Executive Summary

ES.1 Key Findings

- This analysis determined that over 7,000 megawatts (MW_{AC}) of solar energy development is technically feasible and financially viable at several Department of Defense (DoD) installations in the Mojave and Colorado Deserts of California.
- Approximately 25,000 acres are "suitable" for solar development and another 100,000 acres are "likely" or "questionably" suitable for solar.
- This level of solar potential exists even though 96 percent of the surface area of the installations is unsuitable for solar energy development due to conflicts between solar energy development and military mission activities occurring at the installations or due to steep slope, flash flood hazards, biological resource conflicts, cultural resource conflicts, and other factors.
- Private developers can tap the solar potential with no capital investment requirement from the DoD.
- The Federal Government could potentially receive approximately $100 million/year in the form of rental payments, reduced cost power, in-kind considerations, or some combination among them.
- There are a range of technical, policy and programmatic barriers that can slow or, in some cases, stop solar development. Transmission capacity and the management of withdrawn lands are the two most important issues.

ES.2 Report Purpose

This study addresses current solar development activities and includes an evaluation of the potential for solar energy development inside the boundaries of nine large military installations located in the Mojave and Colorado Deserts of southern California and Nevada (see Figure ES.1 and Table ES.1). In addition to assessing the solar energy potential of the military installations, this report also discusses the potential mission compatibility and energy security impacts of on-installation solar energy development and the broader context for solar energy development in the Mojave and Colorado Deserts. The Department initiated the study in response to a congressional request.

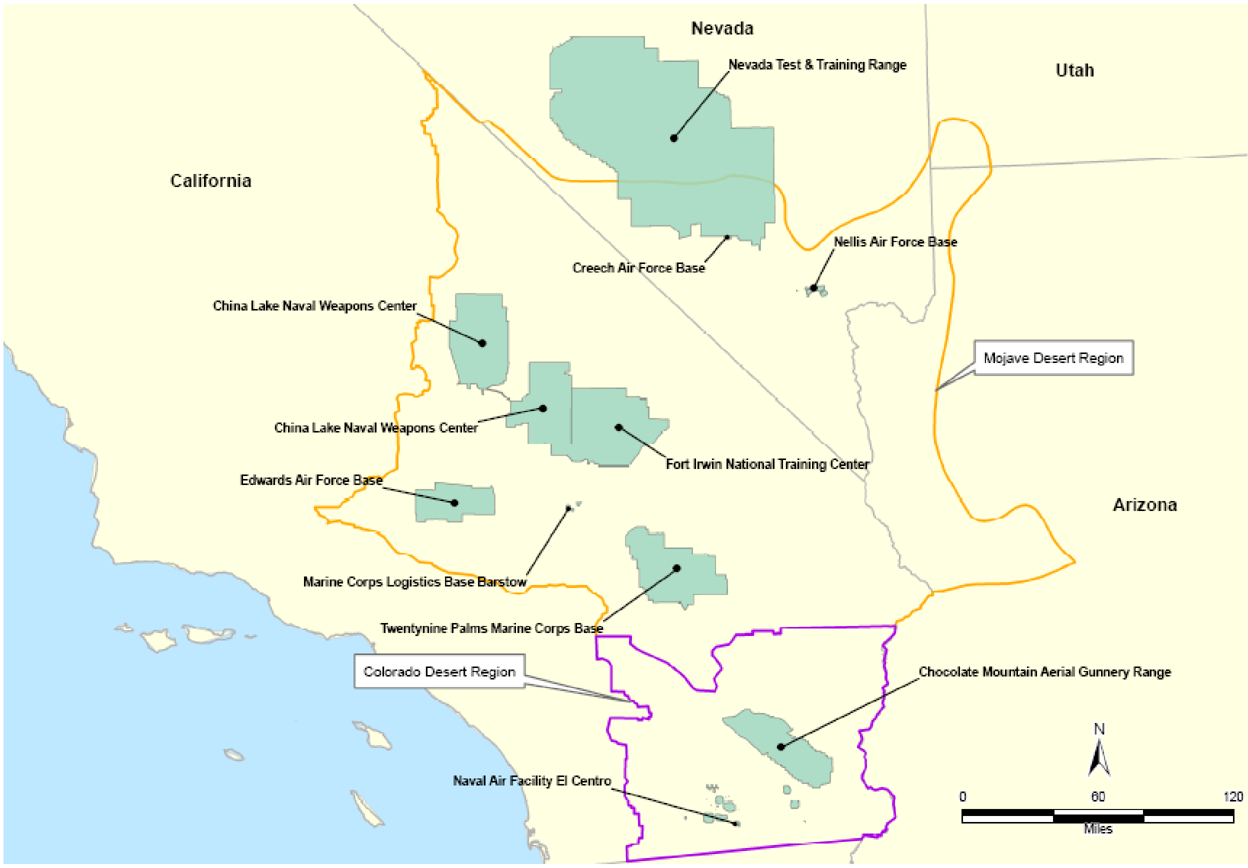

Figure ES.1 – DoD Installations Addressed by this Study

The nine installations are diverse, and each needs to be considered in the context of its unique mission role, land endowment, utility service arrangements, and solar development flexibility. The installations include representation from the Army, Air Force, Navy and Marine Corps. Their mission roles span a wide range of activities, including air, ground and combined arms training; weapons system research and development; human- and technical-factor weapons system testing and evaluation; and logistics support and management. Most of these installations already have 1-2 megawatts (MW) of solar energy systems in operation, and Nellis AFB is host to the largest photovoltaic (PV) system sited on a military facility in the U.S., a 14.2 MW solar PV facility completed in 2007.

