgetown Climate Center that provides recommendations on meaningful community engagement involving affected frontline communities at the earliest stages of decision-making.
- The Spectrum of Community Engagement to Ownership – Developed by Facilitating Power, a resource that charts a pathway to strengthen and transform our local democracies.

Resources on Alternative Dispute Resolution

- Association for Conflict Resolution Environmental and Public Policy
- International Association for Public Participation: The Pillars of Public Participation

2 Adopt regionally appropriate incentives

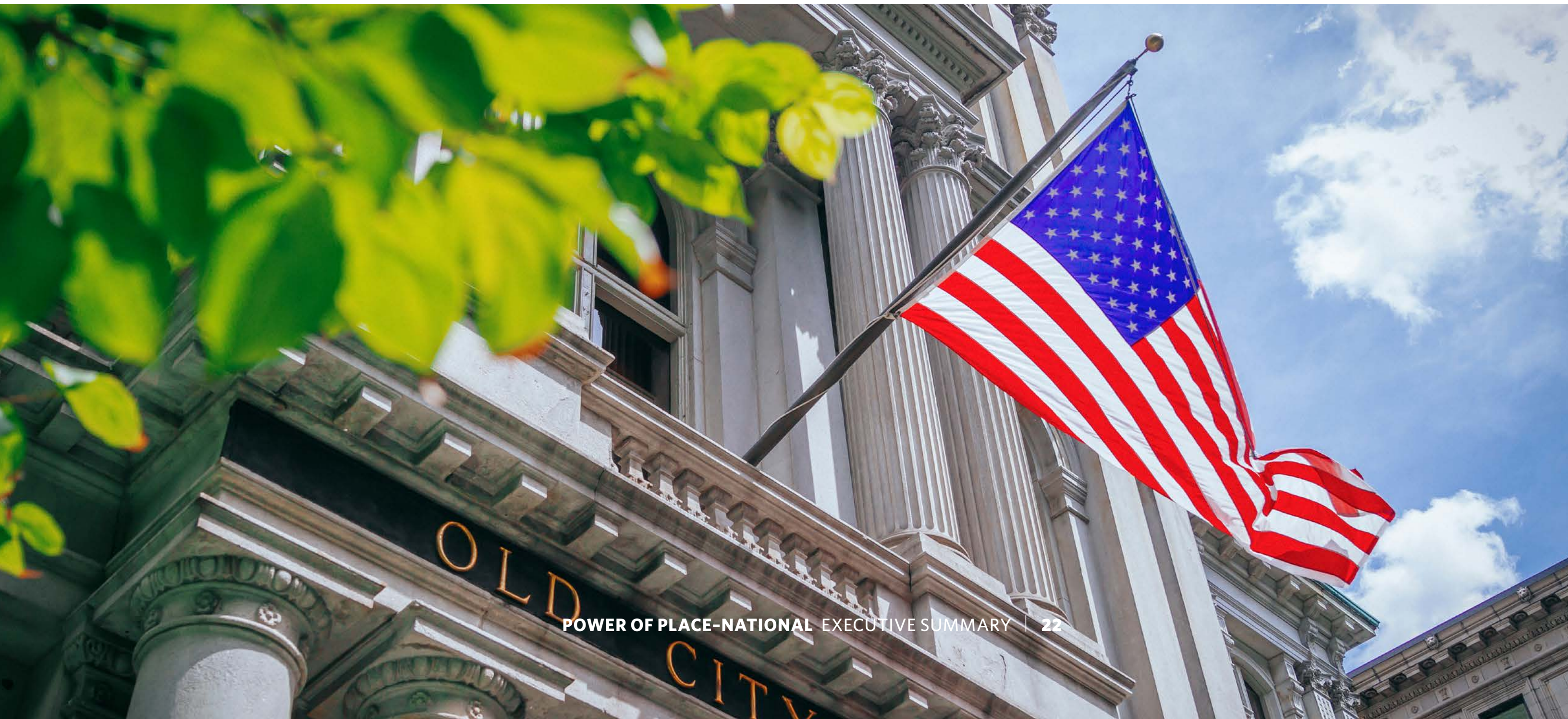
The U.S. is highly diverse economically, environmentally, and socially. Land ownership patterns and dominant land uses also differ from region to region. The way state electricity markets are structured across the country is not uniform. Federal policy is critical to supporting the mix of technologies and land-saving renewable energy approaches that maximize benefits for climate, conservation, and communities. State policy solutions are also essential and need to be tailored to the circumstances of the geography. Coordination between states and the federal government can amplify the right mix of policy solutions.

