Key Economic Benefits of Renewable Energy on Public Lands

Yale Center for Business and the Environment

The Wilderness Society

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A digital version of this report can be found at https://cbey.yale.edu/renewable-energy-on-public-lands-report and www.wilderness.org/renewableenergyreport.

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Renewable energy on public lands is already generating billions of dollars in capital investment; hundreds of millions in federal, state, and local revenue; and thousands of jobs. A smart approach to responsible development can further boost our economy while preserving special places and providing a range of environmental benefits.

EXECUTIVE SUMMARY

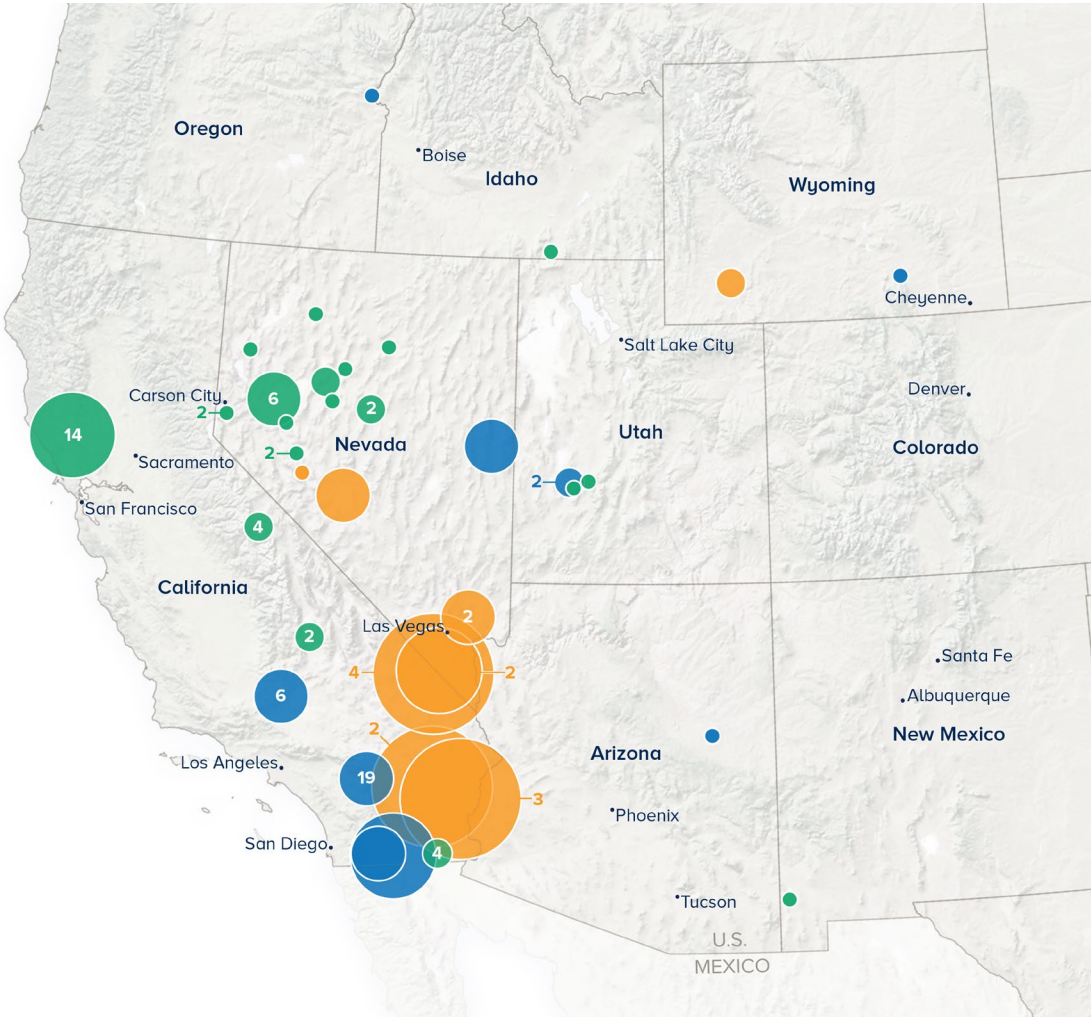

FIGURE 1

Megawatt Capacity of Renewable Energy Projects Operating on Federal Public Lands in 2019

Circle size does not represent land area. Map by Marty Schnure and Mackenzie Bosher, The Wilderness Society. Data source: BLM.

America's federal public lands have been an important source of energy for over a century, along with providing other important resources and amenities like clean air and water, recreation opportunities, and sustaining wildlands and wildlife habitat.[1] Our nation's energy needs continue to grow and evolve, and renewable energy generation on public lands has now also become a contributor to a diverse and sustainable national energy portfolio.

Renewable energy generation on public lands makes important contributions to our economy. These projects represent billions of dollars in capital investments and provide thousands of construction and operations and maintenance jobs. Once online, the projects provide steady revenue to the U.S. Treasury as well as state and local governments. They also provide other important local economic benefits, including for some rural communities with few other economic opportunities. Renewable energy can also be part of a strategy to help communities currently dependent on fossil fuel production diversify their economies. **Solar, wind, and geothermal energy also reduce our dependence on fossil fuels, which protects our clean air and water and helps address the threat of climate change.**

Although increased renewable energy development has many benefits, it is not without its own impacts and challenges, and poorly sited projects can threaten important wildlands, wildlife habitat and cultural resources. Stakeholders have pushed for a "smart" approach to siting renewable energy infrastructure to address these issues, and the Bureau of Land Management (BLM) has developed a suite of policies in response. This smart approach can facilitate more efficient project permitting and responsible use of public lands by focusing development in areas with high energy potential and lower environmental impacts and other conflicts, helping protect our extraordinary deserts, mountains, forests, and rivers for future generations. **Though progress on implementation has slowed drastically in recent years, we can achieve these goals through continued investment in and commitment to the smart approach, as described in this report.**

This report compiles and assesses some of the key economic benefits of onshore renewable energy generated from wind, solar, and geothermal resources on public lands managed by the BLM.[2] It also highlights the success of the Dry Lake Solar Energy Zone in focusing development in priority areas, and emphasizes the economic, procedural, and environmental benefits of developing renewable energy using the BLM's smart approach.

As shown by this report, there is immense value in continuing to support the responsible development of renewable energy on public lands. In 2019 there were 96 utility-scale solar, wind, and geothermal projects operating on public lands with a total generation capacity of over 5,000 megawatts (MW), enough energy to power over two million homes (see Figures 1 and 2). The best available data show that rent and royalty payments from renewable energy development on public lands have contributed over $660 million in 2019 dollars to federal, state, and local governments since 1982.[3] This report concludes that the capital costs for construction of the renewable energy projects operating on public lands have contributed over $13 billion in 2019 dollars to the economy since 1996.[4] Estimates show that these projects have created over 12,000 construction jobs and over 1,700 operations and maintenance jobs. These estimates are gathered from the multiple federal agencies that manage this development. This report also identifies the steps needed to sustain and increase this development going forward.

Through thoughtful and strategic action, we can ensure the responsible, economically beneficial development and generation of renewable energy on public lands, while preserving special places for current and future generations.

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INTRODUCTION

Alex Daue

THE VAST AND VARIED VALUE OF AMERICA'S PUBLIC LANDS

The immense and unique value of America's public lands is undeniable. The United States has over 640 million acres of public lands managed by the BLM, the U.S. Forest Service, the National Park Service and other federal agencies. This land encompasses over one-quarter of the total land area of the United States, and we all benefit from these lands in a multitude of ways. While it is difficult to estimate their full market value, these lands have made significant contributions to the nation's economic growth and identity. For example, the Outdoor Industry Association's 2017 National Recreation Economy Report finds that our national parks alone host nearly 331 million visitors each year and that "national parks, national wildlife refuges, national monuments and other public lands and waters account for $45 billion in economic output and about 396,000 jobs nationwide."[5]

In addition to recreation income, studies have quantified the value of the ecosystem services provided by public lands, including air and water purification, wildlife habitat, biodiversity, nutrient cycling, and climate change mitigation. Sometimes deemed 'non-market' benefits by economists, ecosystem services provide essential benefits to human health and well-being. A 2009 study by the Gund Institute for Ecological Economics at the University of Vermont and The Wilderness Society estimated the value of ecosystem services on public lands to be more than $241 billion per year.[6]

Because they host such a wealth of resources, thoughtful agency guidance on the

management of our public lands is critical. The Federal Land Policy and Management Act requires these lands be managed under the dual mandate of multiple use and sustained yield, addressing the need to both generate economic value via natural resource use and extraction, and to protect these special lands for their ecological, cultural, and recreation values in perpetuity.