Table ES.1 – U.S. Department of Defense Installations Reviewed in Study

Installation	Service	State	Geographic Region
Marine Corps Air Ground Combat Center (MCAGCC) Twentynine Palms	Marine Corps	CA	Mojave Desert
Marine Corps Logistics Base (MCLB) Barstow	Marine Corps	CA	Mojave Desert
Chocolate Mountain Aerial Gunnery Range (CMAGR)	Marine Corps	CA	Colorado Desert
Naval Air Weapons Station (NAWS) China Lake	Navy	CA	Mojave Desert
Naval Air Facility (NAF) El Centro	Navy	CA	Colorado Desert
Edwards Air Force Base (AFB)	Air Force	CA	Mojave Desert

Fort Irwin	Army	CA	Mojave Desert
Creech Air Force Base (AFB)	Air Force	NV	Mojave Desert
Nellis Air Force Base (AFB) and the Nevada Test and Training Range (NTTR)	Air Force	NV	Mojave and Great Basin Deserts

ES.3 Mission Compatibility

The military services use the nine military installations as key assets for training, test and evaluation, and research and development. Their size and relatively remote locations offer the military the ability to train personnel and conduct research and development on technology in ways that would not be possible at other locations. The military's need for large, unrestricted landholdings has increased in recent years because modern systems and platforms – aircraft, missiles, sensors, etc. – have effective ranges and impacts vastly larger than their predecessors from the 1940s, when most of the installations in this study were established. Large areas are needed to test, evaluate and train with these systems, both to exploit their full capabilities, and to ensure that any unanticipated incidents occur over controlled ranges, rather than populated areas.

Although the effective battlespace requirement is growing, the military's landholdings are not. Because it is unlikely that any new major installations will be created in the region, the existing installations should be considered irreplaceable, and any degradation of their ability to perform their missions has an impact on both the near and long term capabilities of the military to protect and defend the U.S. Any plan for large-scale solar development on these installations needs to acknowledge and start with that premise.

There are two broad categories of conflict between solar technology and mission activities. The first category comprises "spectrum" issues, where the conflict between solar technology and military activities occurs through interactions in the radio frequency, infrared or visual spectra (see Table ES.2).

Table ES.2 – Function and Band of Military EM Spectrum Use

Spectrum	Sensors	Weapons	Communications
UV	Threat Warning	Missile Guidance	Data Link
Visible	Optical, Telescopic sights, NVD, Electro-Optical imaging, precision tracking	Aiming and Guidance, Fuzing	Light signals, Navigation lights
IR	Threat warning, NVD, IR Imaging, Laser warning, Laser ranging, Precision tracking	Active and passive Laser guidance, IR passive guidance, Laser Proximity fuzing, High Power Laser	IR beacons, Modulated Laser Data link, voice
Radio	Threat Warning, Electronic Support, Radar, IFF, GPS, Navigation, Telemetry, Precision measurement	HPM, Electronic Attack (Jammers), Anti-Radiation Missiles, Radar and Radio guided Missiles, Proximity Fuzing	AM, FM, HF Voice, Data Link, SATCOM, Telemetry, UAS Control

See Appendix C for full names of the acronyms in the table.

The second category comprises “physical” issues, where the conflict arises from hazardous or destructive interaction between military vehicles, ordnance, and other hardware on the one hand, and solar technology on the other (see Table ES.3).

Table ES.3 – Summary of Training and Testing Activities on Bases and Ranges

	Fort Irwin	NAWS China Lake	El Centro NAF	MCAGCC Twentynine Palms	MCLB Barstow	Chocolate Mtn. AGR	Edwards AFB	Nellis AFB & NTTR	Creech AFB
Live Training	X	X	X	X	X	X	X	X	X
Dismounted Maneuver Training	X	X		X		X			
Mounted Maneuver Training	X	X		X					
Air Operations Training	X	X	X	X		X	X	X	X
Individual & Unit Live Fire Weapons Training	X	X	X	X	X	X	X	X	
Joint/Combined Arms Maneuver Training	X	X	X	X		X			
Joint/Combined Arms Live Fire and Maneuver Training	X	X		X		X	X	X	
Test and Evaluation		X		X			X	X	X
Support Facilities	X	X	X	X	X		X	X	X

Because the installations support the complex scope of the Nation’s military activities, the range of interactions between their activities and solar development is also complex and wide-ranging. Certain issues are more prevalent on some installations, while others are present at all of the installations. Some conflicts can be mitigated, while others cannot. It is also important to note that each installation is home to a diversity of activities, so that while mission conflicts may exclude solar development from active range areas, other areas of the installation may be free of mission conflicts. Each proposed facility needs to be evaluated in the context of its specific location and the current, and potential future, mission activities occurring there.
Although the study provides a screening level review of potential mission conflicts, there are gaps in data and analysis on mission compatibility. Very few detailed studies of conflicts between mission activities and solar development are available in the public domain.

ES.4 Solar Potential Assessment

Results

Because the two installations in Nevada lack significant solar development potential in addition to projects already developed or planned, the solar potential assessment portion of this study focuses on the seven military installations located in southern California. For the seven California installations, 96 percent of the land surface, largely active range land, is unsuitable for solar development. About 25,000 acres are "suitable" for solar development and another 100,000 acres are "likely" or "questionably" suitable for solar.

Assuming that 100 percent of the "suitable" acreage plus 25 percent of the "likely" and "questionable" acreage is available for solar development, the study determined that over 7,000 MW_{AC} of technically and economically feasible solar capacity could be sited on these lands. In this study "economically feasible" means that the solar projects would be financially attractive from the perspective of the project investor. However, the study found that only private investors would find it attractive to invest in these projects because private investors have access to Federal and State tax-based incentives, which permit them to earn an attractive rate of return on their investments. The study found that government investment (e.g., direct DoD funding of construction) would be financially unattractive in all cases. The most important federal solar tax incentive is mandated to be available through the end of 2016, but it is possible that legislative action in the interim could phase-out or eliminate this incentive, which would make private project investment less viable.

