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ECOLOGICAL GUIDANCE FOR RENEWABLE ENERGY PROJECTS

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ECOLOGICAL GUIDANCE FOR RENEWABLE ENERGY PROJECTS

1. Purpose.

a. This Public Works Technical Bulletin (PWTB) transmits information on factors affecting adoption of renewable energy projects to replace or supplement current non-renewable energy use practices. It is intended to assist Army Installation Managers in making decisions regarding energy use, energy availability, and energy production at their installations. Decision factors include current and potential future mission use and requirements, fiscal, and other costs for energy infrastructures, and available technologies.

b. All PWTBs are available electronically (in Adobe® Acrobat® portable document format [PDF]) through the World Wide Web (WWW) at the National Institute of Building Sciences' Whole Building Design Guide (WBDG) web page, which is accessible through this link:

http://www.wbdg.org/ccb/browse_cat.php?o=31&c=215

2. Applicability. This PWTB applies to all U.S. Army facilities engineering activities.

3. References.

a. Army Regulation (AR) 200-1, "Environmental Protection and Enhancement," 28 August 2007.

b. Energy Policy Act of 2005, Public Law (PL) 109–58, 8 August 2005.

c. Energy Independence and Security Act of 2007, PL 110–140, 19 December 2007.

d. Executive Order (EO) 13123, “Greening the Government Through Efficient Energy Management,” 3 June 1999.

e. EO 13423, “Strengthening Federal Environmental, Energy, and Transportation Management,” 24 January 2007.

f. Department of the Army (DA), “The U.S. Army Energy Strategy for Installations,” 8 July 2005.

g. DA, “The U.S. Army Energy and Water Campaign Plan for Installations; The Army’s 25 Year Plan in Support of POM FY 2010-2015,” 1 December 2007.

4. Discussion.

a. AR 200-1 states that it implements “Federal, State, and local environmental laws and Department of Defense policies for preserving, protecting, conserving, and restoring the quality of the environment.”

b. In accordance with the Energy Policy Act of 2005, the Energy Independence and Security Act of 2007, and EOs 13123 and 13423 (see Section 3 above), the federal government is required to significantly improve its energy management to reduce energy use and emissions, expand the use of renewable energy, and save fiscal resources.

c. As part of its obligations under the various legislation, EOs, and military regulations, the Army has simultaneously developed an approach to (1) more effectively manage its energy needs and (2) maintain its strength and obligation to defend and ensure national security. The Army’s Energy Strategy and Campaign Plan calls for achieving a “net zero energy” status, which will necessarily require additional power and energy production capability. To meet these goals, the Army will have to increase energy management and conservation efforts, as well as aggressively pursue on-site renewable energy development on a large, utility scale.

d. Appendix A contains information for installation managers and other decision makers to use when considering renewable energy options for their facilities.

e. Appendix B contains references used in this PWTB and other resources.

f. Appendix C lists acronyms and abbreviations.

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APPENDIX A:

ECOLOGICAL GUIDANCE FOR RENEWABLE ENERGY PROJECTS

Energy Overview

Economically developed and rapidly developing countries worldwide are highly reliant on non-renewable fossil fuel energy sources (coal, oil, and natural gas). Those fossil fuels, however, are widely acknowledged in a variety of environmental impacts including carbon dioxide (CO_2) emissions that are implicated in climate-related temperature alteration, altered precipitation patterns, changes in extremes in droughts and floods, reduced ice packs, and rising sea levels (IPCC 2007).

A list of factors pointing toward increasing the amount of energy obtain from renewable sources (e.g., solar, wind, geothermal)includes: (a) increasing energy needs and demands by national and world societies; (b) energy sources residing with foreign and often hostile governments; (c) environmental pollution and climatic alteration associated with traditional (i.e., fossil fuel) energy source consumption; (d) increasing costs of energy source extraction and delivery; and (e) declining supplies of these finite resources.

Whatever the origin, energy is absolutely essential and critical to the nation’s military mission. The Department of Defense (DoD) is the nation’s single largest user of energy. Although it uses only 1% of the nation’s total energy, DoD uses 78% of the federal government’s total, of which 12% is for electricity. In fiscal year (FY) 2006, the cost of that energy was $13.6 billion ($12 billion in fuel), which equates to 300,000 barrels of oil per day. In more practical Army-specific terms, a 1% decrease in conventional fuel usage could result in a decrease of more than 6,400 soldiers for security and transport in troop convoys.

Overall, energy use is perhaps the major budgetary and overall infrastructure challenge facing the Army. The generation, transmission, and use of energy leads to a wide range of environmental, economic, and associated impacts and effects, not the least of which is a reliance of foreign fossil fuels, which in itself is a national security threat (Cornell 2009; Kleber 2009).

Thus the use of renewable energy fuel sources can be translated into immediate decreased economic and other vulnerabilities, increased soldier safety, and increased power “at the point of the spear,” in part because fewer soldiers need to be devoted to securing and guarding conventional fuel resources.

As part of its obligations under the various Congressional Acts and Executive Orders, the Army has developed an approach to more effectively manage its energy needs, while at the same time maintaining its strength and obligation to defend and ensure national security. The Army’s Energy Strategy and Campaign Plan calls for achieving a “net zero energy” status, which will necessarily require additional power and energy production capability (DA 2005). To meet these energy goals, the Army will have to increase energy management and conservation efforts, as well as aggressively pursue on-site renewable energy development on a large, utility scale.

The Army’s energy strategy and plan includes several major initiatives, including those related to:

- eliminating energy waste in existing facilities;
- increasing energy efficiency in new construction and renovations;
- improving energy security;
- reducing dependence on fossil fuels through increased use of clean, renewable energy to optimize environmental benefits and sustainability; and
- conserving water resources.

