REVISED SPECIAL REPORT

Sustainability and Environmental Group

COMMANDERS GUIDE TO RENEWABLE ENERGY

ABERDEEN TEST CENTER
DUGWAY PROVING GROUND
ELECTRONIC PROVING GROUND
REAGAN TEST SITE
REDSTONE TEST CENTER
WHITE SANDS TEST CENTER
YUMA PROVING GROUND

NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION PATUXENT RIVER
NAVAL AIR WARFARE CENTER WEAPONS DIVISION CHINA LAKE
NAVAL AIR WARFARE CENTER WEAPONS DIVISION POINT MUGU
NAVAL SURFACE WARFARE CENTER DAHLGREN DIVISION
NAVAL UNDERSEA WARFARE CENTER DIVISION KEYPORT
NAVAL UNDERSEA WARFARE CENTER DIVISION NEWPORT
PACIFIC MISSILE RANGE FACILITY

96TH TEST WING
412TH TEST WING
ARNOLD ENGINEERING DEVELOPMENT CENTER

SPACE LAUNCH DELTA 30
SPACE LAUNCH DELTA 45

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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SPECIAL REPORT

COMMANDERS GUIDE TO RENEWABLE ENERGY

January 2023

Prepared by
Sustainability and Environmental Group (SEG)
Range Commanders Council (RCC)

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Preface

This revised special report presents the results of Task SEG-008, "Update to *Commanders Guide - Renewable Energy Encroachment*." In 2011, an initial Commanders Guide was produced through a joint effort the Sustainability Group and the Signature Measurement Standards Group of the Range Commanders Council (RCC). However, since 2011, both the prospects for, and the lessons learned from, renewable energy projects within DoD operational areas have grown substantially. Further, under the RCC, the Sustainability Group and Range Environmental Group merged into one group - the Sustainability and Environmental Group (SEG) – providing a more comprehensive, interdisciplinary capability for addressing potential range-related concerns from renewables. Accordingly, the SEG has prepared this update.

Discussed herein are the impacts that renewable energy infrastructure projects (wind, solar, geothermal, biomass, nuclear, etc.) and off-range energy/power transmission have on the member range missions. Also included are tools and strategies for engaging local, state, and Federal agencies, as well as energy developers. Lastly, this guide presents a compendium of research efforts, studies, testing, and other documentation related to impacts of energy infrastructure on military testing and training.

The purpose of this report is to provide member ranges with information and tools they can use to ensure renewable energy infrastructure and transmission proposals are mission compatible. It will benefit all Major Range and Test Facility Base (MRTFB) ranges, and in many instances, training ranges as well.

Please direct any questions regarding this document to the Range Commanders Council Secretariat.

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Summary of Change

This update is generally an update for information and legislation. Maps were updated to indicate where renewable energy development has shifted. As we move forward, updates will always have to take into account the fact that renewable energy will continue to be a cutting-edge technology. The legislation that governs renewable energy will also continue to develop and expand as renewable energy becomes more and more mainstream. This update considers the most recent Executive Orders, allowing commanders the opportunity to examine legislative and executive guidance.

The updates on different types of renewable energy will also be an ever-changing part of this document. Current innovative technologies, like concentrated solar, are the way of the future and will present new challenges for the DoD. It is difficult to say how future renewables will affect operation; this report explores the most current forms of renewable energy and locations that those energy platforms will most likely be employed.

As states put more and more importance on the development of renewable energies it is safe to assume that the percentage of power produced by renewables will increase. This report reflects the current forecast for the percentage of states' power produced by renewables. Future reports should expect to see these numbers increase.

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Acronyms

AFB	Air Force Base
AGL	above ground level
BLM	Bureau of Land Management
CSP	concentrating solar power
CWA	Clean Water Act
DOI	Department of the Interior
ESA	Endangered Species Act
FAA	Federal Aviation Administration
GAC	Geographic Area of Concern
MILREP	military representative
MRTFB	Major Range and Test Facility Base
MTR	military training routes
MW	megawatt
NDAA	National Defense Authorization Act
NEPA	National Environmental Policy Act
OCS	Outer Continental Shelf
OE/AAA	Obstruction Evaluation/Airport Airspace Analysis
PEIS	Programmatic Environmental Impact Statement
PV	photovoltaic
RCC	Range Commanders Council
RETI	Renewable Energy Transmission Initiative
ROD	Record of Decision
ROW	right of way
RPS	renewable portfolio standard
SEG	Sustainability and Environmental Group
SME	subject matter expert
SUA	special use airspace
U.S.	United States
USFS	U.S. Forest Service
WREZ	Western Renewable Energy Zones

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Commanders Guide to Renewable Energy

1. Introduction

The development of renewable energy can benefit and even sustain the DoDs mission, but if projects are improperly cited they have the potential to significantly impact military testing and training. Compatible development of renewable energy is possible, but requires engagement throughout all levels in the chain of command, early planning, and thorough coordination between subject matter experts (SMEs) to include operational, facility support, energy managers, master planning, environmental/natural resources, and other relevant stakeholders.

Interest in renewable energy has increased dramatically during the last 14 years. Executive Orders 14008[1] and 13990[2] are the driving national policies as it relates to renewable energy. Many states have renewable portfolio standards (RPSs) that require minimum percentages of energy consumed in the state to be from renewable sources. Figure 1 outlines the most recent state RPS targets. Additionally, the American Recovery and Reinvestment Act of 2009 and other incentives promote renewable energy spending at a far more rapid pace.

State Amendments to RPS/CES Legislation Since 2018

State Amendments to RPS/CES Legislation Since 2018		
State	**New RPS/CES Target**	**By Years**
California	100%	2045
Colorado	100%	2050
Connecticut	44%	2030
Delaware	40%	2035
Maine	100%	2050
Maryland	50%	2030
Massachusetts	35%	2030
Minnesota	26.5%	2025
Nevada	100%	2050
New Jersey	50%	2030
New Mexico	100%	2045
New York	70%	2030
Oregon	100%	2040
Virginia	100%	2045/2050
Washington	100%	2045
Washington D.C.	100%	2032
Guam	100%	2045
Puerto Rico	100%	2050

Figure 1. State Amendments to Renewable Portfolio Standards

[1] Exec. Order No. 14,008, 86 FR 7619 (27 January 2021)
[2] Exec. Order No. 13,990, 86 FR 7037 (20 January 2021)

Renewable energy comes in many forms, including wind, solar, geothermal, hydro, and biomass. Some forms of renewable energy have no mission impacts, but others have major impacts. Wind turbines are typically 400 to 850 feet tall and create avoidance zones in low-level special use airspace (SUA) or military training routes (MTRs). Electromagnetic fields created from generation and transmission of energy across power lines can create frequency interference with radar and other sensors used by the DoD. Offshore wind facilities could impact sea lanes, submarine transit lanes, and coastal test and training ranges. Energy and energy-related facilities have the potential to create sustained electromagnetic and acoustic interference that can negatively affect ground-based, shipborne, airborne, and submarine-borne communications, sensors, and navigational aids. Some types of solar facilities incorporate towers over 600 feet tall. All renewable energy facilities require transmission lines with towers averaging 180 ft., which can limit aircraft from flying low, create electromagnetic interference, and limit buffer zones. Even biomass and geothermal plants can cause negative impacts to military testing, training, and operational missions.