Assuming private development and ownership of economically-viable solar capacity on the seven California installations, the Federal Government could expect to receive over $100 million of annual value, in the form of rental payments, discounted power, in-kind considerations, or some combination thereof. Full development would also result in the avoided emissions of millions of tons of greenhouse gases and criteria air pollutants.

These available acreage and solar capacity figures represent the maximum potential for solar electricity development, if one placed solar on all sites that could feasibly host it from the technical and economic perspectives. The actual level of solar energy development on these military installations is likely to remain well below the maximum potential number for a wide variety of reasons, including a shortage of available transmission in the region, environmental constraints that could not be incorporated into this study, administrative and legal complexity, and competition from other generation sources.

The potential annual electricity generation from this solar energy capacity would be equivalent to two-thirds of the current annual electricity consumption of the entire DoD, nationwide. While complete development of all of the identified solar energy potential is unlikely, allowing full solar development on approximately 6% of the identified, economically-viable lands would generate enough electricity to meet all of the DoD's EPAct 2005 renewable energy goals while solar development on less than half of the identified lands would be sufficient to meet all of the DoD's NDAA 2010 renewable energy goals (25% of facility energy supplied by renewable energy sources in 2025).

It is important to note that the geographical and technical aspects of this analysis were not designed to be a detailed engineering analysis of specific solar projects, nor was the economic analysis intended to be of sufficient detail for investment decision-making for any particular site. Rather, this process provides a reasonable estimate of the technical and economic potential for solar development across millions of acres of complex landscape within a constrained study schedule and budget. However, while bearing this disclaimer in mind, it is reasonable to treat the results of this study as a robust screening of potential solar development areas. Each installation and each Service's center of expertise for solar development (e.g., NAVFAC, AFCESA, Corps of Engineers, MCI, etc.) can use the outputs of this analysis as inputs to their own process of solar site selection and development.

<u>Methodology</u>

The study organized the many issues affecting solar viability into three categories – geographic, technological, and economic.

Geographic Analysis

The study analyzed these issues in a step-by-step manner, with **geographic** screening analyses occurring first. The geographic analysis identified potential sites for roof, parking, and ground-mounted solar projects from among the military installations' total inventory of buildings, parking facilities, and lands. Five distinct "site types" were used: building rooftops; shading structures over paved parking lots; shading structures over unpaved parking lots; cantonment[1] ground sites; and, range ground sites. Hundreds of layers of Geographic Information System (GIS) data were obtained from public, Service and installation databases in support of this study (see Figure ES.2).

[1] Each installation except for Chocolate Mountain AGR, was segmented into a cantonment area representing the developed zone of the installation, and a range area representing the undeveloped zone. The study applied different criteria and decision rules for solar projects in the two zones, except Edwards AFB where transmission calculations for the installation's cantonment and range zones were combined because they are especially co-mingled.

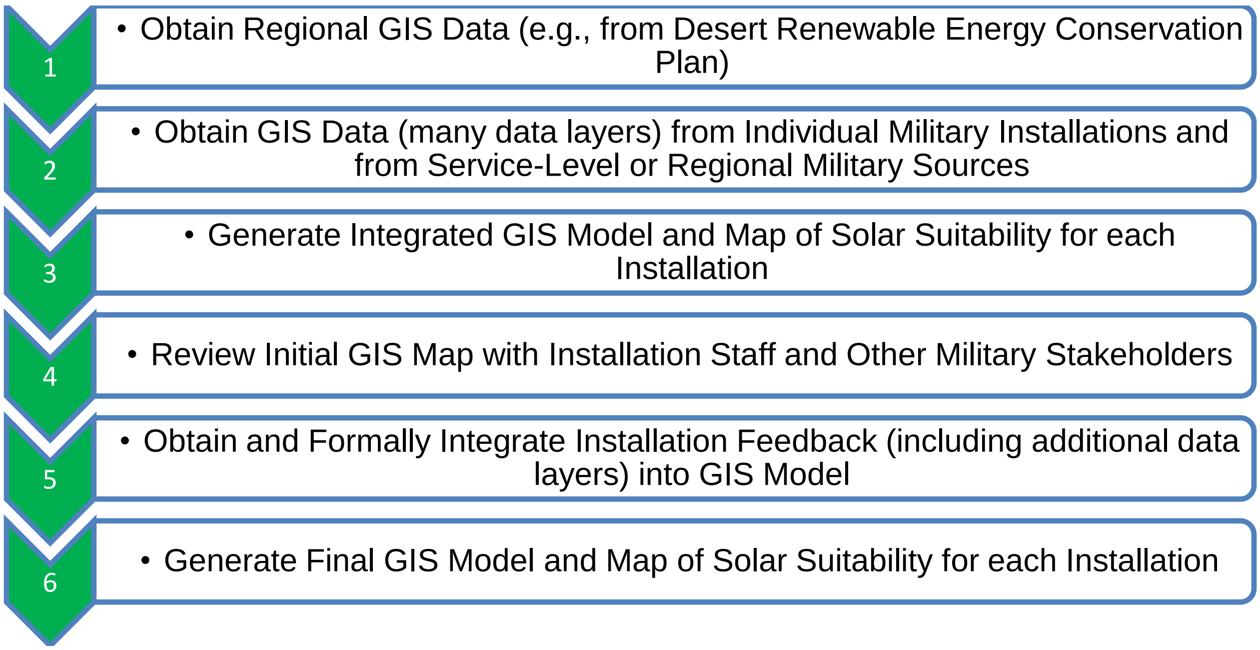

Figure ES.2 – GIS Data Collection Methodology

For the ground sites that comprise the vast majority of this study, GIS techniques were used to overlay 20 to 40 independent variables per installation to identify areas where solar development can and cannot occur. The GIS variables were typically in the categories of built infrastructure, construction plans, biological resources, cultural resources, environmental resources and hazards, military mission and operational activities including explosive arcs, topography, shading, and buffers around various areas. Figure ES.3 summarizes the GIS analysis process.