In order to meet these goals, the Army — at all levels but perhaps particularly at the installation level — will have to make decisions regarding energy use, energy availability, and energy production. These decisions will be made with consideration for current and potential future mission use along with requirements, fiscal and other costs for energy infrastructures, and available technologies.

In making these decisions, installation managers will have to address issues such as:

- What are the potential impacts of new energy infrastructures on the missions, habitats, water resources, and other uses of lands and airspaces of the military installation?
- How do managers make informed decisions about the tradeoffs between: renewable energy production and ecosystem services, energy and water availability, and producing energy or acquiring energy off-site?

- What research, policy guidance, lease arrangements, and analyses are needed to help installation managers find the appropriate tools to address these challenges so that their installations welcome efforts to generate or obtain renewable energy for their lands and needs?

At the same time, these efforts must ensure that the consequences of these new energy assets are fully understood, the tradeoffs are accurately and quantitatively expressed, and installation managers, the public, and all stakeholders are well informed about the full costs and benefits of these investments. In a broad perspective, these efforts and resources will include renewable energy assets which are identified as integral to installation energy security and which are at locations remote from the installation itself.

The Army's sustainability triple bottom line is: mission, environment, and community. In an effort to support Army and DoD sustainability, this PWTB addresses environmental and ecological considerations in the development and implementation of renewable energy projects.

Renewable Energy

Regardless of its origin or source, energy availability and energy security are affected by the four main segments in the energy chain——resources, generation, transmission and distribution, and the end user.

Renewable energy is generated from natural resources such as sunlight, wind, geothermal heat, biomass conversion of a variety of sources, and (looking toward the future) ocean currents and tides. Ocean currents and tides can be considered similar to harnessing the movement of water in rivers as a source of renewable energy (e.g., hydroelectric dams).

In typical usage, energy is generated in the form of electrical energy or electricity. In some cases, heat from geothermal or biomass sources may be either an endpoint or may in turn be converted into electricity. Table A-1 shows sources of renewable energy and their applications.

In 1998, the United Nations (2000) estimated that approximately 14% of the world's primary energy consumption came from renewable energy. By 2006, they reported approximately 18% of global final energy consumption came from renewables, with 13% coming from traditional biomass such as wood burning. Hydroelectricity was the next largest renewable source at 3% followed by solar hot water/heating at 1.3%. Modern technologies, such as geothermal energy, wind power, solar power, and ocean energy together provided some 0.8% of final energy consumption (REN21 2007). In 2009, renewables were 25% of the global power capacity and delivered 18% of the global power supply (REN21 2010). Factors such as climate change concerns emanating from fossil fuel emissions, high fossil fuel prices (e.g., oil), and increasing public and government support for curtailing fossil fuel emissions are driving increased renewable energy legislation, incentives, and commercialization (UNEP 2007). Public support for the combined benefits of decreased fossil fuel use, which in turn reduces atmospheric greenhouse gas (such as CO_2) emissions, and increased energy independence and security, should not be underestimated or underemphasized.

Table A-1. Renewable energy, energy products, and applications.

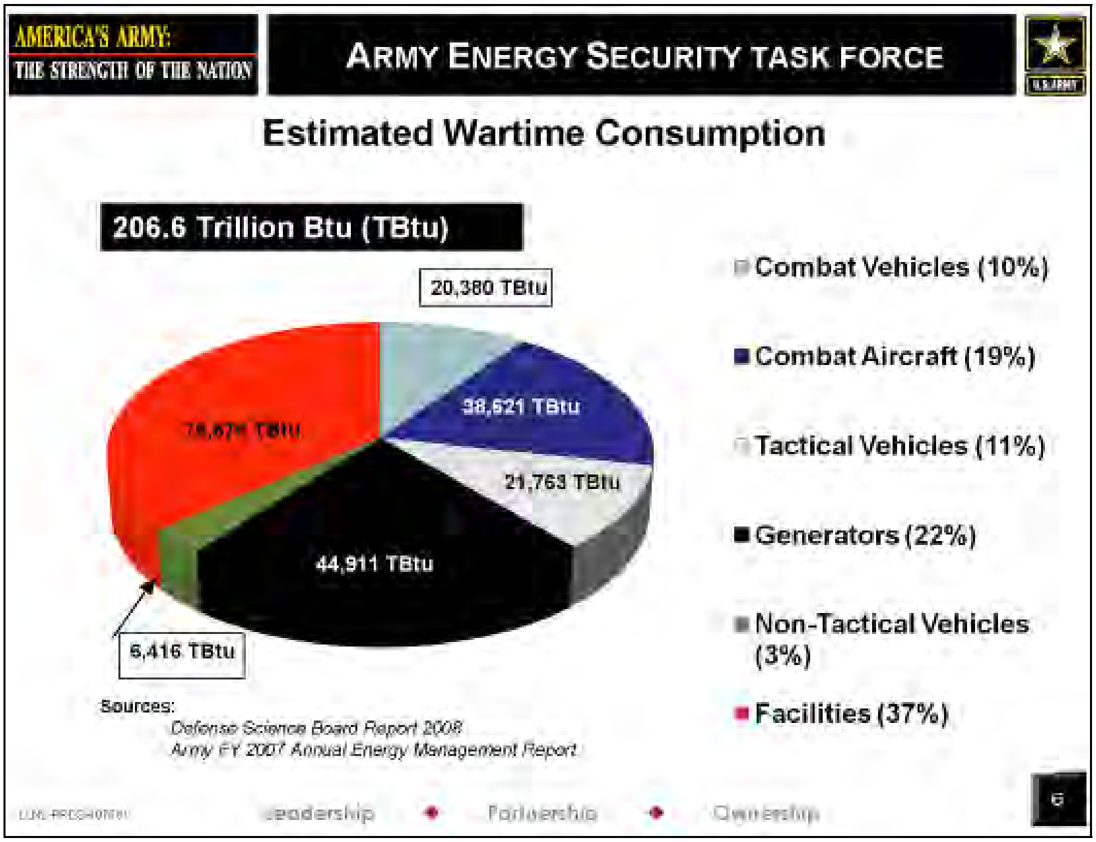
Energy Source	**Energy Product**	**Application**
Solar energy		
Photovoltaic solar energy conversion	Electricity	Widely applied; further development needed
Solar thermal electricity	Heat, steam, electricity	Demonstrated; further development needed
Low-temperature solar energy use	Heat and cold	Solar collectors commercially applied
Passive solar energy use	Heat, cold, light, ventilation	Demonstrations and applications
Artificial photosynthesis	H_2 or hydrogen-rich fuels	Fundamental and applied research
Biofuels	Electricity	Replacement of fossil fuels
Wind energy		
Water pumping and battery charging	Movement, power	Small wind machines, widely applied
Onshore wind turbines	Electricity	Widely applied commercially
Offshore wind turbines	Electricity	Development and demonstration phase
Hydropower		
	Power, electricity	Commercially applied; both small- and large-scale applications
Geothermal energy		
	Heat, steam, electricity	Commercially applied
Ocean energy		
	Power, electricity	Fundamental and applied research