America's public lands offer a wide range of energy sources, including traditional coal, oil, and gas fields, as well as expansive deserts with solar and wind resources and pockets of geothermal energy deep within the earth. Abundant, readily available, and affordable energy has been a critical driver of America's growth, economic prosperity, and global leadership. However, as both our demand for energy and the environmental consequences of extracting fossil fuels continue to increase, people all across the country are changing the way they develop and source energy.

BENEFITS OF RENEWABLE ENERGY DEVELOPMENT

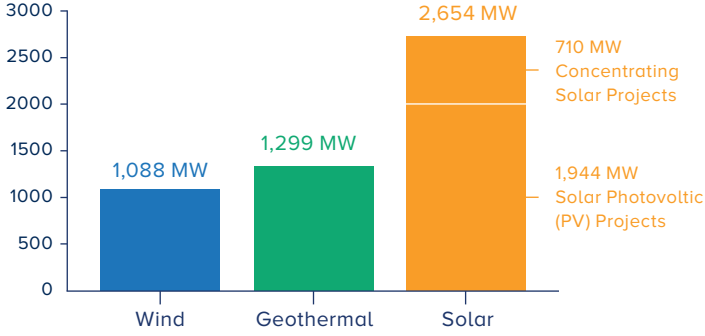
The benefits of renewable energy development and production are significant and numerous. In addition to the key economic benefits detailed in this report, energy produced from renewable sources also helps protect our shared environment and preserve other eco-system services, including reducing greenhouse gas emissions which helps address the threat of climate change.

FIGURE 2

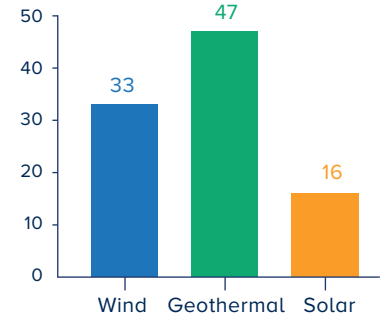
Generating Capacity (in MW) Of Renewable Energy Projects Operating On Public Lands In 2019

These projects can power over two million homes.

TOTAL GENERATING CAPACITY: 5,041 MW



TOTAL NUMBER OF PROJECTS: 96



Sustainable sources of energy, such as those from solar, wind, and geothermal resources, help stabilize the economy by reducing uncertainty in future energy prices and help to ensure the nation has a sufficient supply of energy for future generations. Increasing renewable energy development decreases our country's dependence on foreign oil, which helps support national security and eases foreign relations.

Renewable energy development also supports a strong domestic economy and creates jobs with competitive wages, often in rural or economically depressed areas, and further, helps sustain local economies via capital investments, taxes, and related economic activities. The development of large renewable energy projects can also prompt other infrastructure investments that provide additional benefits to local communities, such as roads and data communication infrastructure.

It is important to note that some communities whose economies are currently closely tied to fossil fuels, such as communities with many jobs in coal mines or at coal-fired power plants, are facing economic uncertainty as America's energy mix evolves. Renewable energy provides some important opportunities — for example, imagine a community facing a loss of jobs from a coal-fired power plant. If solar energy were developed nearby to take advantage of the existing transmission lines running from the coal-fired power plant, some solar construction and operations and maintenance jobs would be created. However, as a nation, we must ensure we are developing comprehensive plans to assist these communities as they diversify their economies. Given the differences in staffing requirements between the fossil fuel energy sector and the renewable energy sector, especially for long-term operations and maintenance jobs, truly comprehensive transition plans will likely require job training and investment in sectors beyond renewable energy alone.

Renewable energy development on public lands, particularly in the southwestern states, is becoming an important contributor to national, state, and local economies. As detailed in the following section, the Department of the Interior (DOI) and the BLM have established and are refining several strategies to continue to facilitate the positive economic impact of renewable energy development for the American public, while at the same time helping to reduce environmental impacts.

As of 2019 there were 96 utility-scale renewable energy projects operating on public lands (see Figures 1 and 2). In 2019, these projects had a total generating capacity of 5,041 MW; 2,654 MW of solar from 16 projects (including 1,944 MW of solar photovoltaic (PV) projects and 710 MW of concentrating solar projects), 1,299 MW of geothermal from 47 projects and 1,088 MW of wind from 33 projects.[7] The solar PV projects have the capacity to power about 453,244 homes.[8] The concentrating solar projects have the capacity to power about 303,000 homes.[9] In total, the solar projects can power about 756,244 homes. The geothermal projects can power about 1,007,325 homes.[10] The wind projects can power about 380,800 homes.[11] In total, these projects can power about 2,144,369 homes. The BLM has permitted over a dozen additional projects on public lands that will add thousands of megawatts of additional generation capacity when they are built.[12] The BLM has also permitted roads, water lines, and transmission lines across federal lands for numerous renewable energy projects on city, state, and private lands, and the BLM has worked with the Bureau of Indian Affairs to permit solar development on tribal lands.

As detailed below, while the projects operating on public lands are already providing important clean energy and economic benefits, they represent less than five percent of the total solar, wind, and geothermal capacity installed in the U.S., so there is significant opportunity for growth.[13]

THE IMPORTANCE OF RESPONSIBLE RENEWABLE ENERGY DEVELOPMENT

As described above, renewable energy offers many positive environmental benefits when compared with traditional energy generation from fossil fuels. However, no energy source is without impacts and large-scale renewable energy projects are no exception. Solar projects create a nearly exclusive use of hundreds or thousands of acres of land; wind projects have more dispersed impacts (from individual turbine towers and access roads) but the total acreage within project footprints is much larger; and geothermal projects require drilling, pipelines and other related infrastructure. Careful siting is crucial and key wildlands, wildlife habitat, and cultural resources should be protected from development of any kind, including renewable energy.

The extent of impacts from renewable energy projects can vary drastically depending on the technology type, location, project design, and operational strategy. Strategic siting to avoid sensitive areas, along with site-specific design considerations and operational and maintenance strategies, can reduce many negative environmental consequences, including direct, indirect, and cumulative impacts; conservation investments in land and habitat protection and restoration can also help offset unavoidable impacts.

To address these issues stakeholders pushed for a smart approach, and the BLM has revised its siting and environmental assessment approach for solar and wind development from a reactive, case-by-case basis to a proactive, regional perspective that incorporates the best available science from federal and state agencies, project developers, and the public to identify and assess pre-screened, priority development sites. Priority sites, known today as Designated Leasing Areas (DLAs), are selected using several criteria: excellent solar or wind resources, proximity to existing or planned transmission and highway corridors, and lower environmental, social, cultural, and recreational impacts (see Figure 3). The BLM has most of the tools it needs to advance responsible development, but the lack of progress in recent years on the agency's use of the smart approach demonstrates why it is imperative that the BLM and Congress continue to invest in strong implementation of the program.

FIGURE 3

Designated Leasing Area (DLA) Selection Criteria

DLAs are priority, lower-impact areas for renewable energy development on public lands, identified using these criteria:

- Excellent solar or wind resources
- Proximity to existing or planned transmission and highway corridors
- Lower environmental, social, cultural and recreational impacts

FIGURE 4

3 Principles For "Smart" Renewable Energy Development

The BLM's work on these policies was catalyzed by the passage of the Energy Policy Act of 2005 (EPAct 2005), which established permitting goals for new non-hydropower renewable energy facilities on public lands. To address a rapid increase in applications for solar energy projects, DOI agencies including the BLM, U.S. Fish and Wildlife Service, and National Park Service, began the important task of surveying key public lands and developing planning methodologies to identify priority sites (called "Solar Energy Zones" at the time and now known as DLAs) for solar energy on BLM lands in the six southwestern states through the creation of the 2012 Western Solar Plan (WSP).[14] The BLM, in consultation with its sister agencies, worked to identify DLAs in locations with excellent solar energy potential and lower environmental impacts. Note that while the majority of DLAs designated to-date are for solar energy, the BLM has also completed a regional assessment in the California Desert that designated some priority development sites that are available for both solar and wind energy development and are now classified as DLAs; this regional assessment also designated some priority development sites for geothermal energy.

The smart approach developed by the WSP follows three main principles: (1) identifying pre-screened, priority locations for development with the aim that they a) have excellent renewable energy resources, b) are close to existing or planned transmission infrastructure, and c) minimize environmental, cultural, and other resource impacts — and encouraging development in these DLAs via financial and efficient permitting incentives; (2) avoiding development in areas of high-quality wildlife habitat, areas managed to protect wilderness qualities, areas of tribal and cultural resource importance or other special places and in some cases buttressing protection for these areas; and (3) minimizing and/or offsetting those impacts that are unavoidable (see Figure 4).