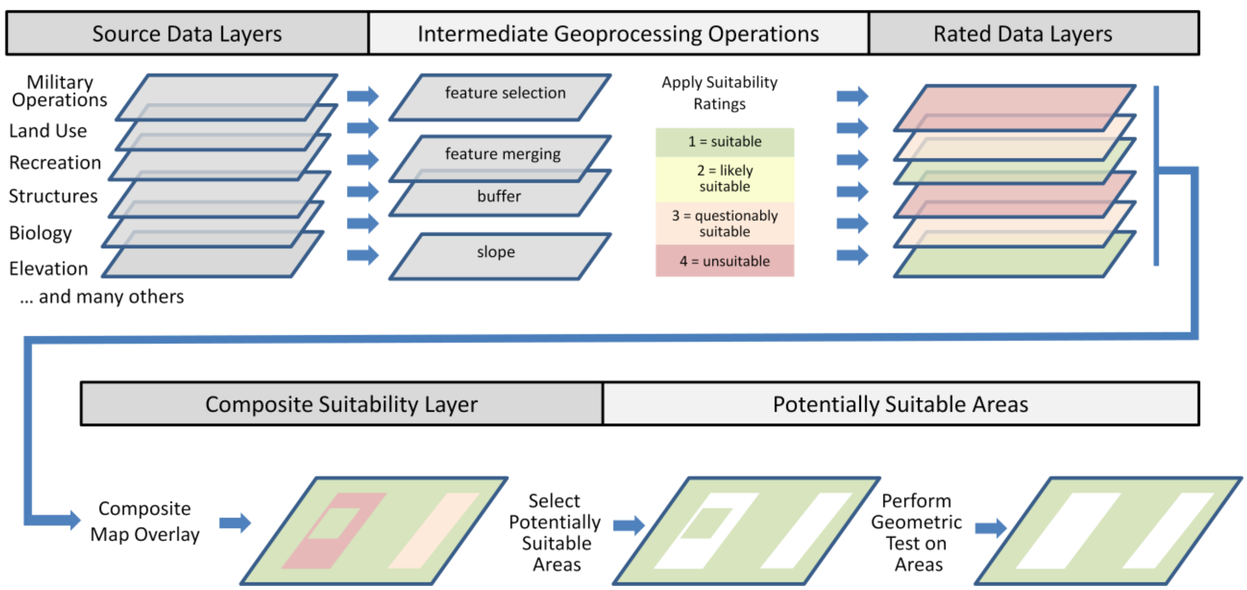

Figure ES.3 – Geographic Information Systems Analysis Flow

As shown in Figure ES.4 below (an example drawn from NAWS China Lake), at most of the installations studied, the vast majority of the land surface was screened out during the geographic analysis phase due to mission compatibility conflicts.