(Adapted from United Nations Department of Economic and Social Affairs and World Energy Council: World Energy Assessment, Energy and the Challenge of Sustainability, New York, 2000, p 221).

While there are many large-scale projects to produce renewable energy, renewable technologies are also suited to small off-grid applications. Such off-grid applications are useful not only for recurring and regular Army infrastructure operations (UNDP 2001), but also useful in more traditional and classic contingency military actions (AEPI 2007). While renewable energy systems are used by the Army, according to the DoD (2005) most systems in current use are at the garrison level throughout the continental United States (CONUS).

Within the Army, facilities are the largest energy users (Figure A-1). The 1,200 active sites, containing thousands of buildings (780 million sq ft in CONUS alone) and other infrastructure (59,000 miles of roads), are essential to the Army mission. Not only can these installations be physically large (e.g., White Sands Missile Range, NM is 2 million acres), they also are home to thousands of soldiers and support personnel (AEPI 2002).

Military bases, Army or otherwise, are not evenly distributed geographically (Figure A-2). Similarly, while opportunities for the implementation of renewable energy projects abound, the renewable energy sources are not evenly distributed either.


AMERICA'S ARMY:
THE STRENGTH OF THE NATION

ARMY ENERGY SECURITY TASK FORCE

Estimated Wartime Consumption

206.6 Trillion Btu (TBtu)

Sources:
Defense Science Board Report 2008
Army FY 2007 Annual Energy Management Report

Figure A-1. Estimated Army energy consumption in FY2007.

Data Sources:
This digital data of U.S. military bases was originally provided by Geo-Marine, Inc. of Plano, Texas in separate UTM Zones and at various scales. The separate zones were joined into this coverage.

Map Information:
Lambert Azimuthal Equal Area ; Scale 1:5845860
The numbers on the map represent the locations of military bases.
Please reference these numbers with the accompanying sheets entitled "Military Bases- CAST 5/96".

Figure A-2. Military bases in CONUS.

Solar energy

Two attractive features and advantages of solar power is that the energy itself costs nothing, and the solar panels used to convert solar energy into heat or electricity give off no pollution. Solar energy can also be used for water desalinization, a feature that may become more important as concern over water supply and quality increases. However, the high initial cost of solar collection installation must be weighed against cost savings over the equipment’s effective life span. Additionally, electricity resulting from solar sources can only be produced during the day and can necessitate the need for electrical storage and other electrical generating systems. Further, common air pollution and overcast or cloudy conditions in some areas effectively limit the number of days of solar radiation and reduce radiation efficiency.

Wind energy

The earliest known use of wind power was by the Egyptians some 5,000 years ago, when they used it to sail boats on the Nile. (It is likely, but undocumented, that wind power actually was used even earlier in time.) Around 2000 BC, the first windmill was built in Babylonia (present-day Iraq). In what is present-day Afghanistan, large windmills (as large as 30 ft high with 16-ft-long blades), were in use by the 10th century BC. In 2005, the United States was the fastest growing wind energy producer in the world; today it is China (MRBI 2010).

The potential for wind energy, as with solar energy, is attractive because it is derived from a ubiquitous, widespread, and abundant source. Costs depend on the scale of the electrical generation wind turbines and available wind. Off-shore siting of wind turbines or “wind farms” has some attraction; however, they are more expensive to maintain than land-based plants as access to them has to be by ship or air. While wind-generated energy is attractive from supply and cost standpoints, it does have disadvantages. In addition to an unreliable (not constant) energy flow, wind turbines are not always aesthetically pleasing to those in the open, natural areas where they are commonly placed. Additionally, others raise significant concerns and issues with bat and migratory bird mortality.

Biomass conversion

While seemingly of lesser potential than other alternative or renewable energy sources such as solar, wind, or even hydropower, biomass-derived energy can be a part of the equation to reduce foreign oil dependency. Biomass is solar in origin because plants use photosynthesis to convert solar energy into plant material and carbon dioxide (CO_2). Plant or plant-derived materials (e.g., wood, paper, manure, sewage and waste, and agricultural crops) can be further utilized to produce usable forms of energy.