The BLM codified this program for solar and expanded it to wind in its 2016 Solar and Wind

Energy Rule.[15] The agency has now designated 700,000 acres of priority DLAs on public lands through the WSP and other regional planning efforts. In addition to being pre-screened to reduce environmental conflicts, these areas also offer additional financial incentives for wind and solar projects via the Solar and Wind Energy Rule. Benefits include faster permitting, longer phase-in periods for megawatt capacity fees, and minimized developer risk through upfront completion of preliminary environmental reviews.

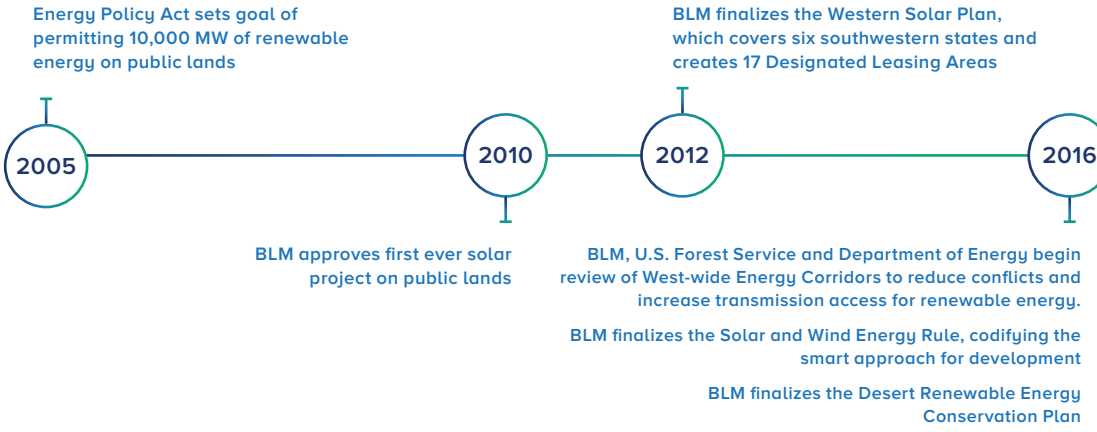
Successes like the Dry Lake Solar Energy Zone (detailed in the Dry Lake Case Study on page 23) show the value of this approach, but implementation of the BLM's new program is still a work in progress — for example, applications submitted under the BLM's old permitting system continue to work their way through the development pipeline and some poorly sited proposals for new projects have threatened sensitive areas. The BLM has also received recommendations to reduce its rents and other fees to ensure development on public lands remains competitive with development on private lands, and some of the BLM's efforts to designate new DLAs have not moved ahead as quickly as they might. However, on the whole these endeavors showcase how the smart approach can deliver better outcomes for both renewable energy and the environment so long as there is continued commitment to and investment in the program.

In addition to pre-screening suitable sites for development, the BLM has developed Regional Mitigation Strategies for several of the DLAs. These strategies help identify the anticipated impacts of development within the DLAs, assess the most pressing ecological concerns and recommend a mitigation fee to help pay for conservation, habitat protection, and restoration of threatened areas near a given project. These strategies give developers up-front, predictable mitigation costs for offsetting the impacts of their projects, an important part of incentivizing development. In addition,

FIGURE 5

Timeline Of Recent Progress On Renewable Energy On Public Lands

In addition to approving projects, BLM has made progress on renewable energy policies and plans.



coordinating mitigation efforts at the regional level helps ensure funds are put to the best possible use and generate the greatest cumulative benefits. Though the BLM's 2018 guidance limits the agency's ability to require "compensatory" mitigation for new projects, it remains a critical tool that developers should use to offset unavoidable impacts.

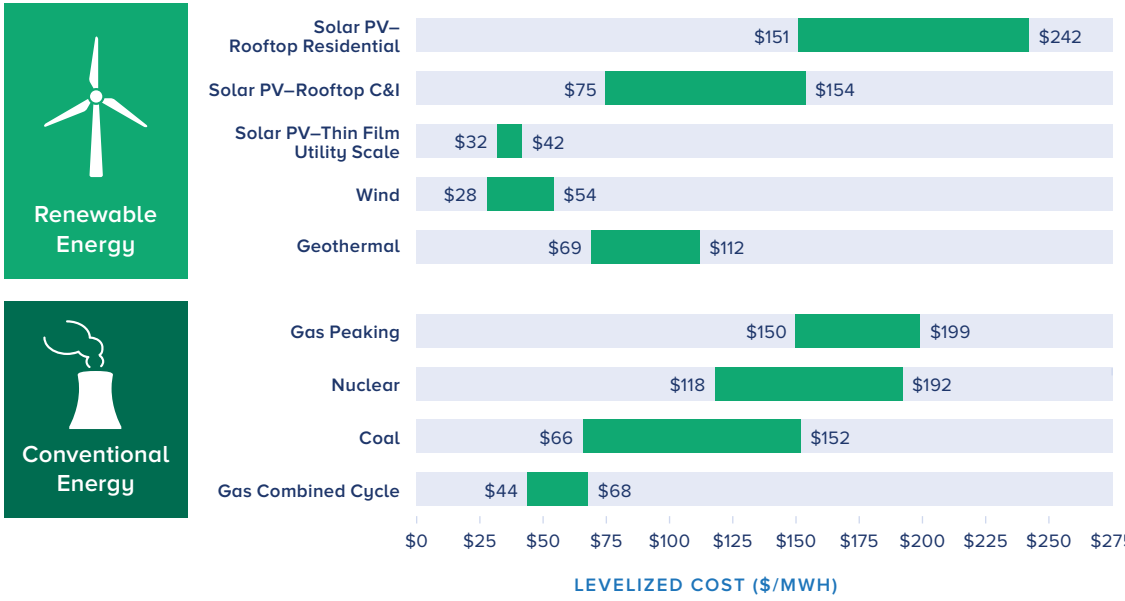
The benefits of this smart development approach are multiple. While it will have a significant role in steering development away from some of the country's most ecologically-sensitive and culturally-important landscapes, it has also been shown to help streamline and expedite the permitting and development process for industry. Because project sites within the DLAs have already been pre-screened for environmental suitability under a regional environmental review, the individual project site assessment and environmental review "tiers," or builds upon regional-scale assessments, which can save time and reduce uncertainty and redundancy. Additionally, this process is designed to foster public and community engagement in the identification of DLAs, helping build support for responsible renewable energy projects and reducing the time and costs associated with opposition that often faces poorly sited development.

RENEWABLE ENERGY IS NOW COST COMPETITIVE WITH FOSSIL FUELS

Stemming from both rapid technological advancement and the investments and incentives provided by federal and state governments, the cost of renewable energy

FIGURE 6

Lazard's 2019 Levelized Cost Of Energy Comparison – Unsubsidized Analysis



continues to decrease, and new wind and solar power plants are now often less expensive than new coal and natural gas power plants.

Lazard, a leader in analyzing the levelized cost of energy (LCOE), reports that the cost of both utility-scale PV solar and onshore wind on the global market continues to decline.[16] In their unsubsidized LCOE comparison, Lazard reported that the 2019 unsubsidized cost of utility-scale PV crystalline was $36-$44/MWh, utility-scale PV thin film was $32-$42/MWh, and wind was $28-$54/MWh, while comparative cost for coal was $66-$152/MWh and natural gas combined cycle was $44-$68/MWh.[17] Lazard reports that the unsubsidized cost of geothermal energy was $69-$112 (see Figure 6).[18]

In addition, it is becoming increasingly common that energy generation from new wind and solar projects is even less expensive than energy from existing coal plants, particularly in areas with the most abundant wind and solar resources. The addition of the federal renewable electricity production tax credit (PTC) and federal business energy investment tax credit (ITC) in place for the next few years makes replacing existing coal with renewables even more financially attractive.

RENEWABLE ENERGY ON PUBLIC LANDS HAS SIGNIFICANT OPPORTUNITY FOR GROWTH

While renewable energy development on public lands has increased significantly in recent years, it still only accounts for a relatively small portion of the total renewable energy generated in the United States.

The combined wind, solar, and geothermal generation capacity on public lands accounted for less than five percent of all wind, solar, and geothermal capacity in the U.S. in 2019.

Despite these numbers, there is great potential for growth in renewable energy on public lands. The 700,000 acres of DLAs that the BLM has already designated can accommodate hundreds more utility-scale solar and wind projects with tens of thousands of megawatts of potential capacity, and the BLM is designating additional DLAs in regions with high solar energy potential like southern Nevada and in regions with high wind energy potential like southern Utah. Though the BLM has not established a program for designating geothermal DLAs, the BLM has designated some priority development sites and there are public lands with high geothermal energy potential in several regions in the west.

Facilitating increased responsible renewable energy development on public lands via the strategies described at the end of this report will help support and expedite growth in our overall renewable energy portfolio. These efforts should be paired with serious investments in rooftop solar, energy conservation, and energy efficiency to achieve a sustainable clean energy economy.