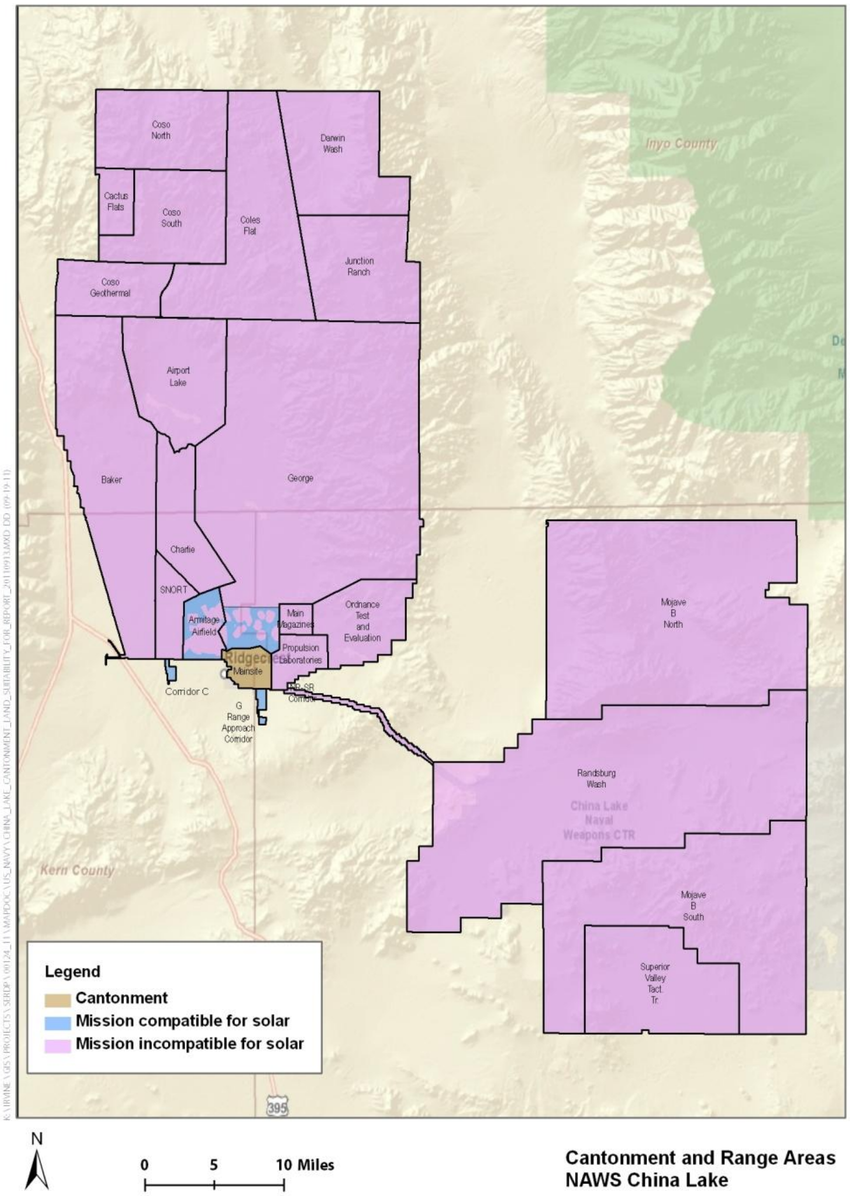

Figure ES.4 – Mission Compatibility at NAWS China Lake

However, as show in Figure ES.5, even the relatively small area surviving this screening process still has significant solar potential.

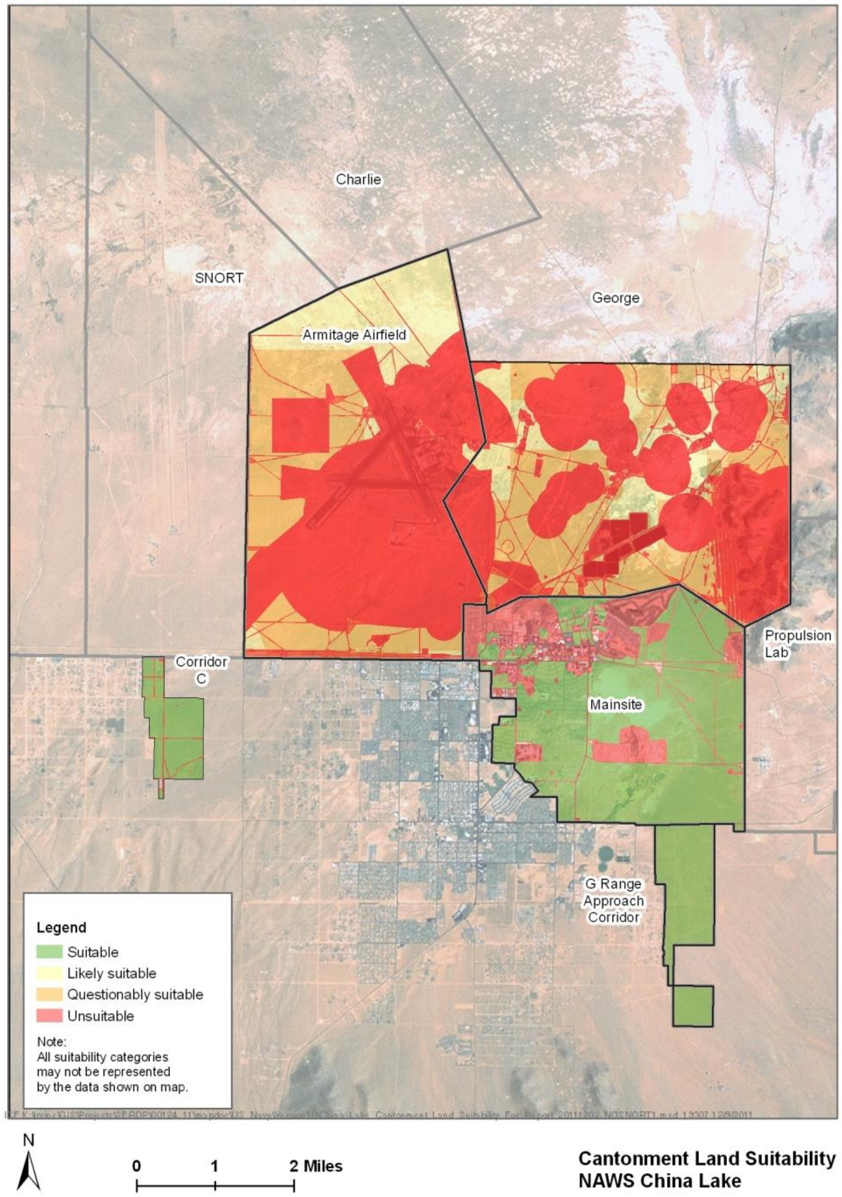

Figure ES.5 – Solar Suitability at NAWS China Lake

The geographic analysis calculated the acres of roof, parking, and ground sites that are suitable for solar development on each installation. Table ES.4 presents the total number of acres for each military installation that passed all the screening variables resulting in a "suitable" rating (suitability score = 1) for solar development for each type of solar site.

Table ES.4 – Acres Suitable for Solar Development (Suitability Score = 1 after minimum parcel size test)								
Military Installation	**(A) Rooftop (acres)**	**(B) Paved Parking (acres)**	**(C) Unpaved Parking (acres)**	**(D)= (B)+(C) Subtotal – All (Paved & Unpaved) Parking (acres)**	**(E) Canton-ment Ground Sites (acres)**	**(F) Range Ground Sites (acres)**	**(G)= (E)+(F) Subtotal – All Ground Sites (acres)**	**(A) + (D) + (G) All Site Types (acres)**
MCAGCC Twentynine Palms	8	110	N/A	110	461	0	461	579
MCLB Barstow	13	17	2	19	660	0	660	692
NAWS China Lake	3	43	N/A	43	3,930	1,339	5,269	5,315
Chocolate Mountain AGR	N/A	N/A	N/A	N/A	N/A	3,768	3,768	3,768
NAF El Centro	0	14	N/A	14	377	0	377	391
Edwards AFB	17	104	38	142	6	1,760	1,766	1,925
Fort Irwin	4	121	230	351	5,757	12,091	17,848	18,203
Total Acres of All Installations by Solar Site Type	**45**	**409**	**270**	**679**	**11,191**	**18,958**	**30,149**	**30,873**

N/A = Not applicable (i.e., the site type is not present at the installation)

The 30,873 acres found to be "suitable" for solar development represented about 1% of the surface area of the seven California installations. Additional areas – rated as "likely suitable" (23,389 acres all seven California installations) and "questionably suitable" (77,485 acres) were also identified at each installation; these represented a further 3% of the surface area of the installations.[2] The other 96% of the surface area was found to be unsuitable due to mission incompatibility, biological resource conflicts, excessive slope, cultural resource conflicts, and many other reasons.