For example, on public lands across the 11 western states, the Bureau of Land Management (BLM) manages roughly half of all land areas. This gives BLM a unique ability to plan where and what kinds of clean energy technologies and related transmission are deployed and create a glide path for the approval of projects in low-impact renewable energy zones. The agency adopted a Western Solar Plan in 2012 covering six states and is considering expanding the geography and approach across all 11 western states in a revised solar plan.

In states where agriculture is a dominant land use, the Natural Resources Conservation Service and state agriculture agencies can provide support for solar on lands not well-suited for agriculture and adoption of land-saving renewable energy approaches, such as agrivoltaics, while avoiding highly productive cropland. Both federal and state policy-makers have created incentives for clean energy deployment in energy communities or on previously degraded lands, such as mine lands, brownfields, and landfills. This includes a federal tax incentive in the Inflation Reduction Act for clean energy development on brownfields or in energy communities. States as varied as Illinois, Maine, Massachusetts, Minnesota, Nevada, and West Virginia have also adopted state legislation that incentivizes deployment on these lands. As demonstrated by this study, additional incentives are needed to overcome remaining barriers and generate more developer interest in energy communities or on previously developed lands.

Public utility commissions (PUCs) play an important role in approving utility investments in new generation, and deciding whether they can pass along the costs of new investments to customers. There are opportunities to expand how these bodies evaluate and approve projects. While many PUCs are constrained to only allowing “least cost” options, some have expanded the definition of what values can be considered in these determinations. For example, states such as California, Maine, Minnesota, and North Dakota, have allowed PUCs to consider a wider array of costs and benefits in their determinations.

When informed by an understanding of which clean energy technologies best fit each state and region, state and federal policy-makers can be powerful enablers of a responsible energy buildout.



3 Allow projects that have mitigated risk to “jump the line”

Renewable energy projects in the project interconnection and environmental review pipelines are typically reviewed on a first-come first-served basis rather than by their financial, environmental, and social risks. Rapidly expanding investments in wind, solar, and energy storage projects result in interconnection backlogs and an overwhelmed review and permitting process.

A growing number of renewable energy projects–an astounding 80% of wind projects and 84% of solar projects–are never completed after they enter an interconnection queue. Renewable energy developers often don’t know what kinds of grid investments they will need to make to interconnect until late in the process and are incentivized to swamp the queue with projects that may not be financially viable. In addition, environmental and other project review and approval processes at the state and local levels can become overrun.

Projects that have mitigated environmental and social risk in advance should be allowed to “jump the line” and be given priority for interconnection and environmental review. Considerations for eligible projects should include those that avoid the most sensitive natural and working lands and vulnerable communities, equitably share benefits with communities, minimize impacts through project design, and offset impacts that cannot be avoided or minimized.

For example, grid operators could choose, or the Federal Energy Regulatory Commission could direct grid operators, to allow groups of projects that clearly and demonstrably have avoided or minimized environmental and social impacts to be prioritized for interconnection study, a process often referred to as “first ready, first-served.”

Several states have established “one-stop shopping” offices for clean energy project review to help renewable energy projects navigate the often-complex state and local permitting process. Some states have also created an expedited and consolidated process to approve projects meeting certain criteria, including minimization of environmental and community impacts. Such programs can establish coordinated processes with predictable timelines and provide ample opportunity for funding to local communities to enable active engagement in project review. To be eligible for such processes, projects should also be strongly incentivized or required to enter into community benefit agreements with host localities to ensure that local communities benefit from such projects. New York has taken such an approach with its newly established Office of Renewable Energy Siting. Other states, such as California, Massachusetts, and New Jersey, have adopted similar approaches.

