3 OVERVIEW OF SOLAR ENERGY POWER PRODUCTION TECHNOLOGIES, DEVELOPMENT, AND REGULATION

This chapter provides general information about the types of solar facilities that are likely to be developed in the United States over the next 20 years, along with their sizes and resource needs (Section 3.1); a general description of the phases of solar facility development (from site characterization through decommissioning) and of associated transmission line development (Section 3.2); a brief discussion of regulatory requirements pertaining to solar facilities (Section 3.3); and solar facility considerations with respect to transportation, hazardous materials and waste, and health and safety (Sections 3.4 through 3.6). A description of U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) and U.S. Department of Energy (DOE) processes that are in place and are relevant for solar energy development is given in Section 3.7.

This chapter is intended to provide background information on the characteristics of solar facilities and transmission infrastructure that would be required to support them; the processes that would be employed for their permitting, construction, operation, and decommissioning; and some regulatory information and additional practical considerations for solar facilities. A detailed assessment of the possible impacts associated with solar facilities and potentially applicable mitigation measures is presented in Chapter 5.

3.1 TECHNOLOGIES

The solar technologies discussed in this chapter are those deemed most likely to be deployed at utility scale over the next 20 years. Solar facilities are likely to have an operational lifetime of 30 years or more. Utility-scale facilities are those generating electricity that will be delivered into the electricity transmission grid. For the purposes of analysis in this programmatic environmental impact statement (PEIS), facilities with capacities greater than 20 MW were considered. Utility-scale facilities with lower capacities would have similar impacts but at a smaller scale; elements of the new Solar Energy Program established through this PEIS could also be applicable to facilities with capabilities of less than 20 MW. The upper limit of power production capacity for solar facilities has not been determined; the BLM has received right-of-way (ROW) applications for facilities with nameplate ratings of up to 4,100 MW (the proposed nameplate rating is the maximum power-generating capacity of a facility). For perspective, the entire electricity generating capacity of the United States was approximately 1 million MW in 2008 (EIA 2010). The average nameplate capacity in 2008 was 233 MW for coal-fired power plants, 1,021 MW for nuclear plants, 51 MW for wind facilities, and 6 MW for the few solar thermal and PV facilities in operation (EIA 2010).

The technologies evaluated fall into two general categories—concentrating solar power (CSP) and photovoltaic (PV). CSP technologies are those that concentrate the sun's energy to produce heat; the heat then drives either a steam turbine or an external heat engine to produce electricity. Parabolic trough, power tower, and dish engine technologies fall into the CSP category. In PV technologies, the photons in sunlight are converted directly to electricity. The information contained in this section is extracted from a more detailed discussion in Appendix F regarding the utility-scale solar energy technologies. Information that is most relevant to potential environmental impacts associated with the generation of electricity using solar technologies is presented in the following sections.

3.1.1 Parabolic Trough

The major components of typical utility-scale parabolic trough facilities are the solar field, power block, cooling system (cooling water and steam water support systems, including wells, pipelines, filtration, chemical treatment equipment, blowdown and evaporation ponds, zero-discharge facilities, and pumping stations), electrical switchyard and power conditioning facility, thermal storage facilities (where present), and various support buildings (control building, warehouse, and maintenance facilities). The solar field consists of long rows (approximately 100 to 150 ft [30 to 46 m]) of parabolic solar collectors lined with mirrors that focus the sun's energy on a central absorber tube containing a heat transfer fluid (HTF) (see Figure 3.1-1). The HTF (typically a mix of synthetic organic oils) is heated in the solar field. Efficiency in heating is achieved by using tracking systems that adjust the trough angles to follow the movement of the sun. The heated HTF flows to the power block, where its heat is transferred to steam via a heat exchanger and the steam is used to produce electricity using a steam turbine generator (STG). The power block also contains a substation where electrical equipment is used to condition the power by adjusting its voltage and phase (the frequency at

FIGURE 3.1-1 Solar Field for the Florida Power and Light Parabolic Trough Facility Known as SEGS VI, Kramer Junction, California (Source: Hosoya et al. 2008)

which alternating current [AC] changes polarity [60 cycles per second in the United States]) to match existing conditions on the transmission line segment of the power grid to which the facility is connecting. Cooling systems include a condenser, which cools spent steam leaving the STG to the liquid state, and a cooling tower, which transfers excess heat from the water to the atmosphere. The power block and cooling system components of a parabolic trough facility are generally the same as those used for other electricity-generating plants that are based on transforming heat to electricity by using HTFs, regardless of the source of the heat (i.e., coal, natural gas, and nuclear). The power block and cooling system components are also used for solar power tower technologies (see Section 3.1.2).