ECONOMIC VALUATION OF RENEWABLE ENERGY DEVELOPMENT ON PUBLIC LANDS

Daniel Hoherd, flickr

This report calculates several key economic impacts of solar, wind, and geothermal energy development and production on public lands.[19] Economic value is compiled from several sources: (1) rents, royalties, and other fees paid to the federal government, states, and counties for the use of public lands for renewable energy development, as reported by the BLM and the Office of Natural Resource Revenue (ONRR); (2) capital costs from the construction of these facilities; (3) jobs created by the construction and operation of these facilities; and (4) the economic value of avoided atmospheric carbon from renewable energy generated on public lands. Data was sourced primarily from publicly available sources.

All values are reported in 2019 dollars. Total dollar amounts were translated to 2019 dollars by comparing the average annual inflation rate as reported by the Bureau of Labor Statistics in the Consumer Price Index for a standard basket of goods for each year.[20]

The BLM tracks the approval and construction status, technology, and MW capacity of renewable energy projects on BLM lands in spreadsheets available for download from their website.[21] This data was used to complete the calculations of per-MW capital development costs and job creation.

While the projects operating on public lands are already providing important clean energy and economic benefits, they represent less than five percent of the total solar, wind, and geothermal capacity installed in the U.S., so there is significant opportunity for growth.

RENT, ROYALTIES, AND OTHER FEDERAL REVENUE STREAMS

The federal government collects and deposits in the federal treasury several different fees pertaining to the use of federal lands for the production of renewable energy by private industry. These fees vary by energy type and location.

The main types of fees are:

1. Per-acre land rental fees;
2. Royalties (for geothermal) or megawatt capacity fees (for solar and wind); and
3. Minimum and bonus bids as part of the competitive leasing process.

As detailed below, the total cumulative solar, wind, and geothermal energy revenue collected for use of federal lands for solar, wind, and geothermal development through 2019 was $660,493,934 in 2019 dollars.

Federal Solar and Wind Energy Revenue

The BLM tracks the acreage rental fees and megawatt capacity fees it collects from wind and solar energy development on BLM lands in the agency's publicly available LR2000 database.[22] Fees collected for wind energy development include acreage rental fees associated with right of way (ROW) grants for use of the land for the installation of meteorological testing towers to test the available wind resource at that location (wind testing), as well as acreage rental fees and megawatt capacity fees for ROW grants for use of the land for wind energy development. Fees collected for solar energy development include acreage rental fees and megawatt capacity fees for use of the land for solar energy development. In contrast to wind energy development, solar energy development typically does not require extensive testing of the solar resource.

LR2000 reports for rents and megawatt capacity fees collected by the BLM through December 31, 2019 produced the cumulative numbers below, converted to 2019 dollars (also see Figure 7):

- Solar energy development: $88,848,130
- Wind energy testing: $20,426,377
- Wind energy development: $85,278,419
- Total wind energy fees: $105,704,796
- Total solar and wind energy fees: $194,552,926

Appendix 3 includes the step by step methodology used to generate LR2000 reports for acreage rents and megawatt capacity fees for wind testing and development and solar development on BLM lands.[23]

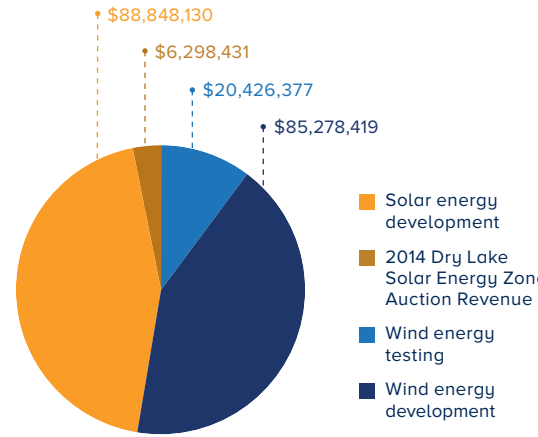
The BLM also collected $5,835,000 in competitive bids to develop solar energy on the Dry Lake Solar Energy Zone during the auction on June 30, 2014, which is equivalent to $6,298,431 in 2019 dollars.[24] Adding this number to the total solar and wind energy fees from above results in $200,851,357 in total solar and wind energy revenue through 2019, in 2019 dollars.

FIGURE 7

Solar And Wind Energy Revenue Through December 2019

*($2019)

Total solar and wind energy revenue: $200,851,357



Federal Geothermal Energy Revenue

The Office of Natural Resource Revenue (ONRR) collects and tracks revenues for development of federal geothermal resources. These include rents, royalties, bonus bids, and other fees. ONRR provides publicly available information on revenues collected over the preceding 10 years on its website.[25] ONRR required submission of a Freedom of Information Act (FOIA) request to access information on geothermal revenues collected more than 10 years ago. The data that ONRR provided in response to the FOIA request is included in Appendix 4 and includes a total of $324,694,830 in geothermal energy revenue collected by ONNR between 1982 and 2017, which is equivalent to $427,695,880 in 2019 dollars.[26] Revenue data for 2018 and 2019 were collected from DOI's Natural Resources Revenue Data website and total $31,946,697 in 2019 dollars.[27] This brings the total geothermal energy revenue collected by ONNR from 1982 to 2019 to $459,642,577 in 2019 dollars.

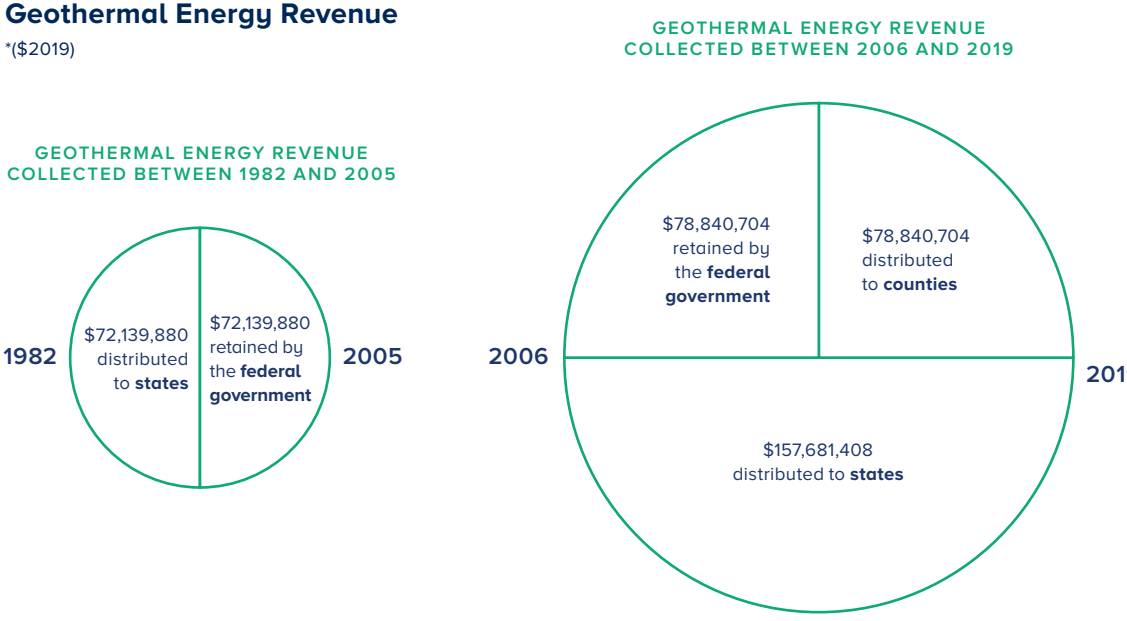
Prior to the passage of EPAct 2005, geothermal energy revenue collected by ONRR was split between the federal government and the state where the development occurs. Since the passage of EPAct 2005, the federal government retains 25% and distributes 50% to the state where development occurs and 25% to the county where development occurs.[28]

Using these revenue splits, geothermal energy revenue collected between 1982 and 2005 included $72,139,880 distributed to states and $72,139,880 retained by the federal government in 2019 dollars. Geothermal energy revenue collected between 2006 and 2019 included $78,840,704 distributed to counties, $157,681,408 distributed to states, and $78,840,704 retained by the federal government in 2019 dollars (see Figure 8).