All renewable energy projects have impacts on wildlife and habitat to some degree. Such impacts can include direct mortality, habitat fragmentation, clearing of vegetation, avoidance behavior from ground nesting birds like sage grouse, significant use of groundwater and other water sources (which in turn impacts wildlife and vegetation dependent on such water supplies), and other impacts. Renewable energy projects have the potential to influence the protected status of a species, especially if they are already under review for listing under the Endangered Species Act (ESA). Listing or increased protected status of a species can result in additional restrictions on DoD activities.

Renewable energy is not just an issue off the installation or range. It is DoD policy to achieve on-base energy security to ensure continuity of operations. The DoD has set a goal of 25% renewable energy sources by 2025. Military organizations responsible for developing on-base renewable energy projects may not be sensitive to or aware of the potential mission impacts. Installation-level coordination amongst mission proponents, energy managers, and environmental staff can greatly improve opportunities to minimize conflicts during the planning phase.

2. Mission Impacts

Renewable energy can bring benefits to the military installations such as lower cost of energy, islanding, and redundancy. However, without careful and methodical planning, coordination, and deconfliction, military capabilities are likely to be irreversibly impacted. Table 1 outlines some of the impacts that the development of renewable energy projects can have on military operations.

Table 1. Potential Impacts on Military Operations from Renewable Energy

Renewable Energy Type	Impact Potential							
	Airspace Conflicts	Radar and Sensor Function	Electromagnetic Frequency and Communication Interference	Acoustic	Land Use or Seaspace Conflicts	OPSEC Conflicts	Natural Resource Protections	Cultural Resource Protections
Wind	X	X	X	X	X	X	X	X
Solar	X	X			X	X	X	X
Geothermal	X	X			X	X	X	X
Biomass	X						X	

Hydro							X	X
Tidal, Wave, and Current					X		X	X

2.1 Wind Energy

a. IMPACT: Airspace for aviation testing and training

(1) Wind turbines can reach well over 400 feet above ground level (AGL) and the largest wind farms can cover thousands of acres. The larger the wind farm and taller the turbine, the greater the potential impacts on use of airspace.

(2) Turbine blade rotation and velocity can cause interference with radar, causing effects such as a 'Doppler shift' or 'Doppler effect'. These effects tend to reduce detection sensitivity, which obscures potential targets and scatters target returns.

(3) Units may have to abandon MTRs and SUA when airspace environments are too encumbered by vertical obstructions.

(4) Electromagnetic interference can negatively affect weapon and communication systems.

(5) In the test environment, airspace free from the physical spectrum intrusions of turbines is critical prior to and during operations, but this becomes difficult to achieve if wind farms are nearby.

(6) Aircraft, to include helicopters, may have to transition around or over turbines at higher altitudes.

(7) Night vision training can be negatively affected.

(8) Operations within line of sight can be negatively affected.

b. IMPACT: Ground-based Radars

(1) Wind turbines impact ground-based radar systems in three ways.

i. Reflections caused by the turbines change the detection behavior of the radar, which can reduce or eliminate the ability of the sensor to detect targets near or around the wind farm.

ii. Wind turbine blade rotation and velocity can alter the frequency spectrum, which falls below Doppler limits.

iii. Targets within the radar can become distorted by making the target appear larger or more attractive than the test item.

(2) In most cases, wind turbines must be in the line of sight of a radar to impact it. However, there are situations in which turbines can cause problems even if they are out of line of sight.

(3) Instrumentation and cross-section radar systems are particularly prone to interference.

c. IMPACT: Airborne Systems. Wind turbines have the same types of impacts on airborne radars as they do for ground-based systems. Turbines can be in line of sight of airborne systems from much further away given the higher altitude of aircraft systems.

d. IMPACT: Groundspace. Large wind farms on Bureau of Land Management (BLM) lands used by the DoD to meet training requirements can impact ground maneuvers. The loss of this land will require the units to locate new maneuver space suitable to meet training requirements. Use of new lands will require environmental documentation in support of the training.

e. IMPACT: Seaspace. Wind turbines can impact sea lanes, submarine transit lanes, and coastal test and training ranges within the surrounding sea area and compromise sonar test and training.

f. IMPACT: Habitat and Species. Wind projects can result in direct mortality to birds and bats, can lead to avoidance behavior in ground-nesting birds such as sage grouse, can fragment habitat and disrupt seasonal migration patterns, and can directly destroy occupied or unoccupied habitat for species. Such impacts on listed, candidate, or otherwise sensitive species or habitat (whether or not occupied by the species concerned) also found on DoD lands can have significant long-term second-tier effects on the DoD by increasing ESA-related restrictions on operations, specifically ground operations.