In the United States, there are two operating parabolic trough facilities. The first is actually a group of facilities, the Solar Energy Generating System (SEGS) I through IX facilities installed in three locations in the southern Mojave Desert in California from 1985 through 1991. These facilities have a combined power capacity of 354 MW and cover 1,600 acres (6.5 km^2). Several of the SEGS facilities also have a natural gas–fired boiler that allows them to augment power production during non-sunlight hours. The other operating United States facility is Nevada Solar One, which is located about 40 mi (64 km) southeast of Las Vegas, has a power capacity of 75 MW, and encompasses 400 acres (1.6 km^2) (Acciona 2008). An application for another facility, the 250-MW Beacon Solar Energy (BSE) Project, has been submitted and could begin operations in late 2011.[1] It will be located on approximately 2,012 acres (8.1 km^2) in Kern County, California, about 100 mi (160 km) north of Los Angeles (Beacon Solar, LLC 2008).

Parabolic trough facilities may include thermal energy storage (TES) capability, whereby any excess heat generated would be stored in a thermal storage medium (typically molten salt, but research and development [R&D] is ongoing for several alternative storage media) and used during non-sunlight hours. The daily amount of additional time that the plant could run on stored thermal energy would be dependent on the amount of additional solar field capacity included in the design; the SEGS I plant included 3 hours of TES. Several proposed parabolic trough facilities include between 1 and 6 hours of TES.

The average land area required for parabolic trough facilities (based on the existing SEGS plants, the BSE project, and the Nevada Solar One project) is about 5 acres (0.02 km^2) per MW. The BLM has received several ROW applications requesting ROW land areas substantially larger than that corresponding to 5 acres (0.02 km^2) per MW. Additional land area could be needed to allow developers to avoid sensitive areas (e.g., drainages) within the ROW. In addition, facilities using TES would require somewhat larger land areas.

A variation of the trough technologies is the compact linear Fresnel reflector (CLFR) technology. This relatively new technology uses flat mirrors rather than the parabolic mirrors typically used in trough systems. CLFR facilities can also be designed to use water as the HTF

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1 Design data from pending applications have been used in this PEIS to estimate resource requirements because they contain good engineering design data considered to be representative of actual future facilities. Also, updated information from other approved projects, particularly fast-track projects, will be included in the Final PEIS.

rather than conventional synthetic oils, producing steam directly at the solar field. Flat mirrors and water used as an HTF simplifies system design and operation and could be expected to result in savings of both capital and operating costs. Notwithstanding such design variations, the power block and cooling system options are the same for CLFR and the standard parabolic trough technology. A potential advantage of CLFR systems is a smaller land requirement. For this technology, the troughs may be built lower to the ground and spaced closer together, resulting in a lower land requirement, about 3 to 4 acres (0.01 to 0.02 km^2) per MW. This lower overall profile also offers less wind resistance, simplifying the design of the supporting superstructures. A 177-MW CLFR facility (the Carrizo Energy Solar Farm) was previously proposed for construction on 640 acres (2.6 km^2) in San Luis Obispo County, California, about 150 mi (241 km) northwest of Los Angeles (Carrizo Energy, LLC 2007). This application, although withdrawn, provides good basic engineering data for CLFR facilities.

A technical limitation for parabolic trough facilities is the need for very flat terrain. Because the piping interconnecting the troughs has a very low tolerance for change in slope, practically speaking, the slope of lands used for parabolic trough facilities needs to be less than 2%, and preferably less than 1%, in order to use the technology.

Water is needed at parabolic trough (and power tower) facilities to run the cooling systems, as well as for mirror washing and other maintenance and sanitary uses to support the workforce. The total water use of a wet-cooled parabolic trough facility is about 800 gal/h/MW (3 m^3/h/MW), of which 2% is used for mirror washing and 98% is used for cooling (DOE 2009). The amount of water used for the cooling system will depend on the type of system selected. Recirculating wet-cooling systems use the most water, estimated at about 780 gal/h/MW (3 m^3/h/MW) for parabolic trough facilities (DOE 2009) (which corresponds to a range of 4.5 to 14.5 acre-ft/yr/MW [5,500 to 18,000 m^3/yr/MW] if operations occur during 30 to 60% of annual hours). For comparison, average annual per-capita water use in the six-state study area is about 0.25 acre-ft/yr (308 m^3/yr) (USGS 2000). Dry-cooling systems would use approximately one-tenth the water of recirculating wet-cooling systems, but would require more input power to run the cooling system fans, thus reducing the overall power-generating capacity of the facility. Hybrid wet-dry cooling systems may also be used to reduce water use substantially. Depending upon the operation of a hybrid cooling system, water use requirements can be reduced by as much as 80% in comparison with wet-cooling systems (DOE 2009).

3.1.2 Power Tower

Utility-scale power tower facilities consist of a central tower surrounded by hundreds or thousands of flat-plate reflectors (heliostats) that concentrate the sun's rays on a central point at the top of the tower, where an HTF can absorb the heat (see Figure 3.1-2). The typical height of towers is about 300 to 450 ft (91 to 137 m). The HTF used in power tower facilities to date has been water, although future facilities may use molten salt as both an HTF and a TES medium. Similar to the parabolic trough systems discussed in Section 3.1.1, the heliostats are equipped with tracking systems to maximize power capture by following the daily movement of the sun. In addition to the tower and the heliostat array, power tower facilities also have a power block, cooling system components, and other major components and facilities similar to those described