FIGURE 8

Geothermal Energy Revenue

*($2019)



CAPITAL INVESTMENT

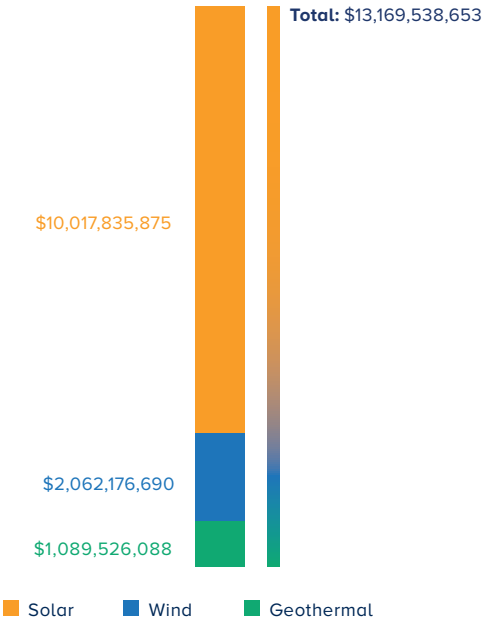
The development and construction of renewable energy infrastructure on public lands represents a significant capital investment in our nation's overall portfolio of modern infrastructure. Capital investment, often via private industry and bolstered by federal incentives, helps move our nation forward and ensures decades of use and value from these projects.

Capital development costs (not including land acquisition costs) were calculated on a per-technology basis using per-MW cost multipliers sourced from the EIA as detailed in Appendix 5. EIA data on capital cost multipliers were only available back to 1996, so capital cost estimates for projects constructed prior to 1996 are not included here. Converting these figures to 2019 dollars estimates that capital costs spent on federal lands for renewable energy development since 1996 total $10,017,835,875 for solar projects, $2,062,176,690 for wind projects, and $1,089,526,088 for geothermal projects, for a combined total of $13,169,538,653 (see Figure 9).

FIGURE 9

Capital Invested Since 1996

*($2019)



JOB CREATION

Renewable energy growth is directly tied to new job opportunities. A 2017 report from the Environmental Defense Fund calculated that renewable energy jobs have experienced an overall compound annual growth rate (CAGR) of close to 6% since 2012, compared to CAGR of -4.25% for fossil fuel extraction over the same time period.[29] A retrospective analysis by the White House Council of Economic Advisers in 2016 found that the American Recovery and Reinvestment Act of 2009 supported approximately 900,000 job-years in clean energy from 2009-2015.[30] Job-years are full-time jobs multiplied by the number of years they exist. For example, a full-time construction job that lasts for two years is two job-years, and a maintenance job that lasts for 30 years is 30 job-years.

Renewable energy jobs offer individuals and communities several important benefits. First, these jobs, particularly those in construction, installation, and facility operation, are domestic and cannot usually be outsourced. They are also location-based, and often bring jobs to rural areas where there are few other viable employment options. This translates to competitive vocations for local residents, as well as an influx of college-educated workers. This dynamic can lead to an overall economic boost for rural communities. While the majority of renewable energy jobs are temporary positions for the construction of these facilities, they nonetheless provide valuable, technology-based skillsets and place-based employment in areas often

lacking other competitive opportunities. Skills and experience gained from the construction of renewable energy facilities helps individuals reinvigorate their careers and returns money to local markets. In addition, as the renewable energy industry grows, short-term construction workers are able to move from project to project in regions with ongoing development, much like other construction-based industries.

Additionally, in many of the counties where renewable energy development is taking place, unemployment rates tend to be higher than in more urbanized areas. For example, the 2017 Bureau of Labor Statistics Local Area Unemployment Statistics Map showed that unemployment in Kern County, CA was 8.6%, more than twice the national average, and Nye County, NV was 5.9%.[31] Renewable energy jobs typically pay above-average wages, and in many cases involve union workers. In addition to competitive wages, renewable energy developers often offer employment benefit packages, providing much-needed services to rural families, such as health care, retirement savings, and company investment options, benefits that may not typically be provided by the jobs common to rural areas.

This report estimates the number of temporary construction and long-term operations and maintenance jobs directly related to solar, wind, and geothermal projects operating on BLM lands (see Figure 10). Job estimates were created using the formulas below. The number of workers necessary for a particular job site will vary in conjunction with many other factors, including the terrain, the local workforce, the permitting requirements, etc. The following estimates use nationwide averages that may be higher in areas where there is not a local available or trained workforce or where weather, terrain or permitting makes it more time consuming to construct or operate a project.

Wind[32]

Jobs/MW for wind project construction = 0.7 – 0.9
Jobs/MW for wind project operations and maintenance = 0.06 – 0.08

Solar

Jobs/MW for utility-scale solar PV project construction = 2.42[33]
Jobs/MW for utility-scale solar PV project operations and maintenance = 0.027[34]

FIGURE 10

Estimated Jobs Created By Renewable Energy Projects Operating On Public Lands In 2019

	MEGAWATTS	CONSTRUCTION JOBS	LONG-TERM OPERATIONS AND MAINTENANCE JOBS
WIND	1,088	762 – 979	65 – 87
SOLAR – PV	1,944	4,704	52
SOLAR – CSP	710	2,850	148
GEOTHERMAL	1,299	4,027	1,520
TOTAL	5,041	12,343 – 12,560	1,785 – 1,807

Geothermal

Jobs/MW for geothermal project construction = 3.1[35]
Jobs/MW for geothermal project operations and maintenance = 1.17[36]

Based on these formulas, the renewable energy projects operating on public lands have created the jobs shown in Figure 10.

The three operating concentrating solar projects on public lands created 2,850 construction jobs and 148 operations and maintenance jobs.[37]

In total estimates, the renewable energy projects operating on public lands in 2019 created the following jobs:

- Total construction jobs from wind, solar, and geothermal projects: 12,343 – 12,560
- Total long-term operations and maintenance jobs from wind, solar, and geothermal projects: 1,785 – 1,807

GREENHOUSE GAS REDUCTION

The avoided carbon dioxide gas (CO_2) emissions from renewable energy use when compared to electricity generation from the burning of fossil fuels also offers economic benefits. As detailed in Appendix 7, through 2019, the solar projects operating on public lands have resulted in an estimated total of 11.39 million metric tons of avoided CO_2 emissions. This is roughly equivalent to taking over 2.4 million passenger vehicles off the road for one year.[38] While estimates of the avoided CO_2 emissions from the wind and geothermal projects operating on public lands were not readily available, they have also contributed significant benefits in avoided CO_2 emissions.

The Social Cost of Carbon (SCC) is a leading tool for quantifying the climate impacts of proposed federal actions. As described by the National Academies of Sciences, Engineering and Medicine, the SCC is "an estimate, in dollars, of the long term damage caused by a one ton increase in carbon dioxide (CO_2) emissions in a given year; or viewed another way, the benefits of reducing CO_2 emissions by that amount in a given year. The SCC is intended to be a comprehensive estimate of climate change damages that includes, among other costs, the changes in net agricultural productivity, risks to human health, and property damages from increased flood risks."[39] The current central estimate of the social cost of carbon (SCC) is roughly $50/metric ton in 2019 dollars. Using this estimate, the cumulative total estimate of the avoided CO_2 emissions from solar projects operating on public lands have a SCC value of over $544 million through the end of 2019 (see Appendix 7).

SPOTLIGHT ON NEVADA

The presence of geothermal, solar, and wind development in Nevada makes the state a good choice for a state-specific look at key economic benefits from renewable energy development on public lands. Nevada benefits from excellent renewable energy resources, a growing in-state market for renewable energy from utilities and major electricity users like casinos and data centers, and proximity to the high-demand California market.

In 2019 there were 26 utility-scale solar, wind, and geothermal projects operating on public lands in Nevada with a total generation capacity of 1,327 MW. This includes five PV projects with a total generation capacity of 529 MW, one concentrating solar project with a generation capacity of 110 MW, one wind project with a generation capacity of 151 MW, and 19 geothermal projects with a total generation capacity of 537 MW.

LR2000 reports included the following total solar and wind rental payments and megawatt capacity fees collected by the BLM in Nevada through December 31, 2019, converted to 2019 dollars:

- Solar energy development: $11,911,685
- Wind energy testing: $4,174,356
- Wind energy development: $5,346,123
- Total wind energy fees: $9,520,479
- Total solar and wind energy fees: $21,432,164

The BLM also collected $5,835,000 in competitive bids to develop solar energy on lands in the Dry Lake Solar Energy Zone during the competitive auction on June 30, 2014, which is equivalent to $6,298,431 in 2019 dollars.[40] This results in a total of $27,730,595 in total Nevada solar and wind energy revenue through 2019, in 2019 dollars.

A total of $146,156,125 in federal geothermal revenue from Nevada has been collected by the Office of Natural Resource Revenue, in 2019 dollars.