2.2 Solar Energy

Solar farms can have multiple impacts on test and training.

a. Solar thermal plants have a high thermal signature and may interact negatively with infrared sensors. The effect that solar thermal plants have on infrared sensors should be further analyzed, potentially through the Sandia National Laboratories Infrared Signature Analysis Tool, to determine the effects in/around ranges.

b. Depending on the solar technology used, it can impact SUAs, MTRs, and areas utilized by the military for ground maneuverability training.

c. Large solar farms can reduce available ground training space.

d. Solar projects using towers can reach heights of over 2000 feet AGL, which can impact many different types of airspaces and operations. The Federal Aviation Administration (FAA) requires all structures above 199 feet AGL to be sent through the Obstruction Evaluation/Airport Airspace Analysis (OE/AAA) office for determinations of impact to aviation.

e. Solar energy facilities sometimes utilize wireless control systems that can interfere with or be interfered by DoD systems.

f. Solar facilities can cause reflectivity from the sun. Glint (instantaneous flash) and glare (continuous blinding) can be quite severe depending on the type of solar facility and angle from the sun/exposure time. Modern photovoltaic panels minimize glint/glare but these potential impacts should be given consideration from a safety-of-flight and eye exposure perspective when deployed on or near DoD installations and ranges.

g. Depending on local water availability, some solar technologies may require excessive amounts of available water. All solar projects should be reviewed early in the planning stages to assess the potential, if any, for impact on local water supplies used by DoD installations. Especially in arid regions, this impact on water supplies, and especially on

groundwater, can in turn have severe impacts on species. This can result in second-tier impacts through additional restrictions on DoD water usage for other purposes and on increased restrictions on DoD operations under the ESA. In the Desert Southwest, the impacts of climate change are expected to significantly decrease water supplies in the future, making impacts on water increasingly significant.

h. Solar plants can destroy the habitat, requiring both leveling and total eradication of vegetation, with periodic retreatment with herbicides. If such impacts are not minimized through careful siting, and if sufficient mitigation (whether or not required by existing provisions of law) isn't provided, installations could be put under more ESA or Clean Water Act (CWA) restrictions with resultant constraints on mission capability.

i. Future disposal of used (outdated) panels is quickly becoming a large concern to installations. Currently there are no disposal sites for old panels. This leads to the following questions: Where is the proper location to dispose of old/used panels? Is this covered in the contract?

j. Security concerns can become a factor if the site is on or in close proximity to the range. Many of the solar panels are manufactured in other countries (i.e., China). Operations within the airspace could be compromised with the panels looking directly into the sky into restricted airspace offering the availability to surveil operations.

Caution: The FAA requires that all projects above 199 feet AGL be processed through the office of OE/AAA for determination for any hazard to flight and coordinated through the military representative (MILREP) at the FAA's regional office. Coordination of each project may not reach all impacted users. In order to insure you are in the loop it is suggested that your local airspace manager establish a good relationship with the local MILREP and FAA office.

2.3 Transmission Lines

Virtually all renewable energy plants require new transmission lines. Since renewable energy sources are often distant from load centers, long-haul transmission lines are being planned to facilitate the construction of renewable energy plants. Transmission lines can have mission impacts such as those described below.

a. Vertical obstructions such as transmission lines or towers can impact SUAs, MTRs, and other low-level aviation missions.

b. Transmission lines emit electromagnetic energy that can impact range systems, especially where electronic warfare testing or training is conducted.

c. Proposed use of electrical transmission lines for broadband wireless may cause additional impacts.

d. Transmission lines may result in fragmentation of habitat and disruption of migratory patterns as well as other adverse impacts on species and habitat.

2.4 Biomass-to-Energy

Converting biomasses can take two general forms: direct and indirect. In the direct conversion, biomass is converted to heat or electricity. In the indirect conversion, biomasses are converted to biofuel. The following are some of the concerns related to the conversion of biomass to energy.

a. Feedstock concerns include: sources, storage requirements, and impacts on transportation corridors, on biodiversity resulting from monoculture cultivation of feedstocks, and on water quantity and quality resulting from nutrient runoffs and other impacts. In areas of the Upper Midwest, the Mid-Atlantic, and the Southeast, such impacts can have potentially significant second-tier impacts on the DoD.

b. Plant concerns include: physical footprint, water requirements, stack heights, and compatibility with nearby land uses.

c. Emissions concerns include: smoke and condensation plume impacts on atmospheric opacity (visual and other spectra), odors, noise, and boiler ash.

d. Management processes are required to ensure mission equities are accurately mapped out and appropriately considered every step of the way.

3. What Can You Do?

Fostering awareness of military missions in the surrounding communities and routinely engaging with stakeholders are key to ensuring renewable energy projects that will negatively impact DoD activities are identified early in the proposal and approval process. This would allow installation points of contact and SMEs to interact with developers to ensure the projects are designed to be mission compatible.

3.1 Potential Strategies

The *Commanders Guide to Community Involvement*[3] provides several strategies that are applicable to all types of encroachment issues, including renewable energy.

a. Proactive engagement with local zoning boards is key to ensuring their land use ordinances accurately reflect DoD interests. Local zoning regulations can provide, at a minimum, notification to installation points of contact on upcoming renewable energy projects. Additionally, a “Red-Yellow-Green” or “stoplight strategy” can be used as a local ordinance-mandated screening tool for allowing renewable energy projects to occur or to establish hard limits. A good example of where this concept is in practice and has been incorporated into zoning ordinances is in Kern County, California.

b. It is important to participate in public hearings and other outreach opportunities to educate renewable energy developers, state and federal government agencies, industry organizations, non-governmental organizations engaged on energy issues, and the general public regarding potential impacts to ranges and the DoD mission.

[3] Range Commanders Council. *Commanders Guide to Community Involvement*. February 2022. May be superseded by update. Retrieved 17 October 2022. Available at https://www.trmc.osd.mil/wiki/x/Zoy8Bg.

c. Regional engagement with the DoD dedicated leads offers opportunities to discuss shared issues and strategize approaches to mitigating impacts from renewable energy development. The Mojave Commanders Summit is a good example of such an organization.

d. It is important to ensure a unified stance by providing consistent and coordinated messaging regarding range and mission impact potential across all DoD Services and ranges to ensure a unified stance.

3.2 Commander Actions

The following are steps commanders can take within DoD and MRTFB ranges themselves.

a. Establish chain of command communication and coordination with tenant organizations or occasional users from other installations or Services about lands, airspace, and seaspace managed primarily by a single installation or a single Service to ensure that impacts on the missions of those users is also taken into full consideration.

b. Ensure range personnel and mission operators participate in various groups that address renewable energy encroachment issues. The RCC SEG, the Southeast Regional Partnership for Planning and Sustainability, and the Western Regional Partnership are outstanding examples.

c. Establish an installation/range office of primary responsibility for alternative energy with access to appropriate SMEs, including environmental, hydrology, and natural resource staffs.