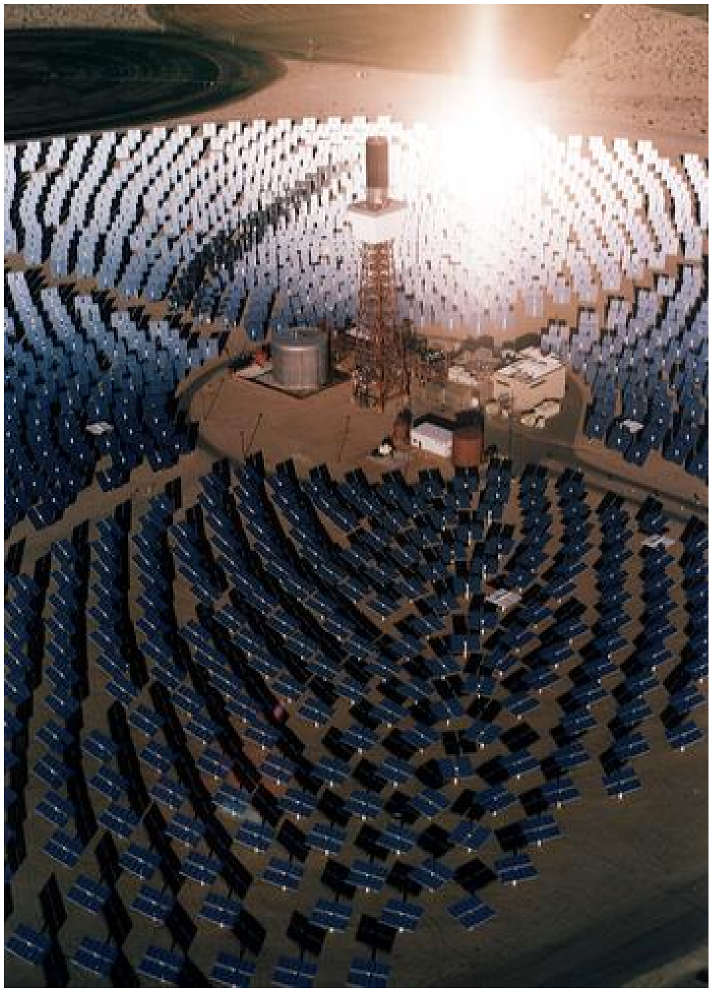

FIGURE 3.1-2 Solar Two, CSP Power Tower Facility in Daggett, California (Credit: SNL; Source: NREL 2009)

in Section 3.1.1 for parabolic trough facilities; the same types of TES systems could also be employed at power tower facilities.

A 10-MW research and demonstration power tower facility called Solar One began operations near Daggett, California, in 1982. It was later retrofitted to incorporate molten salt TES, renamed Solar Two, and operated successfully until 1997. There is also a power tower facility operating in Spain (the PS10 facility; 11 MW). An application is under review for a 370-MW power tower facility on 3,582 acres (14.5 km^2) of BLM-administered land in San Bernardino County, California, about 50 mi (80 km) southwest of Las Vegas.[2] Construction of this facility (the Ivanpah Solar Energy Generating System [ISEGS] facility) is scheduled to begin at the end of 2010 (CEC 2010). Although not utility-scale as defined in this PEIS, a 5-MW

2 Project approved. Updated information will be included in the Final PEIS.

power tower facility built by eSolar started operations in 2009 in Lancaster, California, to demonstrate the steam power tower technology.

Because there are few data on operational power tower facilities in the United States, the land use requirements are difficult to project. The ISEGS facility proposes 3,582 acres (14.5 km^2), corresponding to approximately 10 acres (0.04 km^2) per MW. Other ROW applications for power tower facilities on BLM-administered lands request a range of land areas, from about 9 acres (0.04 km^2) per MW to areas of greater than 30 acres (0.12 km^2) per MW. However, these applications are in the preliminary stages of evaluation and the requested land area may be refined.

Relatively flat terrain is preferable for power tower facilities; developers generally prefer to limit the slope of potential sites to about 1 to 2%. However, this preference is at least partially for ease of construction, because the equipment (tower and heliostats) is fairly tolerant of slope change. If good reasons exist to use lands with higher slopes, power tower facilities may be engineered to accommodate slope change across a site.

Water use for tower facilities is for running the cooling system, heliostat washing as needed, and other maintenance and sanitary uses to support the workforce. The estimated water use is the same as was discussed for parabolic trough systems in Section 3.1.1 (i.e., recirculating wet-cooling systems are estimated to use about 780 gal/h/MW [3 m^3/h/MW], which corresponds to a range of about 4.5 to 14.5 acre-ft/yr/MW [5,500 to 18,000 m^3/yr/MW], assuming a range of 30 to 60% operational hours per year; dry-cooling systems would use approximately one-tenth of that amount; hybrid wet-dry cooling systems have the potential to reduce water use by 80% compared to wet-cooling systems, depending upon operations [DOE 2009]).