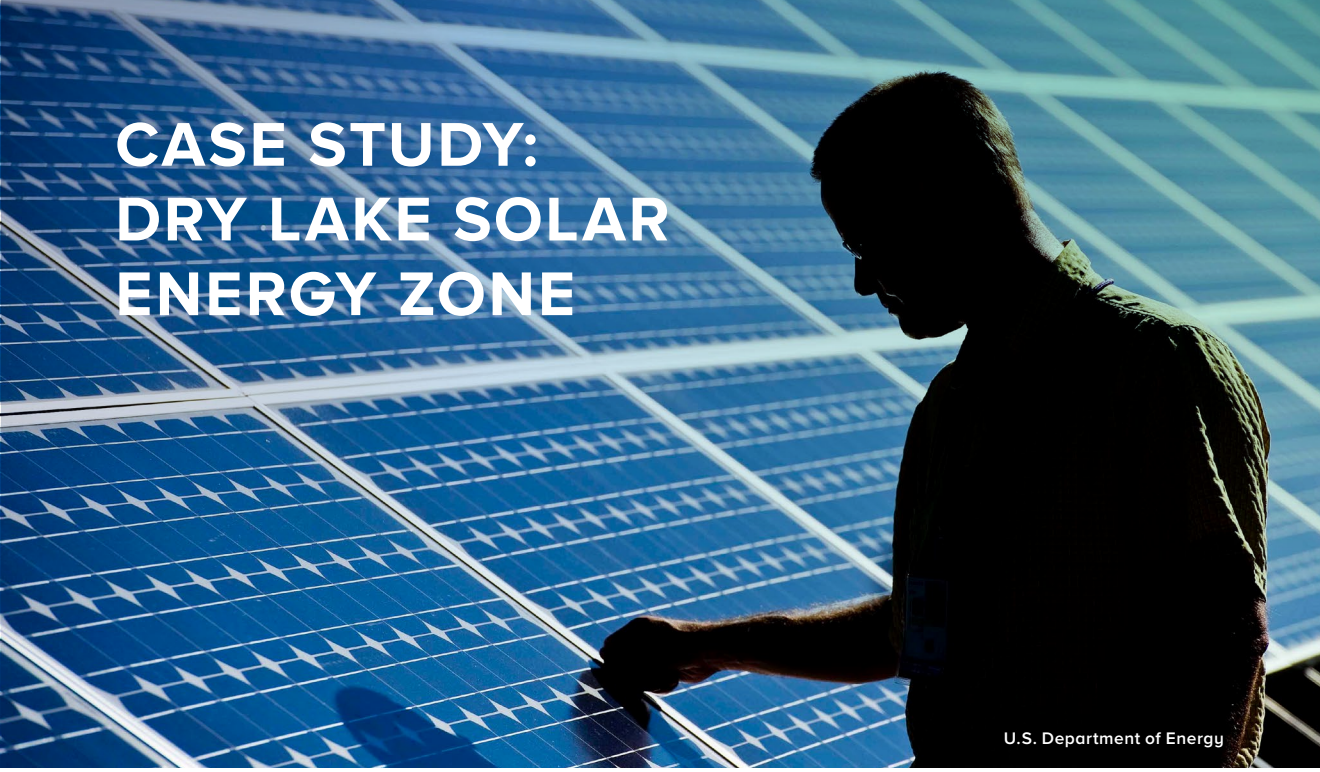
Based on these data, geothermal energy revenue collected between 1982 and 2005 in Nevada included $8,266,817 distributed to the state of Nevada and $8,266,817 retained by the federal government in 2019 dollars. Geothermal energy revenue collected between 2006 and 2019 in Nevada included $32,405,623 distributed to counties, $64,811,245 distributed to states, and $32,405,623 retained by the federal government in 2019 dollars.

The total cumulative solar, wind, and geothermal energy revenue collected in Nevada through 2019 was $173,886,720 in 2019 dollars.

Using the estimates described earlier in this report, in 2019 dollars, capital costs for projects operating in Nevada were $1,983,717,287 for solar projects, $433,852,584 for wind projects, and $716,780,507 for geothermal projects, for a total of $3,134,350,378.

Rents, royalties, and capital costs for projects operating in Nevada total $3,308,237,098.

Using the estimates described earlier in this report, the total estimates for jobs created by solar, wind, and geothermal projects operating on public lands in Nevada are 4,101 – 4,131 construction jobs and 691 – 694 operations and maintenance jobs. Solar PV and concentrating solar project construction jobs in Nevada total 2,330 and operations and maintenance jobs total 54. Wind project construction jobs in Nevada total 106 – 136 and operations and maintenance jobs total 9 – 12. Geothermal project construction jobs in Nevada total 1,665 and operations and maintenance jobs total 628.



CASE STUDY: DRY LAKE SOLAR ENERGY ZONE

The Dry Lake Solar Energy Zone (SEZ), a BLM priority area for solar development, has proven to be a successful model for responsible renewable energy development on public lands.

The Dry Lake SEZ was one of the original 17 SEZs designated in the BLM's 2012 WSP, which identified and pre-screened 285,000 acres of public land for utility-scale solar energy development in six southwestern states: Arizona, California, Colorado, New Mexico, Nevada, and Utah. The Dry Lake SEZ is located in southern Nevada, about 20 miles outside of Las Vegas, and sits within an area that includes several power plants and other industrial facilities, mining operations, highways, and a railroad, and is already well-served by transmission infrastructure. The presence of this existing development is one of the reasons the area was selected as a SEZ — the existing disturbance lowers the relative impact of development in this area compared to development in more remote, pristine areas, and the existing infrastructure benefits project development.

The BLM held a competitive auction for six parcels totaling 3,083 acres in the Dry Lake SEZ on June 30, 2014. The auction used a combined oral and sealed competitive bid process to solicit development interest from preferred applicants. In total, the auction resulted in $6,298,431 of revenue in 2019 dollars to the BLM — representing a 90-fold premium over the minimum bid amount. The six parcels were awarded to 3 different developers, who plan to develop a total of over 400 MW of solar across the six sites.

After the auction, the BLM evaluated and approved the three applications it received for development in the Dry Lake SEZ in less than half the time of typical solar project applications in non-SEZ locations.[41] This shows that the WSP is helping to not only locate projects

in areas with reduced environmental conflicts, but also facilitate a more logical and efficient approach to infrastructure permitting.

First Solar, a major solar development company, has successfully developed solar projects on two of the Dry Lake SEZ parcels. These projects, named Switch Station 1 and Switch Station 2, were the first ever to be developed through a competitive auction in a SEZ. Together the projects have a generation capacity of 179 MW — enough to power approximately 46,000 homes in the southern Nevada region. This energy displaces 265,000 metric tons of carbon dioxide — the equivalent of taking almost 52,000 cars off the road each year.[42] Switch Station 1 and 2 came online and started selling solar energy commercially in late 2017. The Dry Lake SEZ was also the first to receive a BLM-completed Regional Mitigation Strategy. Guided by the strategy, First Solar has invested millions of dollars in conservation efforts in the region to offset the impacts of Switch Station 1 and 2.

The Dry Lake SEZ highlights the benefits of the common-sense approach and efficient permitting afforded by the WSP. By providing industry with areas that are pre-screened for renewable energy development, the BLM is helping to guide projects toward areas where environmental impacts can be reduced and industry is likely to see fewer conflicts, opposition, and delays, saving valuable time in the development process. In a press release issued by EDF Renewables, owner of the Dry Lake SEZ projects, John Ruhs, who was the BLM Nevada State Director at the time, stated: "This is another great example of the Federal Government and private industry collaborating on improving our nation's energy independence and infrastructure under the auspices of multiple use of our shared public lands."[43]

Demand for renewable energy is constantly increasing, and the BLM needs to designate new DLAs as market conditions evolve and existing DLAs continue to be populated with new projects — for example, the BLM should complete the effort underway to expand the Dry Lake SEZ by designating and leasing a new DLA on similar lands to the east.

LOOKING AHEAD

Mason Cummings

More than 10 years after the passing of EPAct 2005, the United States has met and exceeded its initial public lands renewable energy goals. Through a number of common-sense programs and smart permitting approaches, projects operating on BLM lands now have a total generation capacity of over 5,000 MW — enough to power more than two million American homes. While this is an important contribution, wind, solar, and geothermal energy on public lands make up less than five percent of the total renewable energy generated across the nation, demonstrating clear opportunities for growth.

This report details the important and growing economic value of developing renewable energy on public lands. However, that value cannot be sustained and increased without strong support from agency leaders and congressional representatives, and the lack of progress in recent years demonstrates how important continued support is. This section summarizes the actions required to continue to support renewable energy development on public lands, while ensuring preservation of landscapes of special ecological and cultural significance.