Biomass energy can be used directly or indirectly. Burning is a common example of direct use by combustion. Gas derived from thermal or biological processes can be used directly — as a heating source for example — or to drive turbines to generate electricity. Biomass energy can also be transformed into other forms of fuel. Ethanol manufactured from agricultural crops such as sugar cane and methane captured from sewage and landfills are examples of practical indirect use.

The use of biomass energy does have some disadvantages. Unlike solar, wind, geothermal, or ocean energy, burning or fuel combustion produces greenhouse gases (GHG). Further, large-scale crop production uses large amounts of land, water, and fuel. Nonetheless, biomass energy has a place as one component of a renewable energy “portfolio.”

It is not likely that Army installations will set aside large sections of land for producing “energy crops,” which are then used to produce ethanol or other renewable alternative fuels. However, the biomass concept of waste-to-energy will likely be added to their portfolio of renewable energy resources, as it will help deal with waste streams as resources rather than as a costly expense of installation operations. Biomass resource streams such as municipal solid waste (MSW), anaerobic digester gas (ADG) from wastewater treatment plants, and landfill gas, can be converted into useful energy through a number of different technologies. For example, MSW can be direct-fired in a heat recovery incinerator (HRI) and the heat energy used to directly serve a heat load or to drive a steam turbine for producing electricity.

Geothermal

Geothermal energy is defined as heat from the Earth and is a powerful energy source. Heat dating from the origin of the planet continues to radiate from the Earth’s core into the intermediate mantle zone. Where the mantle is close to the Earth’s surface or crust, geothermal energy can be observed in the form of volcanoes, geysers, and hot pools of water or mud. Although areas such as hot springs are most obvious and are often the first places geothermal resources are used, the heat of the earth is available everywhere and we are learning to use it in a broader range of applications. The heat flows continuously from the Earth’s interior, primarily by conduction, and is estimated to be equivalent to 42 million megawatts of power. This energy is expected to remain constant for billions of years to come, ensuring an inexhaustible supply (GEA 2010).

Unlike the intermittent nature of solar and wind energy, geothermal energy can be used for continuous electricity production for commercial, industrial, and residential direct heating purposes, and for efficient home heating and cooling through geothermal heat pumps.

To utilize this heat energy requires literal hot spot locations within the Earth’s crust. These hot spots are common around volcanoes and fault lines but such hot spots are not necessarily areas where one would want to build a geothermal energy plant. Thus, given current technology, suitable locations for large geothermal energy applications are somewhat limited.

Nonetheless, there are developing technologies that can use geothermal heat sources. These technologies are readily available and can be sized for a wide variety (e.g., 50–260 KW) of applications.[1]

Compared to similar-scale solar and wind power plants, geothermal power plants have a much smaller “footprint”; however, there is still a comprehensive list of environmental issues that must be addressed with the same rigor as with other renewable energy technologies.

Ecosystem Considerations

Whether the DoD is a proponent, a user, or a combination of both, development and implementation of renewable energy opportunities, efforts, and projects can present significant challenges in ecosystem management and tradeoffs. These challenges can include the large physical size of some renewable energy systems, their extensive or remote placement, and the sensitive environments into which these systems may potentially be placed. The associated infrastructure to support those developments (e.g., transmission, transportation, and roads) can result in changes not only in environmental demographics but also in human distributions and demographics.

Following is a discussion of environmental and ecologic attributes and decision factors for consideration. The discussion of each attribute or factor is not intended to be encyclopedic, all-inclusive, or complete. Rather, the intent is to illustrate and call attention to ecosystem considerations that need to be addressed when considering renewable energy projects. By fully recognizing and analyzing ecosystem attributes, decision makers can more effectively balance the ecosystem, environmental, and other tradeoffs necessary to effect renewable energy projects that achieve DoD and Army renewable energy goals, comply with Congressional mandates, and maintain national energy, military, and environmental security.

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[1] Examples include the Green Machine by ElectraTherm (currently being tested at Fort Huachuca, AZ), and Purecycle from United Technologies Corp.

These ecosystem factors do not stand alone. Rather they are interrelated and the alteration of one can result in significant changes or effects on others. For example, soil, water, and land use are linked in the natural environment—they contribute and influence each other. In turn, they help to influence and determine other factors such as human population distribution and native species composition. Thus, these factors must be examined not only in the context of the nature and extent of the renewable energy effort proposed, but also in the context of the natural and human environments.[2]

Geology, soils, seismic activity

As with any construction or facility development, substrate is important in planning and siting renewable energy developments. The likelihood and influences of water and wind erosion need to be considered and appropriate mitigation measures incorporated into site plans. Similarly, in northern locations, the presence and influence of permafrost needs to be considered. For obvious reasons, other than perhaps for geothermal energy applications, facilities should not be built on fault lines and earthquake zones where they would be at high risk for seismic damage.

The importance of geologic conditions to the siting of geothermal energy facilities is also obvious. In a sense, this is also an impediment in that one of the biggest disadvantages of geothermal energy is the low number of suitable locations. An ideal location has suitable heat sources at a depth that allows for easy drilling. The type of rock above the hot rocks must also be easy enough to drill through. If ground water is not present, then large surface water supplies may be required. This requirement may, in turn, result in other ecological concerns and place other ecological and environmental constraints on development.

Climate

Climate and climatology can play a major role in renewable energy development considerations. As indicated previously, there are regional differences in renewable energy production potential. Larger scale solar energy development in the Pacific Northwest, where cloud cover is common, would not be as practic-

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[2] The human environment is defined as including the natural and physical environment and the relationship of people within that environment (40 CFR 1508.14).

al as in the Southwest, where cloudless days are the norm. A similar situation exists with wind energy potential: open areas, which mostly happen to be associated with private land ownership, are not necessarily in close proximity to Army or DoD installations. Thus, the realities of climatic influence on renewable energy “location” will require consideration of transmission facilities to transport that energy to military locations.