3.3 Other Potential Strategies

Other strategies may be employed to address renewable energy issues. These include the following.

a. It is important to maintain a robust Geographic Information System, such as the Mission Compatibility Analysis Tool, to provide quick analyses regarding potential projects.

b. Section 358 of the National Defense Authorization Act (NDAA) of 2011, as amended, states that the DoD shall identify Geographic Areas of Concern (GACs) selected as proposed locations for projects filed, or which may be filed in the future, with the Secretary of Transportation pursuant to Title 49 U.S.C., Section 44718, where such projects could have an adverse impact on military operations and readiness. Establishing a GAC or leveraging an existing GAC may assist in managing for long-term renewable energy conflicts. An existing Concept of Operations for establishing a GAC (formerly known as a Risk of Adverse Impact on Military Operations and Readiness Areas), was signed in 2015 by the Assistant Secretary of Defense (Readiness).

c. An agreement may be required to mitigate for impacts to range and airborne testing operations caused by renewable energy, especially wind turbines. These agreements, commonly called Mitigation Agreements, are agreements between renewable energy developers/operators and the DoD to curtail certain activities during heightened range operations and testing/training events, where the operation of the renewable energy facility may result in interference to the range operations. Contact the Military Aviation

and Installation Assurance Siting Clearinghouse[4] for additional information on developing a Mitigation Agreement. Their website also has a list of Curtailment Agreement samples in the online library that are available for download.

d. Mitigations can be developed.[5] Size, shape, and materials of the wind turbines can reduce or increase interference. Line of sight, addition of more radars around a wind farm (augmentation), and specific upgrades to the radar can also reduce interference.

e. The DoD Readiness and Environmental Protection Integration (REPI) Program (https://www.repi.mil/) is a key organization to assist installations and Services in combating encroachment that can limit or restrict military training, testing, and operations. The DoD created the REPI Program in response to the incompatible development and loss of habitat around its installations that can lead to restrictions or costly and inadequate training and testing alternatives. This program facilitates cost-sharing partnerships between military departments, other federal agencies, state and local governments, and private conservation organizations to help relieve or avoid land use conflicts near military installations and address regulatory restrictions that inhibit military activities. Conservation easements (private landowners) or limited use restriction or condition easements (state-owned lands) can limit or restrict the types of renewable energy projects constructed along the boundaries of an installation.[6]

f. A Joint Land Use Study[7] is a cooperative planning effort conducted as a joint venture between an active military installation, surrounding jurisdictions, state and federal agencies and other affected stakeholders to address compatibility around military installations.

4. Processes

The processes for planning, reviewing, and approving of renewable energy projects vary by location, type of project, size, and even the technology being utilized. On federal land, the agency controlling the land, such as the BLM or the U.S. Forest Service (USFS), has final authority. On private land, the local city or county typically has jurisdiction, with state agencies having concurrent or primary jurisdiction in cases of projects exceeding a specified size. In some states, local zoning ordinances govern the size and location of plants, but many states do not have zoning laws. These zoning and land use ordinances offer an attractive means for local commanders to raise awareness of DoD concerns with these technologies. Public utility commissions, energy commissions, and other agencies are often involved in the process. For plants involving structures 200 feet or higher, near an airport, or with potential impacts on air navigation radar, the FAA gets involved through the OE/AAA process.

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[4] Military Aviation and Installation Assurance Siting Clearinghouse. https://www.acq.osd.mil/dodsc/index.html.
[5] Sandia National Laboratories. *IFT&E Industry Report. Wind Turbine-Radar Interference Test Summary*. SAND2014-19003. September 2014. Retrieved 23 June 2022. Available at https://www.energy.gov/sites/prod/files/2014/10/f18/IFTE%20Industry%20Report_FINAL.pdf.
[6] Department of Defense. "What is the REPI Program?" Retrieved 23 June 2022. Available at https://www.repi.mil/Portals/44/Documents/Resources/REPI_FactSheet_WhatisREPI.pdf.
[7] Department of Defense. "Subject: Joint Land Use Study (JLUS) Program." DoDI 3030.03. 13 July 2004. Incorporating Change 1 31 August 2018. Retrieved 11 October 2022. Available at https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/303003p.pdf.

Developers must obtain a right of way (ROW) to build renewable energy projects on land under the jurisdiction of the BLM or a special use permit for energy projects on land under the jurisdiction of the USFS (including National Grasslands). After receiving a ROW or special use permit application, the federal agency involved (typically, BLM or the USFS) and other federal agencies must utilize the National Environmental Policy Act (NEPA) process to make a decision whether or not to grant the ROW or special use permit. On private lands, the process varies depending on the jurisdiction. Some jurisdictions require zoning changes or other environmental reviews. Other jurisdictions have designated renewable energy zones in their general plans so that approval of new projects is a relatively streamlined process. Many have no policies in place. Depending on the potential impacts of a proposed project, processes under NEPA, the ESA, the CWA, the Coastal Zone Management Act, the National Historic Preservation Act, and other federal or state regulatory statutes may also apply.

4.1 BLM-DoD Wind Generated Energy Facility Protocol

Signed in July 2008, the Policy requires DoD review of all proposed wind energy projects on BLM lands.[8] The Protocol establishes a 45-day timeline for the review and with a DoD option to request a 45-day extension. Action is initiated at the local level. The Protocol includes a dispute resolution process if agreement cannot be reached at the local level. Currently, internal DoD review processes do not consider all potential impacts of projects impacting DoD operations. Potentially problematic is the failure to consider impacts on candidate species of concern to the DoD, as the BLM is not required to conduct its own ESA analysis or consultation with regard to candidate (as distinct from listed) species.

4.2 Offshore Projects

States have jurisdiction out to three nautical miles from shore (and further in the case of some states) and the processes for review and approval of renewable energy projects are as varied as they are on land. The FAA's jurisdiction for project review via OE/AAA is out to 12 NM from shoreline; beyond state waters is federal jurisdiction. The Department of the Interior (DOI), Bureau of Ocean Energy Management, Regulation and Enforcement, the U.S. Army Corps of Engineers, and the U.S. Coast Guard have jurisdiction, with the DOI having the primary jurisdiction. The National Oceanic and Atmospheric Administration also has a role with regard to potential impacts on marine mammals and other protected marine species. There is a Memorandum of Agreement between the DOI and the DoD to address mutual concerns on the Outer Continental Shelf (OCS). In 2009, the DoD provided an assessment of proposed OCS oil and gas exploration and production, including areas in which such activities would be incompatible with military activities. The assessment also included site-specific stipulations in other areas if oil and gas exploration and production are approved. The recommendations were accepted by the DOI.

4.3 DoD Clearinghouse

The Office of the Secretary of Defense has established a Clearinghouse to ensure consistent DoD responses on proposed renewable energy projects. Section 358 of the 2011 NDAA establishes timeframes for Clearinghouse review of certain existing and new projects

[8] Bureau of Land Management. *Wind Energy Development Policy*. IM 2009-043. Retrieved 5 October 2022. Available at https://www.blm.gov/policy/im-2009-043.