Key implications of the solar geographic analysis

- The ranges of most installations were deemed "unsuitable" because of conflicts with military mission activities, as detailed in the chapter on Mission Compatibility.
- The GIS modeling results indicated that solar development potential exists within or adjacent to nearly all installation cantonment areas.
- Even though extensive range areas were found to be unsuitable, there were still substantial areas suitable for ground-mounted solar development in other range areas and in installation cantonments.
- Rooftop installations are familiar, economically-viable, and seen by many people, but ground sites offer the vast majority of the acreage available for solar development.

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[2] Only 25% of the "likely suitable" and "questionably suitable" areas were carried forward into subsequent analytical steps, to account for the probability that much of this area would be found to be unsuitable during on-the-ground investigations.

Technological Analysis

The second step – **technological** analysis – defined the characteristics for each of six solar technology packages on areas that survived the geographic screening process. These packages included crystalline PV, thin film PV, solar trough and Dish/Stirling engine technology. The technological analysis calculated the maximum "technical potential" for solar electricity on each site – i.e., the potential, in capacity and annual electricity output, for solar development unconstrained by project economics.

Economic Analysis

The capacity and output results from the technological analysis was then passed on to last step in the analytic process – **economic analysis.** The heart of the economic analysis was a financial model that calculated the 20-year investment returns for each potential solar project under private or military ownership. The analysis assumed that all construction would occur in 2015 (to allow the DoD sufficient time to complete program planning, site studies and procurement actions), and that PV prices would fall approximately 20% from their Spring 2011 levels. Concentrating solar technology prices in 2015 were assumed to remain level with 2011 prices.

The model included a wide range of other cost inputs:

- Capital costs (e.g., panels, racking, trackers, balance of system, installation labor)
- Running costs (e.g., O&M labor, insurance, inverter replacement accrual, decommissioning accrual)
- Water cost (for concentrating solar power plants only)
- Land lease rates for 3rd party owned projects
- Transmission extension costs

The following revenue and tax-related incentives were included in the model:

- Electricity prices (20-year wholesale and self-generation projection)
- Renewable Energy Certificate (REC) prices (20-year projection)
- Solar incentives taken by private developers (which are not available if funded by MILCON)
    - Business Investment Tax Credit (30% of installed cost)
    - Modified Accelerated Cost Recovery System (MACRS) Depreciation

The 20-year discounted cash-flow model calculated the Net Present Value (NPV) and Internal Rate of Return (IRR) for each technology on each parcel of land for which it was technically suitable. Those "projects" whose IRRs exceeded the investor's discount rate were deemed financially feasible.

Table ES.5 shows the total economically-viable acreage available for development on cantonment and range ground sites. The table's acreage figures reflect 100% of the military installation acreage with a suitability rating of 1 ("suitable") and 25% of the military installation acreage with a suitability rating of 2 ("likely suitable") or 3 ("questionably suitable") that are also economically-viable.

Table ES.5 – Total Economically-Viable Acreage Available for Solar Development on Cantonment and Range Ground Sites			
Military Installation	**Cantonment Ground Sites**	**Range Sites**	**Total for Ground Sites**
MCAGCC Twentynine Palms	553	0	**553**
MCLB Barstow	0	0	**0**
NAWS China Lake	3,930	2,847	**6,777**
Chocolate Mountain AGR	0	0	**0**
NAF El Centro	0	0	**0**
Edwards AFB	933	23,394	**24,327**
Fort Irwin	5,757	12,971	**18,728**
Total	**11,173**	**39,212**	**50,385**

Table ES.6 show the results of the economic analysis by military installation for the five site types using a private project ownership model. (The economic analysis found that no solar energy projects would be economically-viable under military ownership, which demonstrates the importance of the many tax-based incentives for solar energy development that private developers can utilize and the dependence that the DoD will have on those incentives if it wishes to achieve favorable rates of return from solar projects on its installations.)

Table ES.6 – Capacity of Solar Technology with Highest IRR for Economically-Viable Solar Development Sites, under Private Project Ownership (MW_{AC} in Installed Solar Capacity)						
Military Installation	**Cantonment Ground Sites** [3]	**Range Ground Sites**	**Building Roofs**[4]	**Paved Parking Canopies**	**Unpaved Parking Canopies**	**Total (All Site Types)**
MCAGCC Twentynine Palms	77	0	3	0	N/A	**80**
MCLB Barstow	0	0	5	0	0	**5**
NAWS China Lake	557	403	1	0	N/A	**961**
Chocolate Mountain AGR	N/A	0	N/A	N/A	N/A	**0**
NAF El Centro	0	0	N/A	0	N/A	**0**
Edwards AFB	134	3,347	7	0	0	**3,488**
Fort Irwin	808	1,821	1	0	0	**2,630**
Total	**1,576**	**5,571**	**17**	**0**	**0**	**7,164**

[3] Crystalline-silicon PV on single-axis tracking had the highest overall internal rate of return (IRR) among the six solar technologies evaluated on large ground sites. Crystalline-silicon tracking capacity results are reported uniformly in this table for economically-viable sites. However, there was one site at which a different technology had the highest IRR – at the NASA Goldstone range at Fort Irwin, thin-film tracking had a slightly higher IRR than crystalline-tracking and the highest IRR among the three technologies that were economically-viable on the Goldstone range.