4 Ensure community engagement and equitable benefit sharing

Most clean energy projects will primarily benefit consumers that are far removed from the rural communities where the energy is generated. Communities that have been reliant on conventional energy resources may be concerned that the shift to renewables will not bring permanent, good paying jobs. And regions with a strong agricultural tradition often express concern over the changing character of an area. More generally, the benefits of clean energy, such as new local tax revenue, are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often difficult for residents to see or are perceived as inadequate compared to the changes a project brings to a community. These factors have, in part, helped stoke resistance to the deployment of wind and solar projects in local jurisdictions nationwide and perpetuated inequities in how the benefits of clean energy are distributed.

Planning a clean energy future should be done with the engagement and input of the communities where new energy projects are being built. An inclusive process means not only allowing opportunities for public comment, but taking the time to meaningfully engage, educate, and amplify local voices. Policy-makers at state and regional levels should place a particular emphasis on designing energy project siting, review, and approval processes to ensure that the voices of environmental justice communities — who have been historically negatively impacted by energy development — are heard.

In addition, there are many ways to ensure that the benefits of the transition are shared more equitably. Federal lawmakers recognized this when they included a provision in the Infrastructure Investment and Jobs Act directing $760 million in grants to state and local governments for economic development activities in communities affected by the construction and operation of transmission projects. Similarly, to be eligible for New York State's one-stop permit review process, projects must demonstrate that they have consulted with the host community, and project permits must include a community benefit agreement before being approved. These agreements can codify a commitment from developers to fund priority community projects or to use local contractors for project development and operation and maintenance. States can also provide grant funding to communities for local projects if they meet certain eligibility requirements, such as undertaking decarbonization planning and adoption of balanced, permissible ordinances for renewable energy generation and storage projects.

These kinds of approaches are steps in the right direction for ensuring that the benefits of the clean energy transition are shared equitably and with robust, meaningful community engagement.

5 Adopt incentives to encourage land-saving approaches on croplands

A range of incentives and approaches should be used to reduce greenhouse gas emissions while maintaining agricultural production. First and foremost, decision-makers should avoid deployment on highly productive croplands except where agrivoltaics are suitable. We should also increase incentives for land-saving approaches, such as co-location of wind and solar on appropriate agricultural lands and agrivoltaics. In particularly drought-prone areas, it may be important to consider water allocation issues before incentivizing agrivoltaics.

Current incentives are not sufficient to significantly increase the use of land-saving approaches. The Federal Farm Bill and state legislation can bolster the funding available to agricultural producers to embrace these practices. At the state level, Massachusetts and New Jersey have adopted programs incentivizing agrivoltaics, and several other states are considering innovative approaches. Federal and state decision-makers can also explore incentives for siting low-water intensity clean energy on lands that are no longer productive due to water resource restrictions and prolonged drought in some regions of the arid west.

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6 Prioritize transmission investments in inter-regional connections and existing infrastructure

A significant amount of the additional capacity needed to support the net-zero transition can be achieved through investment in grid upgrades and co-locating additional capacity within existing rights-of-way. This was demonstrated in *Power of Place–West* and other recent studies. This is a win-win-win because it minimizes incremental land impacts, can potentially be built faster, and may be done at lower cost. Technologies — both hardware and software — that modernize the electric grid and inject flexibility and resilience into its operation are also necessary to the energy transition.

Federal and state regulators can expedite review and approval of lower impact transmission investments, such as grid upgrades (including reconductoring), projects co-located in existing electrical and transportation rights-of-way, and new transmission infrastructure that has been de-risked. Regulators can also incentivize investments in these projects through the way costs are allocated to customers.

In addition, as previously discussed (*see* Result 5), technology shifts and land-saving approaches can also reduce the investments needed in inter-regional transmission and system upgrades. By prioritizing upgrades to existing infrastructure, in addition to building new transmission lines, transmission planners and developers can limit the amount of new construction needed. This has the potential to accelerate grid capacity expansion and minimize land impacts. Reconductoring is one example of a meaningful improvement to the grid that will enable more clean energy utilization without damaging wildlife habitat or disrupting communities.