(those requiring the OE/AAA FAA review) as well as standards and criteria concerning determinations of adverse impacts on the DoD. Additional policies and procedures are being developed, but the Clearinghouse will be involved in review of all utility-scale renewable energy projects and have final decision authority on projects that would present an unacceptable risk to national security. Regional processes, led by the DoD Regional Environmental Coordinators, were established to provide regional coordination among all the Services. The model for these teams is the DoD Southwest Renewable Energy Work Group, a joint multi-state group formed in 2003. This group was reconstituted as the SW DoD Regional Coordination Team in 2011 to address all aspects of encroachment, including renewable energy. They coordinate review of all renewable energy projects across all Services to ensure consistency and a one-voice approach is utilized to respond to potential mission impacts.

4.4 Offices of Energy Initiatives

Within the DoD, each Service has an office dedicated to energy conservation. Generally, the goals are to reduce consumption of energy, decrease reliance on foreign oil sources, and significantly increase the use of alternative energy. The purposes are to improve combat capabilities, improve readiness, and increase energy security. Renewable energy project development harnesses targets of opportunity for modernizing energy systems and mitigating against increased physical, natural, and cyber threats. These offices are involved with early planning and coordination with stakeholders at an installation level to deconflict mission conflicts. There are processes that facilitate coordination between installation commanders, mission commanders, SMEs, and mission support elements as well as the Office of Secretary of Defense Clearinghouse to validate viable projects prior to implementation.

5. Renewable Energy Basics

Renewable energy technologies are continually evolving and thus need a watchful eye to ensure that they do not become even more of an encroachment threat than they already are.

5.1 Wind Energy

A wind energy system transforms the kinetic energy of the wind into mechanical or electrical energy that can be harnessed for use. Mechanical energy is most commonly used for pumping water in rural or remote locations; the farm windmill still seen in many rural areas of the U.S. is a mechanical wind-driven water pumper. Wind electric turbines generate electricity for homes and businesses.

5.1.1 Basic Designs of Wind Electric Turbines

The two basic designs of wind electric turbines are:

a. Vertical-axis wind turbines (known as VAWTs, or egg-beater style) (shown in Figure 2); and

b. Horizontal-axis turbines (propeller-style).

Figure 2. Vertical-Axis Wind Turbine

Horizontal-axis wind turbines are most common today, constituting nearly all of the *utility-scale* (100 kilowatts [kW] capacity and larger) turbines in the global market. Figure 3 shows a typical utility-scale wind turbine along with operational data.

- Tower Height: ~328 ft
- Rotor Diameter: ~ 361 ft
- Rated Capacity: ~ 3 MW
- Cut-in wind speed: ~6.8 kts
- Cut-out wind speed: ~52 kts
- Rated wind speed: 27 kts
- Rotor speed: 8. 5 – 15.3 rpm
- Blade tip speed: ~170 kts

Figure 3. State-of-the-Art Wind Turbine and Offshore Wind Farm

5.1.2 Wind Turbine Subsystems

Primary components include the following.

a. A rotor, or blades, that convert the wind's energy into rotational shaft energy.

b. A nacelle (enclosure) containing a drive train and usually a gearbox and a generator.

c. A tower, to support the rotor and drive train.

d. Electronic equipment such as controls, electrical cables, ground support equipment, and interconnection equipment.

e. Wireless remote controls

Wind turbines vary in size from small business and residential units that are in the 60 to 120 foot range (50 to 500 kilowatts of generating capacity) to current utility-scale state-of-the-art units that are capable of generating 3 megawatts of electricity and could be over 500 feet tall at the maximum blade tip height. Offshore turbines can be even larger. The most economical application of wind electric turbines is in groups of large machines called *wind power plants* or *wind farms*, which often include scores or hundreds of wind turbines. The electricity generated by a utility-scale wind turbine or wind farm is normally collected and fed into the utility power grid, where it is mixed with electricity from other power plants and then distributed to utility customers.

5.2 Solar Energy

A variety of technologies convert sunlight to usable energy. The most commonly used solar technologies for homes and businesses are solar water heating, passive solar design for space heating and cooling, and solar photovoltaic (PV) for electricity. Solar PV and concentrating solar power (CSP) technologies are used for utility-scale power plants. The PV technology converts sunlight directly into electricity using specially designed panels. The PV plants, like the one at Nellis Air Force Base (AFB) shown in Figure 4, are typically no more than 50 feet high and are considered a low threat with regard to glint and glare for aircrews. The CSPs use the heat from the sun to generate steam that powers conventional turbines, and use significant amounts of water, which can be problematical in arid areas. There are three types of CSPs; they are solar troughs, solar power towers, and Stirling engines. Figure 5 shows a Stirling engine. Troughs and Stirling engine plants are normally less than 50 feet tall. Power towers are typically over 500 feet tall. The largest solar power tower in the world stands at 861 feet in Dubai. The largest solar power tower in the U.S. stands at 458 feet and is in San Bernardino County, CA. (Figure 6 depicts the power tower in Dubai. Figure 7 depicts the power tower in San Bernardino County [Ivanpah]). All solar plants require large, flat areas of land that are totally cleared of any vegetation and that are periodically treated with herbicides. A potential concern is the disposal of older PV panels. White Sands Missile Range (WSMR) is currently trying to determine an adequate location to dispose of 15,000 PV panels that are being replaced.

Figure 4. Nellis AFB Photovoltaic Solar Facility

Figure 5. Stirling Engine Solar Facility

Figure 6. Dubai Solar Power Tower

Figure 7. Ivanpah Solar Power Tower

5.3 Geothermal

Geothermal energy is energy derived from the natural sources of heat inside the Earth. Naturally occurring hot water or steam is converted into electricity. At the Earth's core, temperatures can reach over 9,000 °F. This heat continuously flows outward and is absorbed by the rocks and water deep underground. The most common way of capturing the energy from geothermal sources is to tap into naturally occurring hydrothermal convection systems where cooler water seeps into the Earth's crust, is heated up, and then rises to the surface. When heated water is forced to the surface, it is a relatively simple matter to capture that steam and use it to drive electric generators.