Action 1: Fully fund DOI and BLM renewable energy programs. Critical to ensuring our public lands remain a key part of transitioning to a clean energy future is the continued and complete funding of the DOI and BLM Renewable Energy Programs. These programs have made a measurable difference in streamlining and expediting the development of renewable energy on public lands by helping to clarify agency goals, standardize the permitting processes, and make certain sufficient agency resources are devoted to reviewing, processing, and monitoring this development. Despite the importance of these programs, BLM's renewable energy program budget has remained mostly flat over the last six years, and was

actually reduced by 16% in fiscal year 2019.[44] Full funding for DOI agencies is necessary for the identification and designation of new DLAs, timely completion of important environmental reviews to prepare parcels for auction and leasing, continued training of agency staff, and for allowing responsible projects to progress through the development pipeline without delay, providing more certainty for developers.

Action 2: Maintain focus on timely permitting in appropriate areas and designation of new DLAs, in coordination with transmission planning. The BLM and other federal agencies must continue to focus on the timely permitting of renewable energy infrastructure in DLAs and other appropriate, lower-impact areas, and the designation of new wind and solar DLAs, as well as priority areas for geothermal development. These tasks require close engagement with stakeholders and project developers to ensure that new DLAs meet market needs and industry feasibility requirements and reduce conflicts and negative impacts to environmental and cultural resources. They also require coordination with efforts to identify appropriate energy corridors for transmission lines (including lines 230 kV and under, which are key for connecting renewables projects), such as the ongoing BLM and U.S. Forest Service review of the West-wide Energy Corridors, ensuring that renewable energy can be delivered to our cities and homes.[45] Increasing incentives for projects in DLAs is also crucial for focusing development in these areas. Because key wildlands, wildlife habitat, and cultural resources that are currently unprotected can unfortunately be threatened by poorly sited project applications, the agencies should also ensure that these types of lands are protected from development of any kind.

The BLM's WSP has made significant improvements to the process of siting and developing solar energy infrastructure on BLM lands. Though progress has slowed drastically in recent years, the BLM has most of the tools the agency needs to facilitate responsible development. The success of the Dry Lake SEZ demonstrates the benefits of focusing development in pre-screened areas. Some new project applications approved outside of pre-screened areas have also been in lower conflict areas than in the past, thanks to the higher standards established by the WSP. It is difficult to assess the impact of the 2016 Solar and Wind Energy Rule, since the majority of current solar and wind projects preceded the regulation, but continued investment in its implementation is crucial for carrying forward the BLM's smart approach. Unfortunately, the BLM announced in 2018 that it was proposing to revise the California Desert Renewable Energy Conservation Plan, putting at risk both the conservation gains and opportunities for more efficient and responsible renewable energy development that the plan created. It is critical that the BLM keep this landmark plan intact and focus instead on implementing the plan's balanced conservation and renewable energy framework. The BLM should complete work to designate additional DLAs for wind in Utah and for solar in Nevada, including the expansion of the Dry Lake SEZ, which will help support additional responsible development. The agency should also continue to refine its processes as lessons are learned through program implementation.

Action 3: Pass legislation to facilitate responsible renewable energy development and conservation investments. Important to increasing responsible development of renewable energy on public lands is the Public Land Renewable Energy Development Act (PLREDA), which has garnered strong bi-partisan support in both the House and Senate. If passed, this legislation would promote the development of solar,

wind, and geothermal energy resources on public lands by directing DOI to identify additional priority areas in places with high energy potential and lower impacts on wildlife, habitat, and other resources. PLREDA also includes a revenue sharing clause that will distribute revenue from wind and solar energy development back to the counties and states where the projects are built (geothermal revenue is already shared with counties and states), to the BLM to support resources needed to facilitate the permitting of projects, and to a fund supporting community conservation efforts and securing recreational access to public lands.

Action 4: Repower old mines and brownfield sites with renewable energy. By facilitating the re-development of old mines, landfills, and other contaminated sites with solar, wind, and geothermal energy, federal agencies and Congress can increase renewable energy development while reducing pressure to site projects on undeveloped "greenfield" sites. The Environmental Protection Agency's RE-Powering America's Land initiative has mapped 43 million acres of these lands in the U.S. that have solar, wind, and geothermal potential.[46] These sites also often have existing transmission lines and roads, further increasing their value for potential renewable energy projects. Reducing potential liability and increasing financial incentives for developers can facilitate more development on these types of sites.

Action 5: Take steps to help ensure that the economic benefits of renewable energy development are equitably shared. Leaders should also prioritize supporting the creation of new economic growth through renewable energy development, including for rural communities with limited economic opportunities and as part of a strategy to help communities that are currently dependent on fossil fuel production diversify their economies.

CONCLUSION

While solar, wind, and geothermal development on public lands has increased in recent years, there is great potential for additional responsible development. Building on this progress will require the continued funding and implementation of DOI renewable energy programs; cooperation between government, industry, conservation groups, and other stakeholders; and bi-partisan congressional support to ensure legislation and policies remain up-to-date. Working together, we can help guarantee continued success for the development of the nation's renewable energy resources and protection of our natural and cultural heritage well into the next generation.

APPENDICES

- **Appendix 1**: updated information on approved and operating geothermal projects on public lands
- **Appendix 2**: methods for estimating homes powered by geothermal projects
- **Appendix 3**: methods for generating LR2000 reports on solar and wind rents
- **Appendix 4**: Office of Natural Resource Revenue data on geothermal revenue
- **Appendix 5**: methods for estimating capital costs for renewable energy projects
- **Appendix 6**: solar PV operations and maintenance jobs estimates from projects that applied for Nevada's Renewable Energy Tax Abatement Program
- **Appendix 7**: methods for estimating the Social Cost of Carbon value for solar projects

The appendices for this report are available at https://cbey.yale.edu/public-lands-appendices

ENDNOTES

1 Note that offshore public waters are also important sources of energy development and interest in offshore wind energy development is increasing; this report only addresses onshore renewable energy development on public lands managed by the BLM from solar, wind, and geothermal resources.

2 Note that this report includes key economic impacts of all federal geothermal resources, including resources with federal surface ownership (including BLM public lands and other federal land ownership) and those classified as split-estates.; Note that one wind energy project has been developed on U.S. Forest Service land, the Deerfield Wind project in Vermont. Several renewable energy projects have also been developed on Department of Defense lands, and there may be other renewable energy projects on other types of federal public lands. Because this report is focused on renewable energy development on BLM lands, the economic impacts from projects on other types of federal public lands are not included.

3 As detailed in endnotes **23** and **26**, these numbers are based on best available data but do not include all rents, royalties and revenues.; All numbers in this report have been rounded to the nearest whole number.

4 EIA estimates for capital costs are only available back to 1996, so capital costs for projects constructed prior to 1996 are not included.

5 https://outdoorindustry.org/wp-content/uploads/2017/04/OIA_RecEconomy_FINAL_Single.pdf, p. 14.

6 Esposito, Valerie; Phillips, Spencer; Boumans, Roelof; Moulaert, Azur; Boggs, Jennifer. 2011. Climate change and ecosystem services: The contribution of and impacts on federal public lands in the United States. In: Watson, Alan; Murrieta-Saldivar, Joaquin; McBride, Brooke, comps. Science and stewardship to protect and sustain wilderness values: Ninth World Wilderness Congress symposium; November 6-13, 2009; Merida, Yucatan, Mexico. Proceedings RMRS-P-64. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 155-164. https://www.fs.fed.us/rm/pubs/rmrs_p064/rmrs_p064_155_164.pdf, p. 162.

7 BLM tracks the projects it approves on its website. Solar: https://www.blm.gov/sites/blm.gov/files/B.PROJECT%20LIST%20SOLAR_Dec%202019_0.xlsx; wind: https://www.blm.gov/sites/blm.gov/files/A.PROJECT%20LIST%20WIND_Dec%202019_0.xlsx; geothermal: https://www.blm.gov/sites/blm.gov/files/energy_renewable_GeothermalProjectInfo_2019.xlsx. Note that the BLM's online spreadsheet of approved geothermal projects is outdated. Updated data were collected from BLM resource specialists for this report. These updated data are shown in **Appendix 1**. Note also that the BLM tracks solar and wind "project" approvals through the right of way (ROW) grants it signs with project developers, and some "projects" may have multiple ROW grants, and thus be counted by the BLM as multiple projects. In this report, we are following the BLM's convention and counting each ROW grant as an individual project. In addition, the BLM's solar spreadsheet includes some solar ROW grants for small (less than 2 MW) projects that produce power for various onsite uses. This report only includes projects 2 MW and greater in size.