Conclusion

Informed, integrated energy planning and policy can ensure community benefits, minimize negative environmental impacts, and control costs while achieving net-zero greenhouse gas emissions in the U.S. by mid-century. A thoughtful approach to energy development would also deliver measurable co-benefits to Americans and the economy, such as reductions in air and water pollution that improve public health and environmental quality.

The investment needed to decarbonize the economy is significant – at least $1.87 trillion. The scale of development required for the clean energy transition is larger than that needed to build the U.S. interstate highway system between the 1950s and 1980s. All of this needs to happen within an energy system unprepared to accommodate rapid change, growing local resistance, and overwhelmed project review and approval processes at all levels of government. Thoughtful planning and siting, along with complementary policies, can help address many of these challenges. Not only is it cost-effective and beneficial to people and nature, but failing to employ these solutions jeopardizes our ability to achieve net zero by 2050.

The path we take to a net-zero economy will determine how many co-benefits the clean energy transition will generate along the way. Where, when, and how clean energy technologies are developed matters. Without careful planning, we run the risk of addressing our energy needs at the cost of local communities, natural areas, and wildlife. With informed, equitable, and early planning, by optimizing the mix of technologies we deploy, incentivizing land-saving renewable energy approaches, and making wise investments, we can create a future where climate, nature, and people thrive.

Methods

STEP 1. Develop environmental and social impact scores

To find suitable areas for clean energy development, researchers first identified and extracted areas designated as legally protected from development (i.e. Environmental Exclusion Category 1 in previous *Power of Place* studies). The remaining areas were identified as suitable for solar and wind development and assigned an environmental and social impact score using multiple environmental and social datasets, establishing a dynamic impact avoidance scoring system.

The higher the impact score, the more significant the negative environmental or social impact, and the more the model steered away from those places.

To generate the environmental score for onshore renewable projects, researchers performed a weighted sum of the following broad categories of datasets (with their weights in parentheses): wetlands (30), administratively protected areas (15) (Environmental Exclusion Category 2 in previous *Power of Place* studies), intact habitat (10), threatened and endangered species habitat and occurrences (5), focal bird habitat (5), bat habitat and occurrences (3; wind only). It is important to note that occurrences, abundance, and presence may not translate to species impacts, especially as technologies, research, and monitoring evolve. For the social impact score, researchers used the following datasets and weights: highly productive croplands (15; solar-only), scenic areas (15), recreational areas (10), populated areas (5), energy communities as defined by the Inflation Reduction Act that focus on historic fossil fuel industries (*see* Box 2) (-5), and marginal farmland (-5). The scores of most environmental categories (except focal bird and bat habitat) were discounted by 50% for wind to account for the fact that a wind farm's direct land use is far less than that of a solar farm.

Total (direct and indirect) land/area use assumptions are as follows: 58 MW/km for fixed tilt PV, 40 MW/km^2 for single-axis tracking PV, 2.7 MW/km^2 for onshore wind, and 5 MW/km^2 for offshore wind. Co-location assumed a 1:2 ratio of wind to tracking PV (or 8.1 MW/km^2). To estimate direct impacts, we applied the following percentages to the total impacts: 91% for solar, 3% for wind, 50% for co-location. For further clarification, see sources of indirect (total) land use assumptions for wind and solar: Hise et al., 2022; Wu et al., 2022.

STEP 2. Identify and characterize multi-technology Candidate Project Areas

Candidate Project Areas (CPA) are roughly one square mile areas suitable for onshore wind, solar, agrivoltaics, or offshore wind project development. Suitability was defined using a comprehensive set of social, environmental, and technical criteria for each major renewable technology. These include, legally protected areas (Siting Level 1 in previous versions of *Power of Place*), building setbacks, buffered distance from airports or airstrips, slope, and population density.