3.1.3 Dish Systems

Solar dish engine systems generate electricity through the action of an external heat engine, called a Stirling Engine, rather than through steam production. A typical dish system consists of a parabolic concentrator, a receiver, an external heat engine, and a generator (see Figure 3.1-3). Sunlight is concentrated onto the receiver, which transfers the heat to a gas (usually hydrogen or helium) contained in the sealed external heat engine. As the gas is heated, its increasing pressure drives a piston, thus powering the generator and producing electricity. Individual dish engines have been designed with power-generating capacities of 0.025 to 0.050 MW.

Individual dish engines can be grouped together into facilities with widely varying power capacities. Although the sun’s energy is converted directly to electricity at each individual dish engine, TES applications that store heat for later conversion to steam are nevertheless being considered for dish engine facilities. Preliminary studies funded by the U.S. Department of Energy (DOE) are underway to investigate the feasibility of recovering heat from an operating Stirling-type dish engine for storage in a TES system by using thermally stable phase changing

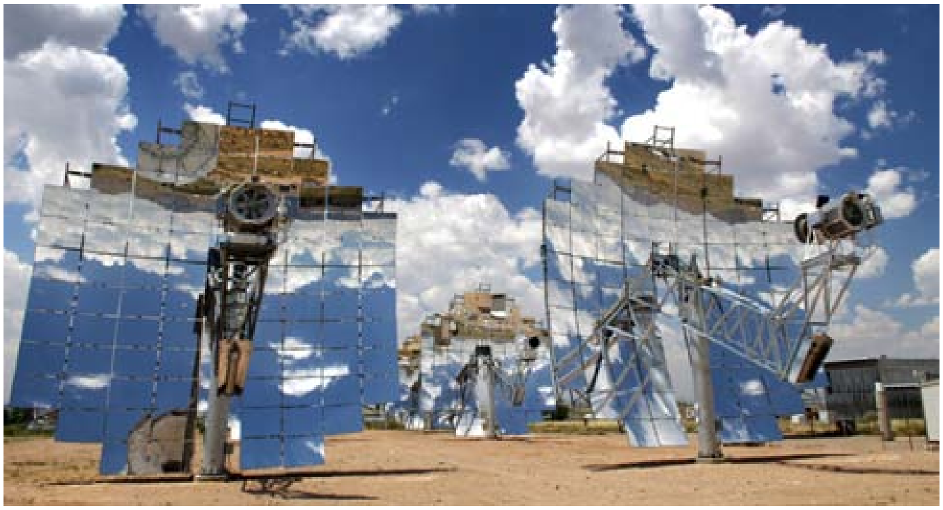

FIGURE 3.1-3 Stirling Dish Engines at the Stirling Energy Systems Test Facility in Albuquerque, New Mexico (Credit: Randy Montoya; Source: SNL 2008)

salts.[3] As with all solar technologies, electrochemical energy storage through the use of deep cycle batteries is technically available for dish engine facilities; however, no practical applications of battery storage at dish engine facilities currently exist.

Dish engines are often used as smaller sources of power for remote areas or individual facilities. They have higher concentration ratios than parabolic trough or power tower. No utility-scale solar dish engine facilities are currently in operation in the United States, although some smaller facilities are in operation (for example, the 1.5 MW Maricopa Sun project near Peoria, Arizona). The BLM has received several applications for ROWs for dish engine system facilities on BLM-administered lands. One example is the proposed Imperial Valley Solar Project (SES Solar Two, LLC 2008). If approved, the 750-MW facility will be located on 6,500 acres (26 km^2) in Imperial County, California.[4]

Because there are currently no operational utility-scale dish engine facilities in the United States, the land use requirements are difficult to project. The application for the Imperial Valley facility requests 6,500 acres (26 km^2), corresponding to approximately 8.7 acres (0.04 km^2) per MW. Other ROW applications for dish engine facilities on BLM-administered lands request a range of land areas, from about 6 to 18 acres (0.024 to 0.073 km^2) per MW. However, these applications are in the preliminary stages of evaluation and the requested land area may be refined.

Similar to the power tower facilities, the equipment required for dish engine facilities is tolerant of slope change, although construction can be more complex on steeper slopes because

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3 For additional details on this as well as other ongoing TES R&D projects, see the DOE Solar Energy Technologies Program Web site (http://www1.eere.energy.gov/solar/pdfs/csp_funding_prospectus_2008.pdf).

4 Project approved. Updated information will be included in the Final PEIS.

of the need to optimize the geometry of the receiver tilt. If good reasons exist to use lands with steeper slopes, dish engine facilities may be engineered to accommodate slope change across a site.

Water use for dish engine facilities is for washing of mirrors when necessary and for miscellaneous industrial processes and sanitary uses to support the workforce. The amount of water needed for mirror washing is dependent upon the fugitive dust conditions and the climate of the region, as well as the time of year, which are all factors that need to be considered in a mirror washing schedule (Cohen et al. 1999). The estimated use for the SES Imperial Valley Facility would only be about 0.044 acre-ft/yr/MW (54 m^3/yr/MW) (SES Solar Two, LLC 2008).