Biological resources

In consideration of ecosystem biology, if nowhere else, it becomes apparent that renewable energy development is not environmentally neutral. Direct impacts from facility construction and placement, including mortality and habitat modification or destruction, and indirect impacts such as habitat fragmentation and the avoidance of habitats in proximity to renewable energy facilities are known to exist. While the impacts are best known for birds and bats, effects on larger animals (e.g., deer), and impacts on small mammals and other life forms (e.g., reptiles such as the desert tortoise) are less well understood. These effects may be local or regional. Renewable energy facility development in bird migration corridors, including those off shore, may be problematic in that they may impact species at population levels. Any renewable energy development project with a federal nexus[3] (which for all practical purposes is any renewable energy development in which DoD might have an interest) will require consideration of threatened and endangered and at-risk species. Given the high social interest in threatened and endangered species, renewable energy developments can be expected to have to allow for and give deference to listed species.

When considering the potential effects of projects related to renewable energy, the installation’s Integrated Natural Resources Management Plan (INRMP) should be consulted.

Water resources

The importance of water resources in ecological and biological considerations is obvious. However, the effects and impacts of renewable energy projects on ground and surface water sources, use, allocation, distribution, quality, and disposal is also of high concern. Many areas of the country with high renewable energy supply or generation potential are also areas of reduced

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[3] A federal connection or nexus exists whenever there is federal agency authorization, proponency, property, funds, permit, or other type of approval.

or limited water resources. These areas are also regions of increasing water demand by an increasing human population. Further, while the exact effect and future situation is unknown, it can be reasonably speculated that global-warming-induced climate change in these regions will result in increased mean or other annual temperatures. These higher temperatures will result in increased water demand.

Any water-related renewable energy development, whether it directly relies on water resources (e.g., geothermal energy), uses water as part of the energy-generating process (e.g., bioenergy), or has water as its resulting product (e.g., solar-powered desalinization) will have to give strong consideration to ecosystem-wide effects on water. In these and other instances, recognition of requirements and obligations under the Clean Water Act and Safe Drinking Water Act is necessary.

Additionally, to the extent that water-related renewable energy projects affect wetlands and flood plains, EO 11990 “Protection of Wetlands” and EO 11988 “Floodplain Management” require efforts to preserve and enhance the natural values of wetlands and flood plains.

Air quality

Production of GHGs with the associated lessening of air quality and their cascading climatic influences are, at least in an indirect way, an impetus for reducing dependency on fossil fuels. As a group, GHGs and emissions include not only CO_2, but also carbon monoxide (CO), methane (CH_4), nitrous oxide (N_2O), terafluromethane (CF_4), hexafluoroethane (C_2F_6), sulphur hexafluoride (SF_6), and hydrofluorocarbons (HFCs).

An important advantage of renewable energy sources and the technologies to convert those energies into more usable forms is that they generally result in much-reduced releases or emissions of these compounds of concern. However, some renewable energy sources and processes can produce significant quantities of GHGs. Composting and similar utilization of landfill gases (primarily methane) can be efficient and effective energy sources. However, system designs have to control methane release to the atmosphere. Furthermore, it is important to recognize that any renewable energy process that has combustion as a component will produce CO_2, CO, and other compounds and products (e.g., particulates). Likewise HFCs have been used increasingly in the past decade or so as an alternative to ozone-damaging chlorofluorocarbons (CFCs) in refrigeration systems. Unfortunately, though they provide an effective alternative to CFCs, they can also be powerful GHGs with long atmospheric lifetimes. Renewable energy systems that utilize HFCs as cooling components may become more problematic in the future.

Basic questions to be addressed when considering potential renewable energy-related effects on air quality include whether the proposed project is located in a designated Clean Air Act non-attainment area relative to ambient air standards and whether the proposed project would emit a criteria or hazardous pollutant during construction or operation.

Air space

Although the supply of air space may seem unlimited, like all other environmental resources, it is limited (AR 95-2).

Large-scale (geographical or physical) development of renewable energy sources and infrastructure may create air space issues, which may be most important near military installations. This possibility also underscores the need for widespread coordination and planning, not only within DoD but also between private, local, state, and federal groups and agencies. That said, air space in and of itself may not be a major issue.

Communications (including radar and sonar)

As a category, renewable energy source development and distribution, when it results in the supply of more electricity, can be considered neutral in its effect on communications. However, as with most things related to the environment, there are exceptions. For example, wind turbines are known to interfere with radar and radio communication through obstruction, diffraction, and reflection of electromagnetic signals. Other potential communication problem areas might include cellular phone towers, microwave repeater stations, military communications installations, wireless Internet sites, radio repeater stations, remote telemetry monitoring stations, remote telecommunication sites, and television and radio broadcast towers. In off-shore application, marine sonar can also be an issue.

Current consensus is that these issues, if they exist, are manageable given the current condition. However, the overall effects of large-scale development and placement of wind turbines is unknown, and much of the equipment and technology in use has not been tested under large-scale development conditions.

Noise

All industrial processes generate noise, and the utilization and generation of renewable energy is no exception. At a national level, The Noise Pollution and Abatement Act of 1972 (42 USC 4901-42) establishes the federal intent of protecting human health and encouraging local municipalities and counties to consider noise in their general or other plans. From a broad environmental standpoint, noise generated by renewable energy development and distribution must be considered and addressed.