For onshore technologies, researchers characterized the potential for the following types of technologies and/or siting strategies within each Candidate Project Area (CPA): fixed tilt solar PV-only, single-axis tracking solar PV-only, co-location of onshore wind and single-axis tracking PV, agrivoltaics with single-axis tracking PV, and onshore wind-only. Solar PV CPAs could be eligible for developing fixed and tracking solar PV CPAs, which differ in their capacity factors, and are modeled using solar radiation time series data and the System Advisory Model (SAM), as well as in their land use efficiency factors (higher values for fixed and lower values for tracking). An extensive literature review on crop suitability for agrivoltaics informed the following list of crops researchers have deemed the most compatible with solar PV development with single-axis tracking: cucumbers, tomatoes, grapes, broccoli, peppers, lettuce, cabbage, cauliflower, potato, celery, and miscellaneous fruits and vegetables. Researchers identified areas growing these crops in the U.S. using the U.S. Department of Agriculture Cropscape dataset for the year 2021 and intersected these areas with the single-axis tracking solar PV CPAs to generate agrivoltaic CPAs. To generate co-location CPAs, analysts identified the areas of overlap between onshore wind and solar PV CPAs and used land use efficiencies based on a 1:2 ratio of wind to solar installed capacity.

STEP 3. Develop transmission assumptions

After identifying CPAs for each technology, researchers generated the least-cost transmission paths to connect CPAs to the nearest existing or planned substation. Modeled transmission routes avoided legally protected areas and considered the cost and difficulty associated with developing lines in more complex terrains, different land cover types, and in areas with environmental sensitivity. Interzonal transmission availability was based on non-spatially-explicit supply of new high voltage transmission lines (e.g., MW of potential transmission capacity and their cost between zones). The amount of additional interzonal transmission capacity required in each scenario was determined on a cost basis by RIO using this supply curve.

STEP 4. Undertake energy capacity modeling

Electrical and fuel demand were estimated out to 2050 to design energy portfolios necessary to achieve economy-wide carbon neutrality in the U.S. The energy portfolios were developed using the EnergyPATHWAYS and RIO models. EnergyPATHWAYS is a detailed stock-rollover accounting model that tracks infrastructure stocks, energy demand by type, and cost every year, for all energy-consuming technologies. RIO is a linear programming model that combines capacity expansion with sequential hourly operations over a sampling of representative days to find the lowest-cost solution for decarbonized energy supply. These models designed energy portfolios based on current and emerging technologies, but they did not account for technological breakthroughs that may occur in time to influence the clean energy transition between now and 2050. The CPAs and their associated gen-tie costs generated in Step 2 were aggregated based on capacity factor, gen-tie cost, regional zones (EPA eGRID zones), social impact score, and environmental impact score, and provided as the available supply of wind and solar projects for RIO. New decision variables were added to allow the model to cost-competitively select between co-location or wind-only or between fixed tilt PV or single-axis tracking PV. New interregional electricity transmission, hydrogen pipelines, and CO^2 pipelines are explicitly represented in RIO and are based on the 2022 Annual Decarbonization Perspective. Initial RIO model runs evaluated the energy portfolio when unconstrained by environmental and social impact. Subsequent scenarios were designed to explore energy portfolio changes resulting from reducing the unconstrained environmental and social impact by increments of increments of 10% — ranging from 90% to 10% (e.g., the 90% scenario capped environmental and social impacts).

STEP 5. Spatially downscale energy portfolios

To determine which CPAs would likely be developed, researchers generated a model to predict the probability of wind and solar development. Essentially, the model identifies the places that are most similar to the locations where onshore wind and solar farms have been developed in the last five years. All of the new energy identified in Step 3 is predicted to be built in these places, starting with the places that are most similar. Specifically, researchers used an empirical random forest regression approach using the following 11 variables to predict the probability of development: Environmental exclusion categories (environmental sensitivity), land acquisition cost, population density, distance to roads, distance to existing and proposed substations, distance to existing and proposed transmission lines, slope, capacity factor, renewable portfolio standards, unemployment, and regional dummy variables.