3.1.4 Photovoltaic Systems

PV systems are based on the use of semiconductors, materials that can generate small amounts of electric current when exposed to sunlight. Semiconductors are materials that hold their bonding electrons tightly in covalent bonds (and therefore act as insulators in their pure state), but that have conducting properties when combined with small amounts of impurities called dopants. In most configurations, the solar cell material is present as a thin film. Silicon, the earth's most abundant material after oxygen, is the cheapest and most frequently used semiconductor. Boron and gallium are common dopants. Research is currently ongoing using different combinations of semiconductors and dopants to increase the efficiency of solar cells for capturing the energy in sunlight. Compound semiconductor materials such as cadmium telluride have also been used for solar cells. Currently, the silicon-based solar cells that have efficiencies of about 15% are likely to be used in utility-scale PV facilities built in the United States; however, multi-junction solar cells that contain two or more semiconductors and can increase efficiency to 30% or greater will likely be used in utility-scale PV facilities in the future. Another means of increasing efficiency is to use concentrating lenses (also known as concentrating PV technology [CPV]) and tracking systems to capture additional energy from the sun over longer periods of daylight.

To produce electricity at utility scale, many individual solar cells are connected as a module; modules are combined to make individual solar panels; and solar panels are grouped into arrays producing direct current (DC) electricity. This modular nature of PV systems allows greater flexibility in sizing facilities based on factors such as the amount of power needed or the amount of land area available.

The power-producing components of utility-scale PV facilities are the solar field, which contains the PV panels, and the power conditioning system (PCS), which contains an inverter to convert the produced DC to AC and a transformer to boost voltage for feeding into the power grid. The PCS also contains devices that can sense grid destabilization and automatically disconnect the PV facility from the grid if needed.

PV technologies can be grouped into two types of systems—flat-plate and concentrating systems. The solar cell materials can be the same in either, typically existing as a thin film in a weather-resistant enclosure. The differences between the two systems lie in the manner in which they capture incident sunlight and direct it to the solar cell materials. In flat-plate systems, the modules are placed in the solar field, either in a fixed position optimal for capturing sunlight, or on a tracking system that follows the sun's path to optimize power production (see Figure 3.1-4). CPV systems use silicon solar cells or high-performance multi-junction solar cells (typically made of aluminum, gallium, indium, nitrogen, phosphorus, antimony) and use concentrating or reflecting optical devices to concentrate sunlight that strikes the solar cells. They also usually incorporate tracking devices. Because of their higher efficiency, CPV systems also generate excess heat; therefore, some require cooling systems to dissipate the heat. The cooling systems may be passive (e.g., cooling fins) or active (e.g., forced air cooling or water cooling).

Utility-scale PV facilities have only recently been developed worldwide; most operational plants have come online in the last 2 to 3 years. In the United States, a large PV facility (14-MW) is located at Nellis Air Force Base in Las Vegas, Nevada; this facility has been in operation since December 2007. The Nellis facility encompasses 140 acres (0.57 km^2). The BLM has also received many applications for ROWs for PV facilities to operate on BLM-administered lands. One large application is for the Topaz Solar Farm, a 550-MW facility to be located in San Luis Obispo County in California (Topaz Solar Farms, LLC 2008; updated Nov. 2009). If approved, this facility would begin operations in 2013. Both Nellis Air Force Base and the proposed Topaz Solar Farm use flat-plate PV systems.

FIGURE 3.1-4 Utility-Scale Flat-Plate PV System at the Prescott, Arizona, Airport Operated by Arizona Public Service Company (This system incorporates flat-plate non-concentrating solar panels [foreground] and concentrating flat-plate solar panels [background].) (Credit: Arizona Public Service; Source: NREL 2010)

The Topaz Solar Farm application and the Nellis Air Force Base facilities indicate a land use requirement for PV facilities of about 10 acres (0.04 km^2) per MW. Other ROW applications for PV facilities on BLM-administered lands request a range of land areas, from about 5 to 35 acres (0.02 to 0.14 km^2) per MW. Many of these applications are preliminary, and the requested land area may be refined.

The equipment required for PV facilities can be tolerant of slope change, depending on the flexibility of the interconnection between modules. In general, construction will be more complex on steeply sloped land (e.g., greater than 5%). If good reasons exist to use lands with steeper slopes, PV facilities may be engineered to accommodate slope change across a site.

Water use during operations for PV facilities is for washing of solar panels when necessary and for miscellaneous industrial processes and sanitary uses to support the workforce. The estimated water use for mirror washing is about 0.05 acre-ft/yr/MW (61.7 m^3/yr/MW; see Table 3.1-1).

Because there is no circulating HTF at PV facilities, TES systems are not applicable. Storage of electricity in batteries is possible, but the technology is not adequately developed at this time for application at utility-scale facilities.

3.1.5 Comparison of Technologies and Assumptions Used for Environmental Analyses

Some important factors for solar energy development with respect to environmental impacts include the overall size of the facilities and the size of facility structures, the water use during operations, and the type and quantity of process chemicals and/or other hazardous materials required. Assumptions used for these parameters to support analysis of impacts in this PEIS were based on the data from actual and proposed facilities presented in Sections 3.1.1 through 3.1.4, and are presented in Table 3.1-1.