8 The Solar Energy Industry Association (SEIA) estimates that solar PV projects in California can power about 260 California homes/MW; using this estimate, the 1,335 MW of solar PV constructed on public lands in California could power about 347,100 California homes. SEIA estimates that solar PV projects in Nevada can power about 176 Nevada homes/MW; using this estimate, the 529 MW of solar PV constructed on public lands in Nevada could power about 93,104 Nevada homes. SEIA estimates that solar PV projects in Wyoming can power about 163 homes/MW; using this estimate the 80 MW of solar PV constructed on public lands in Wyoming could power about 13,040 homes. This is a total of about 453,244 homes powered by PV projects. SEIA's methods for these calculations are found here: https://www.seia.org/initiatives/whats-megawatt. Through personal communication with SEIA, the report authors learned that SEIA has updated the analyses shown on that website to create the new estimates of 260 California homes/MW, 176 Nevada homes/MW, and 163 Wyoming homes/MW, using the same methods.

9 The Ivanpah concentrating solar project can power about 140,000 homes: http://www.brightsourceenergy.com/ivanpah-solar-project.; The Crescent Dunes concentrating solar project can power about 75,000 homes during peak demand: https://www.power-technology.com/projects/crescent-dunes-solar-energy-project-nevada/.; The Genesis concentrating solar project can power nearly 88,000 homes: http://www.nexteraenergyresources.com/pdf_redesign/GenesisFactSheet_v3.pdf.

10 See **Appendix 2** for geothermal homes powered calculations, using methods from an unpublished analysis by the National Renewable Energy Laboratory.

11 The BLM estimates that wind projects can power an average of about 350 homes/MW: https://www.doi.gov/news/pressreleases/secretary-jewell-announces-approval-of-major-wind-energy-project-on-public-lands-in-arizona.

12 See the spreadsheets linked to in endnote **7** and in **Appendix 1**.

13 The most recent Energy Information Administration Numbers for total solar, wind, and geothermal generating capacity in the U.S. are from 2018, and significant additional generation capacity was added across the U.S. in 2019. The total U.S. solar, wind, and geothermal generating capacity in 2018 was 150,202 MW. The 5,041 MW of generating capacity of the solar, wind, and geothermal projects operating on public lands in 2019 is 3.36% of the total 150,202 MW operating in the U.S. in 2018. https://www.eia.gov/electricity/annual/html/epa_04_03.html.

14 Priority sites designated through the WSP were called "Solar Energy Zones;" after completion of the BLM's 2016 Solar and Wind Energy Rule, all priority wind and solar sites are referred to as Designated Leasing Areas.; The BLM has also completed two other regional planning efforts that resulted in designation of wind and solar DLAs: the Desert Renewable Energy Conservation Plan in California (which also included some priority areas for geothermal) and the Restoration Design Energy Project in Arizona.

15 https://www.blm.gov/programs/energy-and-minerals/renewable-energy/laws/solar-and-wind-energy-rule.

16 The LCOE is generally considered the average threshold price of a particular type of energy in order to break even on the capital cost of the generating infrastructure. Technically it is the net present value of the unit cost of electricity measured over the lifetime of the asset or project.

17 https://www.lazard.com/media/451086/lazards-levelized-cost-of-energy-version-130-vf.pdf, p. 2.

18 Ibid.

19 Renewable energy development on BLM lands creates other important economic impacts that are not calculated in this report, such as spending in nearby communities from construction workers.

20 https://www.officialdata.org/.

21 See the spreadsheets linked to in endnote **7** and in **Appendix 1**.

22 https://reports.blm.gov/reports.cfm?application=LR2000.

23 Note that the LR2000 reports include fees the BLM has collected for all wind and solar energy development ROW grants. This includes some development grants where the project developer has not yet constructed the project, and some grants where the project developer paid fees for a period of time and subsequently terminated their ROW grant because they decided not to pursue construction.; Note that LR2000 only provides wind testing fee data back to the year 2000; the report authors were unable to obtain information from the BLM regarding whether wind testing fees were collected prior to the year 2000.

24 https://www.blm.gov/press-release/dry-lake-solar-energy-zone-auction-selects-three-potential-developers.

25 https://revenuedata.doi.gov/downloads/federal-revenue-by-location/.

26 The ONRR FOIA data is reported by fiscal year, not calendar year. Note that although the first federal geothermal project began operations in 1978, the ONRR FOIA data only includes revenue back to 1982. No revenue data was reported in the following years: 1987, 1994, 1995, 1997, 1999, 2000, 2001, 2002. For the years 1982-1998 only bonus revenue was reported; for those years it does not include rents, royalties or other types

of revenue reported for more recent years. ONRR stated that the reason for these issues is that this historical data came before a bookkeeping system conversion, and that the FOIA data is the most accurate and complete data they can provide.

27 https://revenuedata.doi.gov/downloads/federal-revenue-by-location/. To calculate the geothermal revenue data for fiscal years 2018 and 2019, we limited the Mineral Lease Type to "Geothermal" (column K) and limited the Land Class to "Federal" (column B). Note that the data on the Natural Resource Revenue Data website is reported as "Accounting Year" data. The ONRR FOIA data is reported as "Sales Year" data. According to ONRR, Accounting Year data represent all transactions that ONRR accepted into its Financial System during a given fiscal year and Sales Year data represent transactions for sales that took place in a given fiscal year and do not include adjusted or corrected transactions for sales that took place in previous fiscal years.

28 https://www.energycentral.com/c/gn/geothermal-revenue-under-energy-policy-act-2005, p. 6.

29 http://edfclimatecorps.org/sites/edfclimatecorps.org/files/the_growth_of_americas_clean_energy_and_sustainability_jobs.pdf, p. 5.

30 https://obamawhitehouse.archives.gov/sites/default/files/page/files/20160225_cea_final_clean_energy_report.pdf, p. 2.

31 https://www.bls.gov/lau/.

32 Source: personal communication with Suzanne Tegen, Center for the New Energy Economy, 2018. Note that this only includes onsite jobs; it does not include supply chain, indirect, or induced impacts. These numbers are based on interviews with developers about their projects.

33 Source: The Solar Foundation National Solar Jobs Census (2017) http://www.solarwakeup.com/wp-content/uploads/2018/02/FINAL-TSF-SolarJobsCensus2017.pdf, p. 26. Note that this only includes "field jobs," which refers to workers and electricians who physically install a solar system. This does not include sales, design, administrative, or other staff that support the installation.

34 Average operations and maintenance jobs/MW were estimated by averaging the operations and maintenance jobs reported by 19 solar PV projects that applied for the Nevada Renewable Energy Tax Abatement Program: http://energy.nv.gov/Programs/Renewable_Energy_Tax_Abatements/ Job estimates were taken from the application document for each project. The MW capacity and job estimates are detailed in **Appendix 6**. The total MW capacity of these projects is 2,241, and the total operations and maintenance jobs reported is 60. 60 operations and maintenance jobs divided by 2,241 MW equals 0.027 O&M jobs/MW.

35 https://www.eesi.org/papers/view/fact-sheet-jobs-in-renewable-energy-and-energy-efficiency-2015 Note that this only includes construction jobs, not jobs needed to manufacture the plant equipment.

36 Ibid, p. 2.

37 The Ivanpah concentrating solar project created 1,000 construction jobs and 61 operations and maintenance jobs: https://www.energy.gov/lpo/ivanpah.; The Crescent Dunes concentrating solar project created 1,050 construction jobs and 40 operations and maintenance jobs: https://cmimarseille.org/menacspkip/csp-engine-job-creation/.; The Genesis concentrating solar project created 800 construction jobs and 47 operations and maintenance jobs: https://www.energy.gov/lpo/genesis.

38 Note that this report does not attempt to quantify the difference in impacts to the carbon sequestration value of lands disturbed to generate a given quantity of electricity from renewable energy vs. lands disturbed to generate the same quantity of electricity from fossil fuels.

39 http://sites.nationalacademies.org/DBASSE/BECS/CurrentProjects/DBASSE_167526?utm_source=All+D-BASSE+Newsletters&utm_campaign=e84c13e8c4-New_Project_the_Social_Cost_of_Carbon&utm_medium=e-mail&utm_term=0_e16023964e-e84c13e8c4-260006513.

40 https://www.blm.gov/press-release/dry-lake-solar-energy-zone-auction-selects-three-potential-developers.

41 https://www.doi.gov/pressreleases/interior-department-approves-first-solar-energy-zone-projects.

42 https://www.edf-re.com/edf-renewable-energy-announces-acquisition-solar-projects-first-solar/.

43 https://www.edf-re.com/

commissioning-event-celebrates-operation-179-megawatt-switch-station-1-switch-station-2-solar-projects-apex-nevada/.

44 https://appropriations.house.gov/sites/democrats.appropriations.house.gov/files/HR%201865%20-%20Division%20D%20-%20Interior%20SOM%20FY20.pdf, p. 68.

45 http://corridoreis.anl.gov/.

46 https://www.epa.gov/sites/production/files/2015-09/documents/re_powering_program_overview.pdf.

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