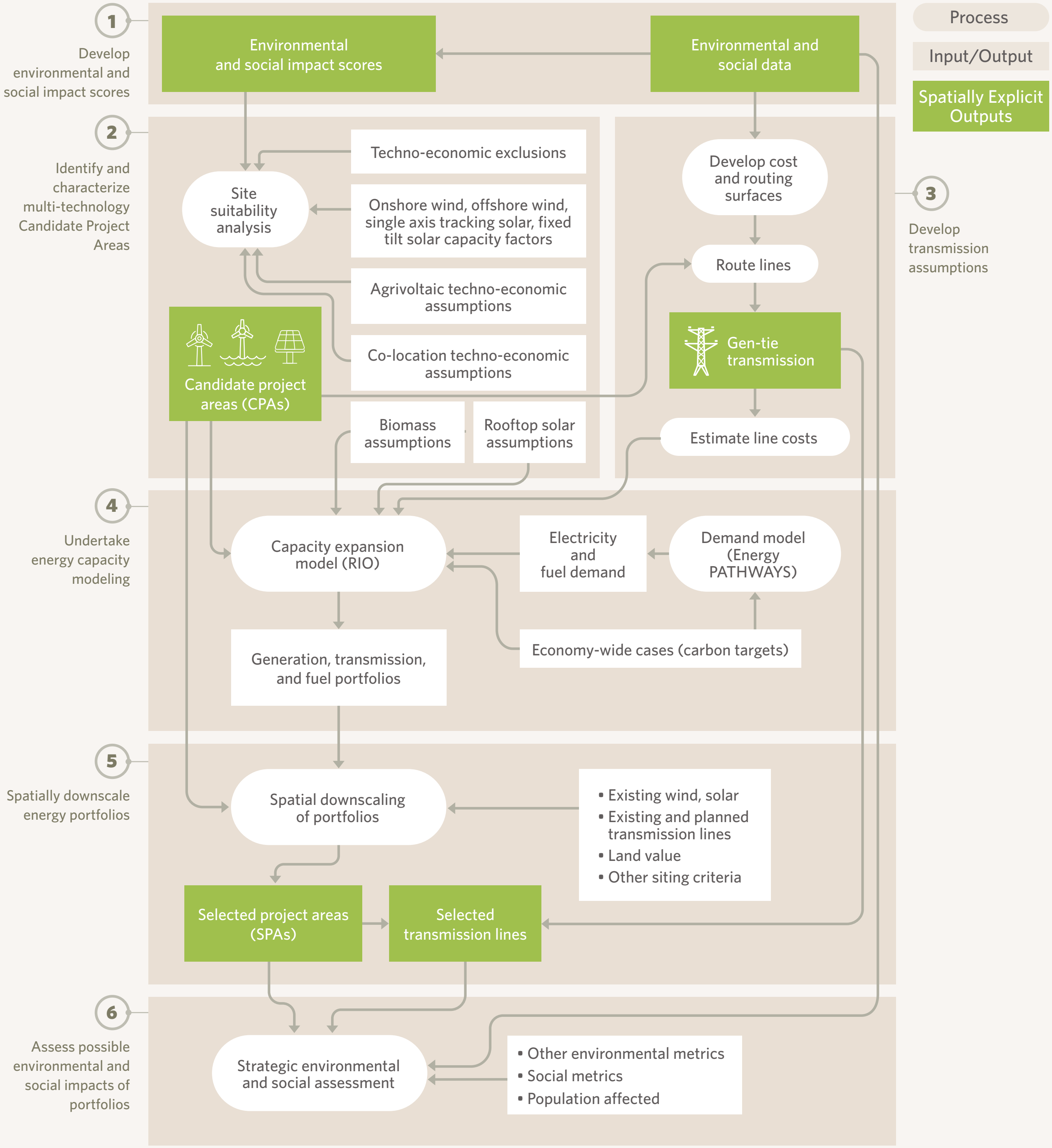
STEP 6. Assess possible environmental and social impacts of portfolios

Researchers quantified potential impacts to natural areas and working lands based on the location of downscaled energy infrastructure. Land area types assessed included administratively protected and high conservation value areas (Environmental Exclusions Categories 2 and 3, croplands, highly productive croplands, marginal farmland, wetlands, forests, conifer forest, shrublands, grasslands, resilient and connected network, intact lands (the least modified places based on the Human Modification Index), intact tallgrass prairie, grouse habitat (i.e., sage grouse and prairie chicken), sensitive desert species habitat (i.e., desert and gopher tortoises), whooping crane habitat and range, bat habitat, public lands, and other sensitive areas. Additionally, researchers estimated the number of energy community census tracts and the number of low-income census tracts that would host a renewable energy project (i.e., projects that would receive Inflation Reduction Act tax incentives). Finally, researchers summarized disaggregated or downscaled results at the six identified regional levels: Northwest, Southwest, Mid-Continent North, Mid-Continent South, Northeast, Southeast.