The initial input needed to estimate these factors on a "per facility" basis is the nameplate capacity, or maximum output for each facility type. Because the utility-scale solar energy industry is in a developmental stage in the United States, the range of possible facility capacities is still unknown. To date, the BLM has received ROW applications that include a wide range of proposed facility power capacities for each of the technologies discussed above (from about 100 to 4,100 MW for parabolic trough and power tower facilities, and from 1 to 2,500 MW for dish engine and PV facilities); however, it is unknown whether facilities with large nameplate capacities will be approved. For parabolic trough facilities, data indicate that the optimum maximum plant size would range from about 250 to 350 MW (see Section F.2.2.3 of Appendix F). Parabolic trough and power tower facilities are not modular; they rely on interconnecting facility lines and the central power block to generate power. It also would not be cost-effective for these facilities to have a low nameplate capacity, given that the power block equipment would be required regardless of the facility capacity. In comparison, the modular nature of dish and PV components allows flexibility in planned facility capacities.

TABLE 3.1-1 Technology-Specific Assumptions for Environmental Impact Analyses

Parameter	Parabolic Trough	Power Tower	Dish Engine	PV
Facility power capacities (MW)	100–400	100–400	10–750	10–750
Land area requirements (acres/MW)[a]	5	9	9	9
Operational water use (ac-ft/yr/MW)				
Wet (recirculating) cooling[b]	4.5–14.5	4.5–14.5	NA[e]	NA
Dry cooling[b]	0.2–1.0	0.2–1.0	NA	NA
Hybrid system[c]	0.9–2.9	0.9–2.9	NA	NA
Mirror/panel washing/other[d]	0.5	0.5	0.5	0.05
Chemicals/hazardous materials present on-site	HTF, water treatment chemicals; herbicides	HTF, water treatment chemicals; herbicides	Hydrogen tanks; herbicides	Encased semiconductor materials; herbicides

[a] Land area estimates were based on areas required for existing facilities and estimated areas for proposed facilities. In some cases disturbed area estimates were not available, so values were based on total plant area (should approximate disturbed area). The estimated land use values for parabolic trough and tower facilities are minimums; the land area requirement could be higher if TES is incorporated into facilities.

[b] Wet-cooling and dry-cooling requirements are based on estimates given as gal/h/MW in DOE (2009). An assumed range of operational hours of 30 to 60% of annual hours (1 gal = ~3.1×10^{-6} ac-ft) was used to generate ac-ft/yr/MW values.

[c] Hybrid systems are assumed to use 20% of the water requirements of wet-cooling systems.

[d] The mirror washing estimates originate from the assumed 2% of total water needs of wet-cooled parabolic trough facilities from DOE (2009). This estimate equals 20 gal/h/MW, which corresponds to 0.5 ac-ft/yr/MW, with no assumption on operational time (conservative estimate). The panel washing estimate for PV facilities was assumed to be a factor of 10 less than that for CSP technologies (Appendix M).

[e] NA = not applicable.

For the purposes of analysis in this PEIS, it was assumed that parabolic trough and power tower facilities permitted on BLM-administered lands would have a nameplate capacity range of 100 to 400 MW. The upper end of the range approximately corresponds to the capacity of the proposed ISEGS power tower facility, which is well into the environmental review stage. The assumed capacity range for dish engine and PV facilities is 10 to 750 MW; the upper end of this range is based on the capacity of the proposed Imperial Valley Dish Engine facility, which is also proceeding through planning and environmental review requirement stages. These values were used as an illustration of size range for solar facilities; however, water and land use (and corresponding impacts) can be estimated for larger facilities by using the parameters given on a per megawatt basis in Table 3.1-1.

3.1.5.1 Land Requirement Assumptions

The assumptions for the land use requirements given in Table 3.1-1 were based on a review of land use for existing and proposed facilities (see Appendix F). Many applications for ROWs on BLM-administered lands request substantially more land than would correspond to the requirements stated in the table. The rationales for requesting additional acreage include allowing flexibility in project design or to avoid lands where resource conflicts might exist within the ROW. For example, it is likely to be appropriate to avoid areas within the facility footprint that serve as natural drainage swales or to avoid uneven or inappropriately sloped areas to preempt the impacts that would occur from the development of such areas.

As shown in Table 3.1-1, the various solar technologies also dictate different land use requirements. These differences result from a number of factors. The majority of land for any solar facility is devoted to the solar field. To ensure optimal operation, it is necessary to place individual sun-capturing devices in the solar field with sufficient separation to avoid shadowing of one device by an adjacent device. Providing for adequate spacing and for access roads needed for inspection, maintenance, and repair contributes substantially to land area requirements. It is also essential to provide sufficient land areas for all components of the facility in addition to the solar field, such as the power block, the power conditioning facility and substation or switchyard, steam cooling and conditioning systems (where present), waste management systems, HTF system reservoirs (where present), and TES storage facilities (where present). Land use requirements expand dramatically when TES capabilities are introduced. Not only must land be provided for the engineering elements of the TES system, such as large-volume storage tanks, transfer pumps, and heat exchangers, but the solar field area must also be expanded proportionally to the additional hours of nameplate operation expected to be provided by the TES system. Solar multiples of 2.0 (i.e., a solar field with double the area) or greater may be needed to support TES (see Appendix F, Section F.2.2.3 for discussion of solar multiples).