Although noise from renewable energy development can be characterized as minimal, total potential effects are uncertain at best. For example, the effects of a low level of noise, such as that generated by wind turbines, on wildlife are unknown but nonetheless potentially significant.

Visual

The visual effects of renewable energy development should not be overlooked. The sight of multiple wind turbines dotting the formerly open landscape and vistas may not be acceptable in some areas. For example, although offshore wind turbine development in Nantucket Sound off Massachusetts is apparently proceeding, it has not been popular with all segments of the public and has resulted in an environmental review process that has extended over 7 years (Boston Globe 2009).

Land use and land ownership

Almost all of the renewable energy sources require large areas for energy collection and/or generation. Solar panel arrays, for example, can cover many acres. Much of the renewable energy development and deployment in the United States will be done without significant government involvement. In many instances, this development will take place on private lands (GAO 2005). It may be possible and feasible in these cases to implement renewable energy easements to facilitate the use of energy generated. If located on private lands, easements will require provisions for energy transmission and distribution to military installations and other use centers. Current and future land use can also play a significant role in the value of land used for renewable energy purposes. Renewable energy facilities in high value urban areas may not be economically feasible or environmentally practical.

Renewable energy development can also take place on federal lands. Table A-2 shows examples of Army land use classifications and where renewable energy related projects could potentially be located or otherwise implemented. In many areas of the United States, the federal government is a significant and/or the largest landowner. However, different federal agency authorities, missions, and responsibilities can translate into differing environmental and ecological priorities and concerns. These differences will require concerted interagency coordination to reach agreement on how to effect this development. Toward that end, there are existing authorities that allow for and direct DoD and other federal agencies to integrate ecological and environmental planning into decision-making efforts (e.g., EO 13352 “Facilitation of Cooperative Conservation”).

Table A-2. Army Land Use Classifications (USACE 2002).

Type	**Explanation**
Airfield Land Use	Landing and takeoff area, aircraft maintenance, airfield operational and training facilities, and navigational and traffic aids
Maintenance Land Use	Depot maintenance, installation maintenance, Table of Organization and Equipment (TOE) unit maintenance
Industrial Land Use	Production; research, development, and test facilities; potable water supply, treatment, and storage; electric power source, transmission, distribution, substations, and switching stations; heat sources, transmission lines, and distribution lines; sewage and industrial waste treatment and disposal; sewage and industrial waste collection; and parking areas
Supply/Storage Land Use	Installation ammunition storage, depot ammunition storage, cold storage, general-purpose warehouse, controlled-humidity warehouse, flammable materials storehouse, fuel storage, engineer material storage, medical warehouse, unit storage, and salvage and surplus property storage
Administration Land Use	Installation command and control, directorates, tenants, organization, and special
Training/Ranges Land Use	Training facilities, buildings, training grounds and facilities other than buildings; firing ranges, training; and firing ranges, research development, testing, and evaluation
Unaccompanied Personnel Housing Land Use	Officer unaccompanied personnel housing, enlisted unaccompanied personnel housing, and visiting officers and soldiers quarters
Family Housing Land Use	Family housing

Type	**Explanation**
Community Land Use	Commercial and services
Medical Land Use	Hospital, dental clinic, clinic without beds, electric power sources, heat source, parking areas
Outdoor Recreation Land Use	Recreation building, outdoor swimming pool, tennis courts, multiple court areas, baseball field, softball field, football field, and soccer field
Open Space Land Use	Unoccupied land, buffer and easement, and greenbelt

Cultural resources

Cultural and historic resources are part of who and what we are as a nation. Renewable energy development should strive to avoid alteration of those resources. In short, if historic properties or cultural resources might possibly be involved, then provisions of the National Historic Preservation Act, particularly Section 106, come into play. This is perhaps most relevant when dealing with Native American entities and the various tribes. Similar to the caveat for natural resources, the installation Integrated Cultural Resources Management Plan (ICRMP) should be consulted in all instances.

Urban growth

Growth of urban and suburban population centers has been in progress for decades and is accelerating. This has important implications for Army and other DoD installations, perhaps most obviously in how it affects the military training mission. The military and the Army in particular, originally established installations in rural areas away from population centers. As the U.S. population has grown, urban sprawl now abuts many installations. Noise, dust, and smoke from weapons, vehicles, and aircraft generated during training and other military operations can conflict with adjacent civilian uses. In this context, renewable energy development also has the potential to become a conflict.

Fortunately, the Army has a means to address these encroachment situations. The Army Compatible Use Buffer (ACUB) Program (10 USC 2684a) allows an installation to work with partners to encumber land for protection of habitat and training without acquiring any new land for Army ownership. This or similar programs could be implemented to promote renewable energy development while minimizing negative ecological and environmental effects.

Socioeconomic factors

Military actions in general and renewable energy-related projects in particular can have varied and diverse social and economic effects. These effects are generally measured and tied to impacts on human populations. The most obvious socioeconomic factor that may be influenced by renewable energy development is human movement due to creation of jobs. The large influx of people to work in non-renewable energy production is well-recognized in areas such as Alaska and Wyoming. Population influx results in demands and needs for other social facilities (e.g., housing, education facilities), services (e.g., fire protection), and environmental amenities (e.g., recreation). Such an influx may also stimulate environmental justice concerns. It is not unreasonable to anticipate that renewable energy development would produce the same sorts of demands and needs for facilities.

A comprehensive renewable energy program or approach will have a private industry component. Certainly the private sector will be involved in the design and construction of renewable energy and related facilities. Depending on the circumstances, however, private interests also may be involved in other, and perhaps not so obvious, ways. Biomass (typically from agricultural crops) conversion to biofuels or agrofuels, for example, can require significant conversions of cropland.