[4] Crystalline-silicon PV fixed-axis had the higher internal rate of return among the two solar technologies evaluated on building roofs.

Table ES.7 shows the significant difference in the economic viability between solar energy technologies assessed in the study. While fixed-mount crystalline silicon PV resulted in the most MW of economically-viable installed capacity, single-axis tracking crystalline silicon PV had the highest overall internal rate of return (IRR) among the six solar technologies evaluated on ground sites. In comparison, the economic viability of concentrating solar power (CSP) technologies was limited, because of higher installation costs, fewer parcels of land within the military installations that met the size, shape, and continuity requirements for these technologies, and special mission conflicts for Dish/Stirling technology at one installation.

Table ES.7 – Capacity for Economically-Viable Solar Development Across Installations, by Solar Technology under Private Project Ownership (MW_{AC})

	PV Technologies				CSP Technologies	
Military Installation	Crystalline-Silicon Fixed-Mount	Thin-Film Fixed-Mount	Crystalline-Silicon Tracking	Thin-Film Tracking	Dish/Stirling	Trough
MCAGCC Twentynine Palms	116	72	77	49	88	0
MCLB Barstow	5	3	0	0	0	0
NAWS China Lake	1,452	901	960	602	0	0
Chocolate Mountain AGR	0	0	0	0	0	0
NAF El Centro	0	0	0	0	0	0
Edwards AFB	5,308	3,295	3,481	2,184	0	0
Fort Irwin	3,930	1	2,629	1,144	0	0
Total	**10,811**	**4,272**	**7,147**	**3,979**	**88**	**0**

The key implications of the economic analysis include:

- Large ground sites on the installations in California are economically viable for PV technologies. Depending on installation specifics, solar development potential may exist in an installation's cantonment and/or range areas.
- Solar development on building roof sites is economically viable, but cannot make a large-scale contribution to the installations' utility scale solar development compared with ground sites.
- Solar development opportunities on paved and unpaved parking facilities at installations are significant, but their economics are currently poor due to the added cost of metal parking canopies.
- Crystalline-silicon PV with single-axis tracking is the solar technology with the highest projected investment returns in the study, due to its combination of low cost of installation and high electricity output. The other PV technology packages analyzed also generate attractive financial returns on many large ground sites.
- The CSP technologies studied were not economically viable in most cases due to their higher installed costs, though great uncertainty exists about present and future CSP costs due to the scarcity of recent CSP projects in the U.S.
- Only privately developed projects were economically viable. Projects funded by the government (e.g., using military construction funds) were not viable, given the current costs of the technology and the tax-based nature of federal solar incentives.

ES.5 Energy Security

Energy security for the DoD means having assured access to reliable supplies of energy and the ability to protect and deliver sufficient energy to meet operational needs. Solar energy can potentially address one key facet of the energy security question: an installation's vulnerability to disruptions of the public electricity grid that powers the installation.

Currently, the DoD relies on individual diesel generators tied to individual critical loads to insure power in case of a grid outage. As the DoD moves toward using secure micro-grids to meet energy security needs, solar power on the installations can play an increasingly important role. Due to the intermittent nature of solar it is unlikely to provide 100% of the required energy and will require energy storage to fully integrate into a micro-grid. The cost and value of solar energy to meet DoD's installation energy security needs is sensitive to individual installation requirements, the future costs of energy storage, and the design and value of the required micro-grid.

ES.6 Solar Development Context

Solar development on the nine DoD installations addressed by this study is governed by a complex web of laws, regulations, and market rules, administered by public and quasi-public entities at the Federal, State, and local levels. Few if any of these rules were designed with solar in mind; several were promulgated long before solar energy began its real penetration in the marketplace in the past 10 years. DoD staff and the private developers they increasingly work with need to fully understand these rules to avoid or mitigate policy barriers and to maximize the benefit of any available incentives.

The Federal Government has challenging goals for renewable energy development on DoD installations. In addition, Federal and state governments created a number of incentives for the development of solar energy. These incentives can reduce the installed cost of a solar energy facility by half or more depending upon the size and location of the facility. In addition, the DoD has more flexibility than other Federal agencies to enter into long-term contracts with third-parties; under these contracts, the third-party developer builds, owns, and operates the solar facility, and the DoD purchases the electricity generated by the solar facility and/or leases the DoD land used for solar development. However, a number of challenges to large-scale solar development on Federal lands exist, most notably the lack of transmission capacity in the Mojave and Colorado Deserts.

A second challenge is the uncertainty related to developing solar projects on withdrawn lands within the boundaries of the nine installations (see Table ES.8). These lands are part of the public domain supervised by the Bureau of Land Management (BLM), but have been withdrawn from the operation of public land laws to serve military mission needs. There is disagreement among the DoD, the Services, and the BLM regarding which organization has the lead for authorizing and managing renewable energy development on withdrawn lands; this creates uncertainty in the development process and leaves private-sector developers unclear as to who their counterparty is.

In addition, the large footprint of utility-scale solar energy facilities means that ground-mounted systems must be individually reviewed to determine their impact on biological, cultural, and visual resources and a wide variety of construction, interconnection, and other permits must be acquired before a potential solar development can move forward. Finally, there is inconsistency within the DoD, and between the DoD and other Federal agencies, in how certain laws, mandates, and processes should be applied; these inconsistencies slow the solar development process and create uncertainty for private sector solar developers.