Buffer zones on fallow land surrounding solar facilities may be appropriate for a variety of reasons, including control of land use to prevent the erection of facilities on adjacent land areas that could interfere with the operation of the solar facility, or to provide for the attenuation of noise from industrial activities to acceptable levels at surrounding human or wildlife receptor locations. The size of ROWs for individual facilities will be established as a part of the site-specific evaluation process.

3.1.5.2 Water Use

Water use during construction is dependent on the location of a project and the specific project design. Values for water use based on the representative projects discussed in Appendix F were used to frame the impact analysis. For operations, a study estimating water use for parabolic trough, power tower, and dish engine technologies was also available (DOE 2009). The values given in that study were assumed for PEIS analyses (see Table 3.1-1). A lower value was assumed for panel washing at PV facilities based on existing applications and the difference in the mode of solar energy production between PV and CSP technologies.

Because the ideal locations for solar facilities are typically in arid areas, water use and water availability are key considerations when thermoelectric technologies (i.e., those utilizing a steam cycle) are selected. Intuitively, cooling technologies using the least amount of water are preferred. However, in practice, many more considerations enter into the selection of the steam cooling system, including institutional policies that discourage the use of freshwater for cooling purposes.

Conventional cooling systems for thermoelectric power plants, usually referred to as wet recirculating cooling or wet closed-loop cooling, provide the best performance under most weather conditions. Unfortunately, since their primary mechanism for heat dissipation is evaporation of some of the water in the recirculating system, their water demands are the greatest among the available cooling options. Dry-cooling technologies that cool steam in a condenser by passing ambient air over the condenser's surface are feasible in desert environments; however, the net power output of CSP facilities equipped with dry cooling will be less than that of a similarly sized facility using wet recirculating cooling.[5] Hybrid wet/dry systems have been developed that introduce water into the air stream passing over the steam condenser or deluge the outer surface of the condenser with water. The cooling mechanism is the same as for wet recirculating cooling systems; water flash evaporates, cooling either the air stream or the surface of the condenser as it does so. Such wet/dry hybrids are not as thermally efficient as conventional wet recirculating cooling systems; however, they use substantially less water and offer somewhat better performance than dry cooling alone, although there is still some reduction in power output. Such hybrid systems perform best in desert environments where relative humidity is typically very low. A recent variant of the hybrid wet/dry systems described above includes the use of a dual cooling system comprised of a conventional closed-loop cooling system using either a mechanical draft or natural draft cooling tower and a dry-cooling system; the facility operator has the discretion to rely on either or both, depending on prevailing conditions and the facility's heat rejection demands. Thus, in arid desert environments, the dry-cooling system with its minimal water demands would be used the majority of time, but the wet-cooling system could be put into service to augment cooling capacity and maintain the performance and maximum power output of the facility when high load demands coincide with the hottest portion of the day. With respect to visual impacts, the mechanical draft or natural draft cooling towers of wet closed-loop systems have a taller profile than do the dry condensers of a dry-cooling system. Adding demisting screens or air mixing zones to the mechanical or natural draft towers to prevent the formation of visible vapor plumes from wet closed-loop systems increases the heights of such systems even more. Mechanical draft cooling towers can have an average height of 30 to 40 ft (9 to 12 m). Natural draft towers that rely on the principle of convection to establish a counterflow of ambient air need to be much taller, often greater than 200 ft (61 m). The heights of dry-cooling system components are typically less than wet closed-loop system components. However, because heat exchange efficiencies of dry systems are typically less than those of wet closed-loop systems, dry systems would need to occupy a larger

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[5] Assuming that a dry-cooling system is sized to have the same heat dissipation capacity as a wet closed-loop cooling system, the lesser amount of net power from the facility equipped with the dry-cooling system reflects the additional parasitic load for such dry systems—specifically, the power needed to operate the fans that force ambient air across the surface of the dry condenser.

overall footprint than wet closed-loop systems in order to have an equivalent heat rejection capacity.

Facilities in dry environments may reduce groundwater or surface water requirements by utilizing reclaimed water from wastewater treatment facilities. However, that will require the facility operator to develop extensive water treatment and storage capabilities, greatly increasing both the initial and operating costs of the facility. Similarly, facilities could consider alternative water sources for mirror washing, but such water would also require extensive treatment before it could perform adequately in mirror washing. Some cooling technologies use organic solvents in closed systems in place of water, although cooling systems of this design have limited capacity and have been successfully applied only to facilities with relatively small generating capacities. However, both of these water-saving systems may be utilized in future solar facilities in arid areas.

While water availability remains the primary consideration in the selection of a cooling system for CSP facilities utilizing steam, land requirements, visual resource impacts (i.e., the physical profiles of the system and, in some cases, the steam plume that may result in some weather conditions), the initial chemistry of the available water[6] and the complexity of the treatment necessary before it can be introduced into the cooling system, capital and operating costs, and the parasitic load (i.e., the amount of power needed to operate the system) also enter into the decision. Section F.2.4.2 of Appendix F provides a detailed discussion of cooling system options for CSP facilities utilizing a Rankine steam cycle, their advantages, and their drawbacks.