Figure 8.

Power of Place–National Modeling Methods

The study approach consisted of six key stages with several interdependencies between stages, as indicated by the arrows. See methods section for a description of each stage of the analysis.



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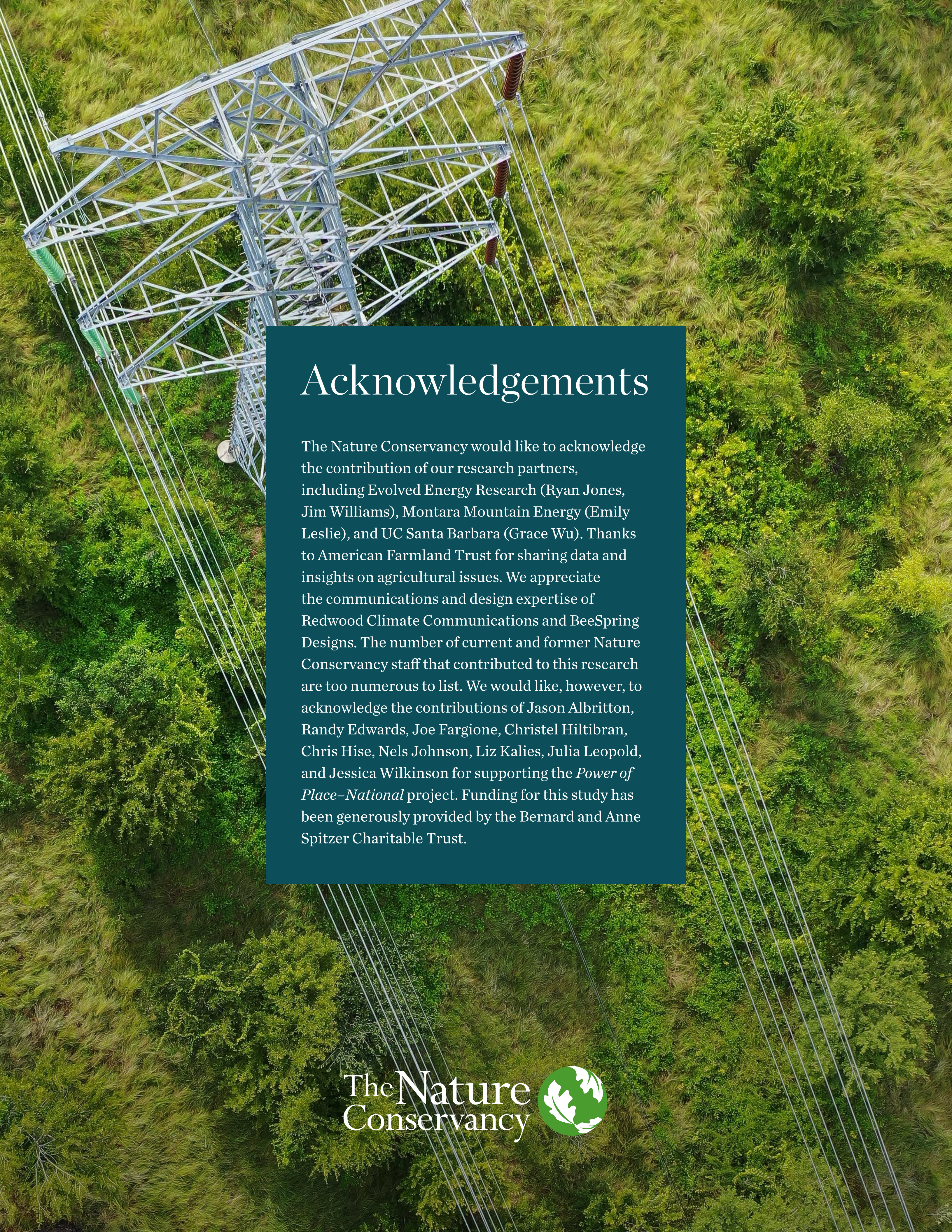

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