Table ES.8 – Withdrawn Lands[5]

Base	Acres Withdrawn	Total Acres	Withdrawn %
Edwards AFB	83,110	308,123	27%
Fort Irwin	725,062	754,134	96%
China Lake	1,108,956	1,108,956	100%
Chocolate Mtn.	226,711	463,623	49%
El Centro	47,870	56,289	85%
29 Palms	472,649	595,578	79%
MCLB Barstow	3,683	6,176	60%
Nellis AFB	10,290	14,000	74%
Nevada T&TR	2,919,890	2,919,890	100%
Creech AFB	2,940	2,940	100%
Total	5,601,161	6,229,709	90%

Source: (Pease, 2011)

ES.7 Conclusions and Recommendations

The study quantifies the technically feasible and economically viable solar potential on several DoD installations. This potential can be harnessed without impact on mission performance and can result in substantial value delivery to the DoD. However, to realize this opportunity, the DoD would need to develop a thoughtful program, with the necessary funding, leadership support, and capacity building to see it to fruition. The following actions may improve the opportunities to develop solar energy in a manner consistent with the military mission:

1. **Clarify withdrawn lands policy with the Department of the Interior (DOI)**
   Withdrawn lands make up the majority of the lands within the boundaries of the nine installations considered in this study, and resolving their status and potential use in third-party financed projects with the DOI is critical if the DoD intends to develop utility-scale solar energy projects.

2. **Work with stakeholders to accelerate transmission development**
   The lack of transmission capacity is the single largest barrier to large-scale solar development on the seven California installations. The DoD and the many other stakeholders affected by this constraint could increase their efforts to encourage transmission owners and planners to expand capacity on existing transmission lines and expedite the necessary transmission build-out.

[5] The withdrawn land acreage figures reported in this table are currently under review by the DoD/DOI Interagency Land Use Coordinating Committee and should be considered preliminary data only. For example, other sources indicate that 8% of China Lake is DoD fee land and 92% is withdrawn land.

3 **Clarify DoD policy on REC ownership and accounting**
In the third-party finance model that will likely dominate renewable energy development on military installations, it is the developer, not the installation that is the initial owner of any RECs arising from a project. While an added expense, the DoD will likely have to join the larger renewable energy market in retaining or purchasing RECs in order to make progress towards complying with its renewable energy mandates and goals.

4 **Clarify and develop programs to achieve energy security goals**
The DoD should continue to demonstrate secure micro-grid technologies on military installations. The DoD could also develop guidance about what types of energy security challenges military installations need to be prepared to overcome, the types of actions that can be taken to improve energy security, and the "price" or value that could be assigned to energy security benefits in the investment process so that the DoD can launch targeted programs to address its energy security needs.

5 **Increase coordination and integration of renewable energy projects and initiatives between military installations and Services**
The DoD should consider making a greater effort to keep energy managers and other key personnel involved in renewable energy project planning at each military installation informed about the efforts, initiatives, and lessons learned by other military installations and Services. This could be one element of a broader effort to build renewable energy analysis and development capacity at the installation and support organization levels. As part of this activity, the DoD could also identify and work to address the inconsistent interpretation of goals, rules, and procedures that currently exists across installations and Services.

6 **Develop a consistent and incentive-focused formula to allocate project benefits and costs between the host installation and parent organizations**
Providing clear incentives for military installations to invest the considerable time and effort required to host renewable energy projects will likely generate increased interest and support from military installation staff.

7 **Work with BLM to ensure that the Federal Government is maximizing its compensation from land rentals consistent with fair market value while allowing solar developers to make an attractive rate of return**
BLM's solar land lease rates could increase substantially and still provide an attractive rate of return for private developers under the study's assumptions. The DoD should consider working with BLM to evaluate whether Federal compensation could be re-calibrated under the BLM's solar rental formula to continue to capture fair market value for the Federal Government against the backdrop of rapidly-changing and regionally-variable solar economics. The DoD and BLM should maintain a cooperative approach so that private solar developers won't have an incentive to work with one agency over the other because of more attractive land rental rates.

8 **Develop and apply a consistent methodology for mission compatibility analysis within DoD installations, and analyze DoD lands in advance of programmatic scale-up**

"Conflicts with mission performance" was the single most important factor limiting the potential for solar development across the nine installations evaluated. This study relied on discussions with range operators and training managers for most of the mission compatibility analysis. Because the results relied, to a great degree, on the best professional judgment of range management staff, they were non-reproducible and difficult to generalize to other installations or to communicate to the solar development community. In the future, the DoD should consider developing a mission compatibility assessment methodology that can be applied within its own installations to address the full range of renewable energy technologies and the full range of mission activities. Developing this methodology will require coordination of representative installation-level staff; managers in the Service-level range management offices; OSD's Training, Readiness, Test and Evaluation offices; OSD's Facilities Energy office; as well as the existing DoD Siting Clearinghouse.

The steps listed above may greatly improve the implementation environment for solar energy on DoD lands. The results of the study's Solar Potential Assessment provide a useful starting point from which each installation can identify high priority areas for further investigation. Private developers could respond to competitive solicitations to conduct the necessary due diligence and to offer the DoD some combination of rental payments, discounted power, in-kind consideration, and/or energy security capability in return for access to these lands.

It is clear that solar developers are highly motivated to develop projects under present conditions, and those conditions are only expected to improve through 2016 as solar prices continue their expected decline. However, at the end of 2016 the most important solar tax incentive will decrease by two thirds. The DoD is in the position to take advantage of the value offered during this 5-year window. It will take time to address the preparatory steps suggested above and to create and launch a focused solar development program. By pursuing these challenging opportunities, the DoD may be able to take advantage of solar resources on military installations in a manner consistent with the military mission.