Geothermal power plants drill holes into the rock to more effectively capture the steam. There are three designs for geothermal power plants, all of which pull hot water and steam from the ground, use them, and then return them as warm water to prolong the life of the heat source. In the simplest design, the steam goes directly through the turbine, then into a condenser where it is condensed into water. In a second design, very hot water is depressurized or flashed into steam that can then be used to drive the turbine. In the third design, called a binary system, the hot water is passed through a heat exchanger, where it heats a second liquid (such as isobutane) in a closed loop. The isobutane boils at a lower temperature than water, so it is more easily converted into steam to run the turbine.

Geothermal power plants have the smallest footprint of any form of renewable energy in terms of surface area used per unit of energy produced, and typically have fewer adverse impacts on species and habitat than any other kind of renewable energy, although some impacts on groundwater can be experienced. Other impacts that should be considered are the disposal of wastewater or geothermal brine, micro-earthquakes when reinjection occurs, and the disposal cost to an installation.

5.4 Biomass to Energy

Biomass power is power obtained from the energy in plants and plant-derived materials, such as food crops, grassy and woody plants, residues from agriculture or forestry, and the organic component of municipal and industrial wastes. Biomass is the burning of material that is a contributor to atmospheric CO_2/SO_2 concentrations to create heat or to be converted into

electricity. While it is not a form of clean energy, it is still considered a form of renewable energy. Biomass can be an attractive petroleum alternative because it is a renewable resource that is more evenly distributed over the Earth's surface than finite energy sources and may be exploited using more environmentally friendly technologies. Biomass can have adverse ecological impacts depending on the type of feedstock used, whether ecologically diverse habitats are converted to monoculture production of feedstocks, and impacts on water quantity or quality either through increased demand or through increased release into water systems of nutrients such as nitrogen or phosphorus used in connection with growing biofuel feedstock.

5.5 Hydro Energy

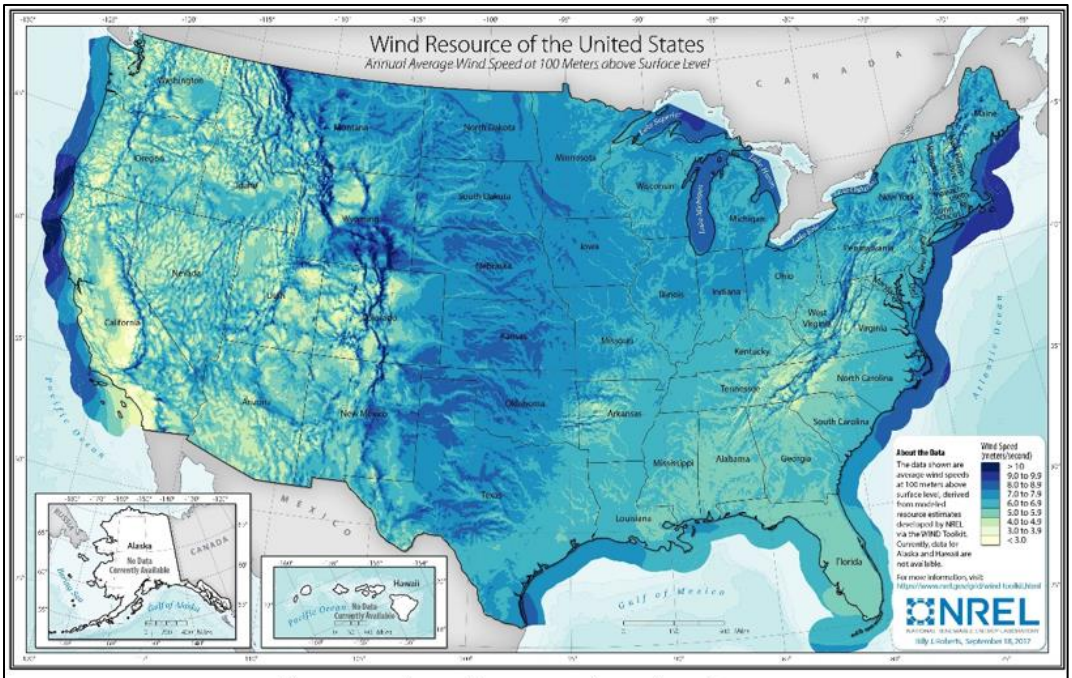
Hydro energy is using the energy of flowing water to generate power. The force of water, as it flows from a higher to lower elevation, converts kinetic energy into mechanical energy. This mechanical energy is used to rotate turbines connected to a generator that converts the energy into electricity. Aside from a plant for electricity production, a hydropower facility consists of a water reservoir enclosed by a dam whose gates can open or close depending on how much water is needed to produce a particular amount of electricity. The U.S. has about 80,000 megawatts (MW) of conventional hydro energy capacity and 18,000 MW of pumped storage. As with other renewable energy production, hydropower can also have adverse ecological impacts, including interruption of the natural ecological flows of a river system, impeding up and downstream movement of fish and other aquatic species, severance of floodplains from river systems with resulting disruption in nutrient refreshment, and other similar impacts.

5.6 Tidal, Current, and Wave

Tidal variation, ocean currents and waves, and, to some extent, rivers can be used to generate electricity. Tidal energy is produced using tidal energy generators. Large underwater turbines are placed in areas with high tidal movements and designed to capture the kinetic motion of the ebb and flow of ocean tides to produce electricity. Current generators are similar. Wave generators utilize the constant up and down movement of the ocean to power generators.