Liquid and gaseous agrofuels can be produced with two common strategies. One strategy is to grow crops high in sugar (e.g., sugar cane), starch (e.g., corn), or cellulose (e.g., grass) and then use fermentation processes to produce ethyl alcohol (ethanol). The second strategy is to grow plants that contain high amounts of vegetable oil such as soybeans. When these oils are heated, their viscosity is altered, and they can be burned directly in a diesel engine or they can be chemically processed to produce fuels such as “biodiesel.” In recent years, much cropland conversion has taken place, supported by government programs to stimulate agrofuel production. A consequence of this conversion has been a reported increase in food prices (Mercer-Blackman et al. 2007) and conversion to crop production of marginal land and land formerly in conservation programs (Ogle et al. 2008). Thus, the overall merits of these conversions are uncertain.

Transportation and utilities

Although technologies are developing that will increase renewable energy production efficiency, few military installations are capable of supporting large (utility-sized) renewable energy systems (DoD 2005). Acquiring (i.e., purchasing) transported renewable energy may be a more practical option.

While the technology of energy transportation is established, it is not necessarily easy and may be costly, not only financially but also environmentally. Thus, at least in that sense, transportation and land use are inextricably tied together. While electrical energy from wind and solar renewable energy sources can be said to move easily, it still requires a distribution infrastructure which may or may not adequately exist. On the other hand, renewable energy in the form of heat from solar and geothermal sources is not easily transported over distance at all.

In any event, transportation of renewable energy through new construction of distribution systems, along with the associated roads, other infrastructure, and human activity, can have unknown and far-reaching ecological effects. Habitat fragmentation, life-form behavioral disruption, facilitated invasion of exotic species, introduction of hazardous materials, and other conditions can be a consequence of renewable energy development and acquisition. The extent of the transportation system necessary and its associated ecological impact have the potential to be even greater than is experienced with continuing non-renewable energy development.

Environmental justice

EO 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,” requires that within the context of their operations, federal agencies address environmental and other conditions of minority and low-income groups. The development of renewable energy resources in some regions of the country, particularly if approximated with international borders, may affect these and other populations. Consideration of this and other environmental analysis requirements should be part of any renewable energy development scenario.

Waste management and hazardous materials

Hazardous materials are defined as substances with physical properties of ignitability, corrosivity, reactivity, or toxicity; hazardous waste is defined as any solid, liquid, gaseous, or semi-solid substance that poses a substantial present or potential future hazard to human or environmental health. By its nature, renewable energy is generally clean and results in little direct pollution. An exception to this lack of pollution may be geothermal energy where hazardous gases and minerals may come from underground along with water or steam. One of the most common substances to be released is hydrogen sulfide, which is extremely difficult to dispose of safely. Other minerals that can be troublesome are arsenic, mercury, and ammonia. In addition to geothermal energy extraction releasing hazardous gases and minerals, it can also cause earthquakes. Another exception may be the use of animal waste to generate methane. Disposal of renewable energy waste and associated odors from that process may be problematic.

Recreation

Renewable energy along with land- and water-based recreation can be considered compatible in and of themselves. However, they may be considered by certain segments of the public to be conflicting on some public lands. For example, recreational use might be curtailed on federal lands that are converted to solar or other renewable energy production. These situations will require careful planning and coordination among federal and state agencies and public interest groups.

Indirect and cumulative effects

The indirect and/or cumulative effects of renewable energy developments cannot be overlooked. For example, reports of large numbers of birds and bats being killed as a result of wind turbine operations would raise concerns about cumulative population-level impacts. Similarly, the siting and development of renewable energy sources and facilities can also result in changes in human demographics brought about by the availability of new energy and the resulting demands on other ecosystem attributes such as water.

Unfortunately, both indirect and cumulative effects are difficult to measure and perhaps even more difficult to predict. Additionally, differing criteria may be used to determine what cumulative effects and impacts may exist and may be important. The Council on Environmental Quality (CEQ)regulation for National Environmental Policy Act (NEPA), for example, defines cumulative effects as the impact on the environment which results from the incremental impact of the action when added to all other (federal, non-federal, private) past, present, and reasonably foreseeable actions (40 CFR 1508.2). With regard to listed species, the

Endangered Species Act (50 CFR 402.2) defines cumulative effects as those effects of future state or private actions that are reasonably certain to occur. Indirect effects are those reasonably foreseeable effects caused by the action at a later time or at a further distance (40 CFR 1508.8). Thus, indirect effects will definitely contribute to cumulative effects. At the very least, the identification of indirect and cumulative environmental effects is mandated in any environmental review and planning for renewable energy projects.

Ultimately, the importance and relevance of indirect and cumulative effects on renewable energy developments will be determined by the scope, magnitude, and location of the renewable energy project, development, or application. For example, small localized developments, such as the placement of small wind turbines on buildings for limited local electrical power supplementation, would be expected to have minimal indirect and cumulative environmental effects. On the other hand, indirect and cumulative effects would be reasonably anticipated for large-scale wind turbine development (i.e., the physical size, area, supporting infrastructure, multiple governmental and non-governmental jurisdictions involved in a wind farm).

While the ecological effects of renewable energy projects and development have to be examined on an individual project or action basis, Table A-3 provides a generalized screening overview that can be applied to Army (and DoD) renewable energy developments.

Table A-3. Generalized screening for renewable energy projects. If the project falls within these categories, or if other information is available, further consideration and analysis is called for.