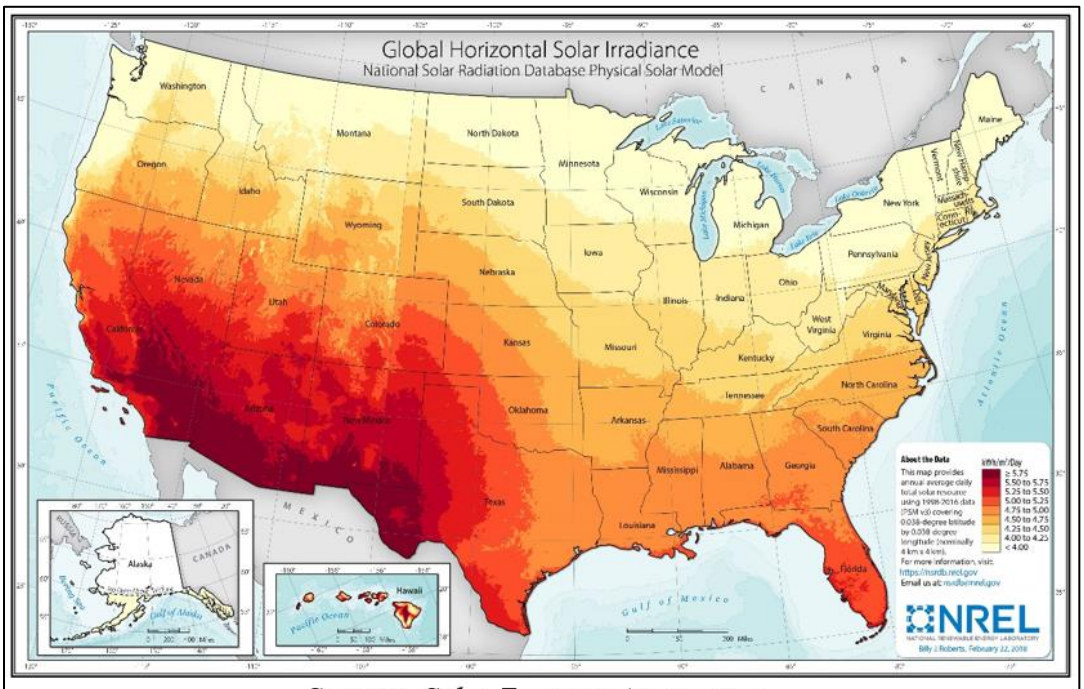
5.7 Available Renewable Resources

One common aspect of most renewable energy plants is that they must be located where there is a readily available renewable resource. Wind farms must be built where the wind blows enough to make the plant economically viable. Figure 8 shows where wind resources are located and Figure 9 shows where solar resources are located based on currently available data. Other factors, such as environmental, operational, and land use restrictions, land and water availability, and especially proximity to and access to transmission lines drive where renewable energy plants are built. These maps provide a good indicator of ideal areas, and it is in those high resource areas that plants are being planned and developed.



Source: *http://www.nrel.gov/rredc*

Figure 8. U.S. Annual Wind Power Resources



Source: *Solar Energies Association*

Figure 9. U.S. Average Annual Solar Resources

5.8 Trends

There is no question that renewable energy is on the rise in this country and around the world. A record 16,836 MW of U.S. wind capacity was installed in 2020, bringing the

cumulative total to 121,955 MW. Wind power installations outpaced those in solar power for the first time in several years. Wind provides more than 10% of electricity in 16 states. Figure 10 shows the growth of wind energy generation from 2010 in the U.S.

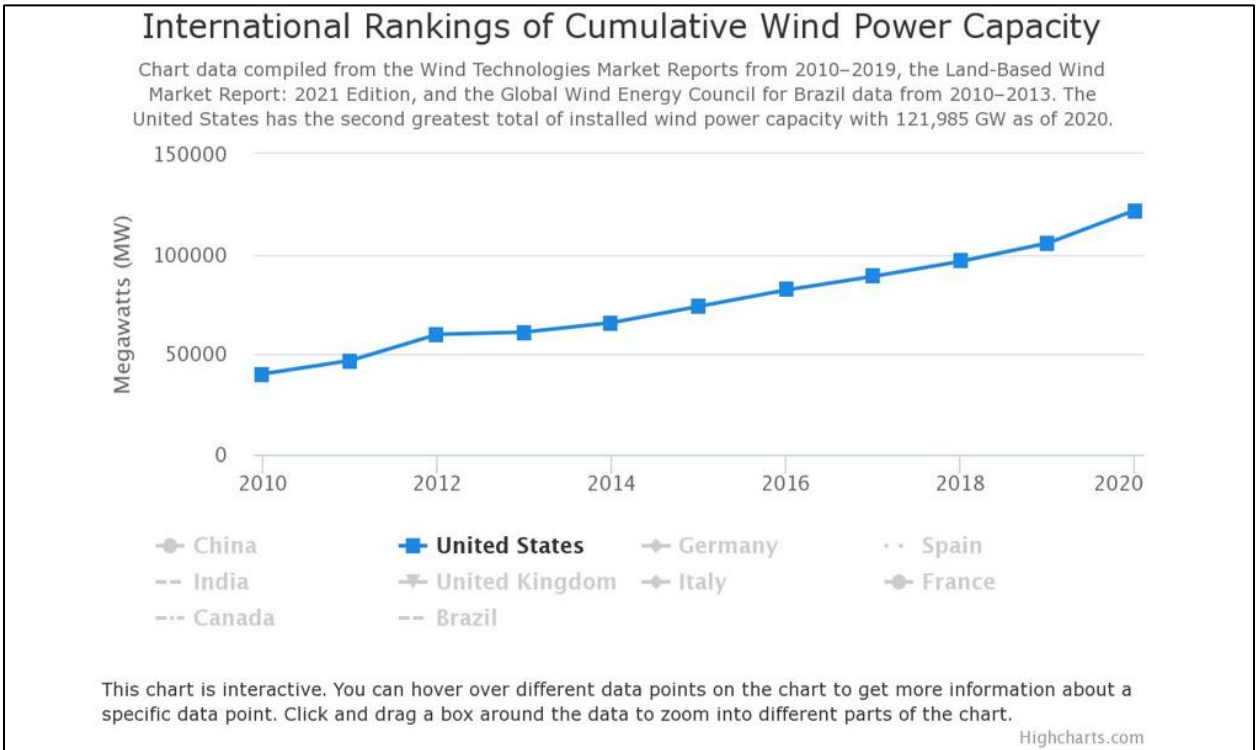


Figure 10. U.S. Wind Energy Generation Capacity

Wind turbines continued to grow in size and power, with the average nameplate capacity of newly installed wind turbines at 2.75 MW - up to 8% from 2019 and 284% since 1998-1999. The U.S. offshore wind pipeline grew 24% over the previous year, with 35,324 MW now in various stages of development. Global offshore wind installations in 2020 totaled 5,519 MW. Turbine sizes continued to grow, with average rotor diameters exceeding 150 meters and turbine capacities more than 12 MW. New trends also emerged in 2020, including increased interest in using offshore wind to produce clean hydrogen. The global pipeline for floating offshore wind energy more than tripled in 2020 to 26,529 MW. There are 15 projects in the U.S. offshore pipeline that have reached the permitting phase, and eight states have set offshore wind energy procurement goals totaling 39,298 MW by 2040. Offshore wind energy, particularly off the Mid-Atlantic Coast, is expected to grow significantly in the near to mid-term. Depending on the development of commercially viable deep water technologies, offshore wind off the Pacific Coast may also be used in the years ahead. The primary reasons may include the proximity to significant load centers (urban areas on or close to the shoreline) and simpler resolution of complex issues related to new transmission infrastructure, which is often a limiting factor for development on land.

Today, the 2 million residential, commercial, and utility-scale solar installations produce enough electricity each year to power more than 12 million American homes. By 2024, 2.5% of all U.S. homes will have a solar installation. The total amount of solar generating capacity that

goes along with the 2 million solar installations has now eclipsed 70 gigawatts. California represented 51% of the first million installations but accounted for 43% of the second million. Other fast-growing states over the last three years include Texas, Utah, Florida, Rhode Island, and Maryland, which combined have grown from around 50,000 installations to more than 200,000. Looking ahead, Illinois will see cumulative installations increase from 4,000 today to nearly 100,000 by 2024. While California will continue to lead the nation in installations, the remaining top 10 state markets will see faster growth. Nearly 750,000 installations are expected in those markets over the next 5 years, compared to 500,000 installations over the last 5 years. See Figure 11. "According to our latest forecasts, by 2024, there will be on average, 1 solar installation per minute," said Michelle Davis, Senior Solar Analyst with Wood Mackenzie. "That's up from one installation every 10 minutes in 2010."

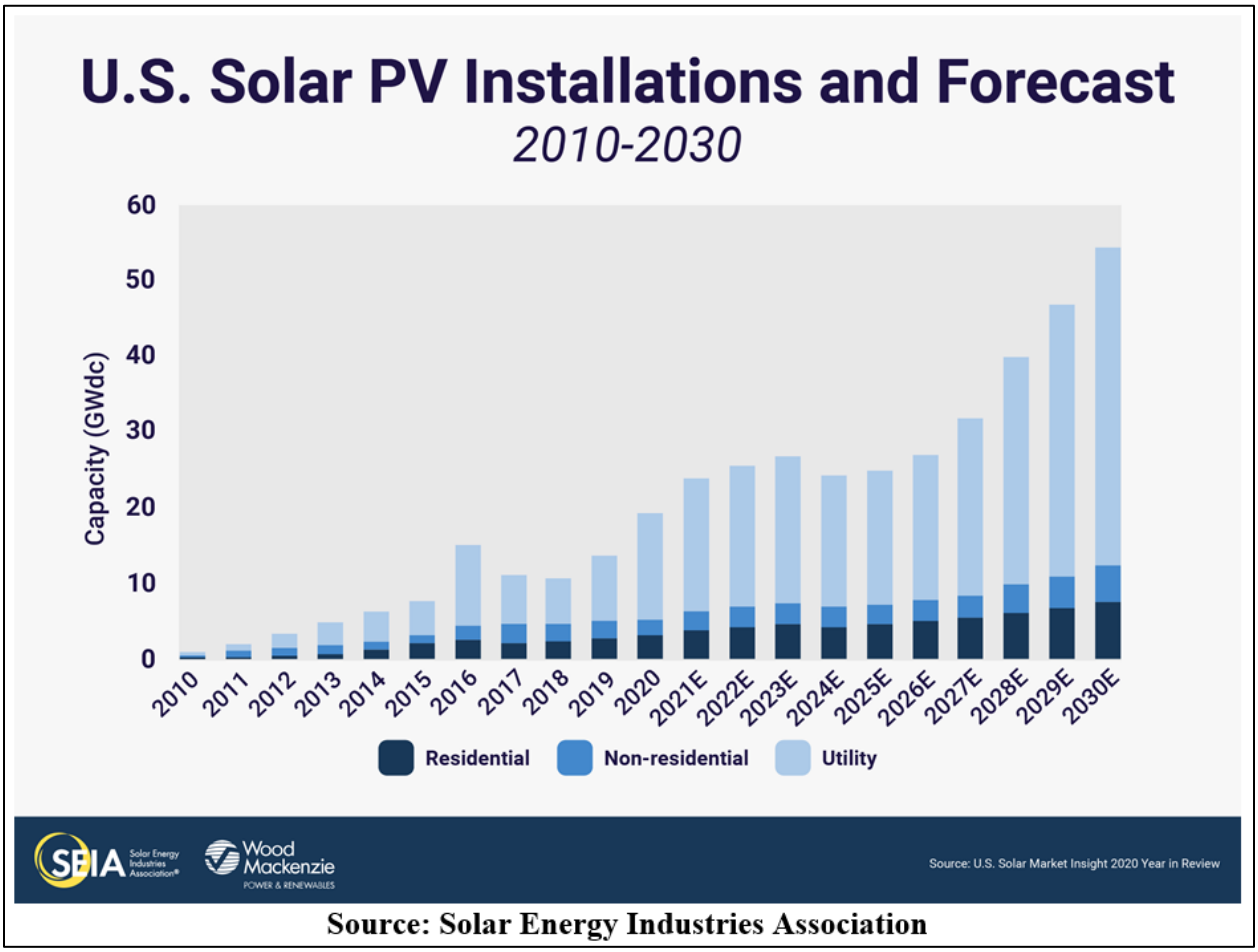


Figure 11. U.S. Cumulative Solar Capacity Growth

6. **Planning Efforts**

Several planning efforts to facilitate renewable energy development are either underway or have been completed. The scope of these efforts is typically statewide or regional in scope. Some examples are given below; others will exist in the future.

6.1 Wind Energy Programmatic Environmental Impact Statement (PEIS)

This PEIS was prepared by the BLM to facilitate the approval of wind energy projects on BLM land in eleven Western states. The Record of Decision (ROD) was signed in 2005. It includes a provision that addresses potential military mission impacts and allows the BLM denial of an application based on those impacts. The PEIS is available at http://windeis.anl.gov/.

6.2 West-wide Energy Corridor PEIS

This PEIS was completed in 2009. The purpose is to facilitate approval and construction of transmission lines on federal lands in eleven Western states to connect renewable energy to load centers. The PEIS is available at http://corridoreis.anl.gov/.

6.3 Solar Energy PEIS

This PEIS was completed in 2012. It provides up-to-date information on the implementation of solar energy development on public lands in the six Southwestern states. The PEIS is available at http://solareis.anl.gov/.

6.4 Western Renewable Energy Zones (WREZ)

The WREZ is an effort by the Western Governors Association to identify renewable energy zones in eleven Western states and the corridors to bring energy produced therein to load centers. The Phase I report was completed in 2009 and is available here.

6.5 California Renewable Energy Transmission Initiative (RETI)

The RETI is similar to the WREZ effort (except for California). The RETI recommendations were used in the WREZ study.

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APPENDIX A

Citations

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