Potentially Affected Environmental Resource	**Renewable Energy Source**			
	Solar	**Wind**	**Biofuel**	**Geothermal**
Military land use	X	X	X	X
Geology, soils, seismic			X	X
Climate	X	X	X	
Biological resources	X	X	X	X
Water resources				X
Air quality			X	X
Air space		X		
Communications		X		
Noise		X		X
Visual	X	X		X
Land use, ownership	X	X	X	X
Cultural resources				
Urban growth	X	X	X	X
Socioeconomic factors	X	X	X	X
Transportation, utilities	X	X	X	X
Environmental justice	X	X	X	X
Waste, hazardous materials			X	X
Recreation	X	X	X	X

Regulatory authority/considerations

The various regulatory authorities that may have a role are an important consideration for renewable energy development projects, particularly those of large scale. A significant amount of, if not most, renewable energy development takes place on private lands (GAO 2005). The federal government plays a minimal role in approving renewable energy power facilities;[4] it is involved in regulating only those facilities that are on federal lands/waters or have some other form of federal involvement (e.g., where federal funding is provided, where a federal permit is involved, or where there is connection to a federal power grid such as the Western Area Power Administration or Bonneville Power Authority). In that case, the renewable energy project must comply with federal laws, such as NEPA. However, there can be overlapping or multiple jurisdictional considerations (Figure A-3), as well as differing permitting processes and data requirements.

For example, wildlife conservation in the United States (with the exception of federal trust species (e.g., threatened or endangered species) lies within the exclusive jurisdictional authority of the states (Partners for Fish and Wildlife Act 2006). Also, most states have statutes that can be applied to regulate siting, construction, and operation of facilities producing renewable energy. The same can be said regarding local zoning. Zoning regulations vary from state to state and from one local jurisdiction to the next. While existing zoning laws seldom categorically address renewable energy generation, they nonetheless may still apply (Table A-2). In some specific situations, Native American tribal regulations may apply.

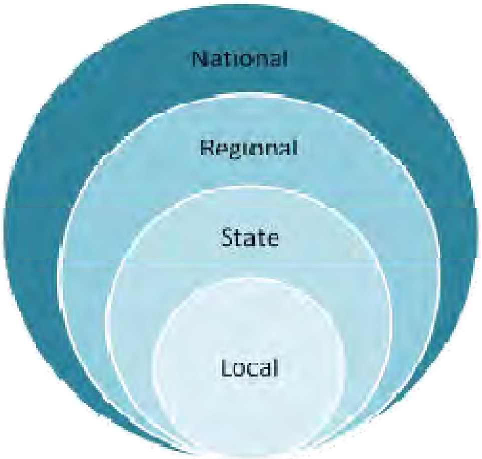

Figure A-3. Overlap of regulatory authority and jurisdictions.

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[4] Notable exceptions are those involving nuclear or hydroelectric generation. In those instances, which are outside the scope of this PWTB, the regulatory nexus is not with renewable energy generation per se, but rather is with the Nuclear Regulatory Commission, Clean Water Act, and other primarily environmental regulations.

Table A-2. Summary of state delegation of zoning authority.

States with zoning enabling laws	50
States with state-level zoning authority	2
States with county zoning authority	39
States with town/township zoning authority	13
States with municipal zoning authority	49
Estimated # of local zoning jurisdictions	20,000

Considerations for Installations

Baseline studies

Renewable energy projects that involve an impact on unimproved lands are being proposed at an increasing pace on or near military bases. The unintended consequences need to be understood before these projects are approved. If not, then many of the projects could have significant delays, work stoppages, costly overruns, and ecological damage. Baseline studies are needed to better understand these consequences and provide information that can be used in the analysis of alternatives for all proposed projects.

Guidelines for planning

Renewable energy plans for DoD and for other relevant public organizations need to be informed by an improved understanding of the “tradeoffs” associated with projects on unimproved land. Guidelines also should be developed to help focus project proposals in a way that minimizes undesirable consequences. Guidelines need to be developed that are sensitive to mission, ecosystem, human health, and other potential concerns.

Long-term studies

Most research and study conducted in association with renewable energy development or acquisition appears to be short-term with little if any follow-up. Long-term studies are needed to address many questions on the impacts of renewable energy development or acquisition on ecosystem components, human health, and mission capability. Some of the impacts may not be apparent in short-term studies, and the types of impacts may differ over time as land use intensifies in regions where renewable infrastructure is sited, or where biomass is generated for biofuels.

APPENDIX B:

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APPENDIX C

ABBREVIATIONS

Term	**Spellout**
ADG	anerobic digester gas
AEPI	Army Environmental Policy Institute
AR	Army Regulation
C2F6	hexafluoroethane
CECW	Directorate of Civil Works, U.S. Army Corps of Engineers
CEMP-CE	Directorate of Military Programs, U.S. Army Corps of Engineers
CFC	chlorofluorocarbon
CF_4	tetrafluoromethane
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CONUS	Continental United States
DA	Department of the Army
DoD	Department of Defense
EO	Executive Order
FR	Federal Register
FY	fiscal year
GAO	Government Accountability Office
GEA	Geothermal Energy Association
GHG	greenhouse gas
HFC	hydrofluorocarbon
HRI	heat recovery incinerator
HQUSACE	Headquarters, U.S. Army Corps of Engineers
IPCC	Intergovernmental Panel on Climate Change
MRBI	Market Research Business Insights
MSW	municipal solid waste
N_2O	nitrous oxide
NEPA	National Environmental Policy Act
PDF	portable document file
PL	Public Law
POC	point of contact
POM	Progress Objective Memorandum
PWTB	Public Works Technical Bulletin
REN21	Renewable Energy Policy Network for the 21st Century
SF_6	sulfur hexafluoride
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USC	United States Code
WBDG	Whole Building Design Guide
WWW	World Wide Web