3.1.5.3 Chemicals/Hazardous Materials

The general types of chemicals and hazardous materials that would be present at solar energy facilities are listed in Table 3.1-1 and include HTFs, water treatment chemicals, and encased semiconductor materials. The range of materials used is discussed in detail in Section 3.5.

3.2 DEVELOPMENT PROCESS OVERVIEW FOR ALL TECHNOLOGIES

3.2.1 Site Characterization

In general, very little in the way of site modification is necessary during this phase. Required site characterization activities would vary depending on the type of technology being

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[6] As discussed in greater detail in Appendix F, water introduced into a wet closed-loop recirculating cooling system must be treated to remove dissolved minerals and to control the growth of biological organisms. Failure to do so will result in biofouling and scale formation on critical parts of the cooling tower and in the recirculating plumbing system, both of which greatly reduce cooling efficiencies and result in increased maintenance downtimes or premature component failures. The amount of treatment required is dependent on the quality of the raw water source.

installed, planned water source (if any), and requirements of Power Purchase Agreements (PPAs).[7] The activities could include construction of meteorological towers (or erection of portable, trailer-mounted towers) for collection of meteorological data, surface hydrology assessment and floodplain mapping, slope evaluation, soil stability studies, due diligence assessment for lands with previous industrial uses, evaluation of seismic stability and potential storm event runoff, and soil coring (especially where substantial foundations would be required). The site characterization phase would include conducting surveys for ecological, cultural, and paleontological resources (including surveys for special status species if needed). Many of these activities would involve minimal or no site disturbance. For example, solar insolation data collection, surface hydrology assessment, floodplain mapping, slope evaluation, and due diligence assessments would primarily involve literature searches and/or on-site walkover surveying techniques and sensor placement. Most soil stability and soil coring activities would involve the use of handheld augers that could be transported to the site on existing roads. Ambient sound measurements that may be required for acoustic impact assessments are typically noninvasive and involve very little or no site disturbance.

Meteorological information (e.g., temperature, precipitation, and wind speed) might be obtained from a nearby existing monitoring station, or a meteorological tower could be erected on-site in order to collect site-specific data. The required height of a meteorological tower in most cases would likely be only 33 to 66 ft (10 to 20 m), since the main wind data required would be for estimating potential wind-shear impacts on facility equipment. (An exception might be for power tower facilities, for which site-specific data at the 164-ft [50-m] [or higher] level could be necessary.) It is estimated that it would take less than 1 day to erect a tower. Towers and instruments are relatively lightweight and often do not require belowground foundations or guy wires, especially if they are to be in service for limited periods of time. The towers typically do not require signal lights (especially the shorter 33- to 66-ft [10- to 20-m] towers). Some of the monitoring towers could remain operational throughout the life of the site and would then require a more permanent installation. In those locations where high winds or wind shear is likely, such permanent installations may require guy wires to ensure adequate structural support for the towers. For these towers, subsurface foundations may be required. Only the most remote sites require construction of a minimum-specification access road, which may be upgraded later to become the site's main access road, to support meteorological tower installation. A small crew (six or fewer individuals) would be required to erect the meteorological towers, and typically no personnel support facilities would be required. Data collected would be transmitted to remote locations; thus only infrequent human presence would be required on- site during the data collection period for equipment inspections or maintenance purposes.

[7] A Power Purchase Agreement (PPA) is executed between a solar site operator and entities such as power brokers or investor-owned or publicly owned utilities. In addition to specifying the terms of a power purchase, the PPA dictates the terms and conditions under which power from the facility will be provided to the transmission grid and typically specifies the required voltage, current, and the phase synchronization of power generated in the facility. It dictates a variety of electrical safety features and monitoring requirements that will be required to prevent destabilization of the grid during upset conditions (conditions outside pre-specified parameters) at the facility. PPA requirements also dictate the type of power conditioning and control equipment that will be present at the solar facility.

For solar projects that anticipate using groundwater obtained from on-site wells, existing area-specific data on groundwater hydrology may suffice in lieu of on-site characterization data. However, in the absence of area-specific data, more extensive ground-disturbing activities, such as installation of monitoring/sampling wells and piezometers, could be required. Large truck-mounted drilling rigs might require wider, higher-specification site-access roads and could cause extensive site disturbance. An appropriately sized and equipped drilling rig, used in conjunction with proper drilling procedures and site management, could minimize such impacts. Additional surface disturbance associated with well drilling could result from the construction of temporary impoundments for well drilling fluids and cuttings, although if closed-loop drilling systems were used, surface impoundments would not be necessary. Improper management of drilling fluids and cuttings could result in surface water and localized soil impacts.

Another activity that could result in substantial ground disturbance would be collecting deep soil corings to gather information necessary for the design of large structure foundations (e.g., for power towers). This type of characterization may also require larger equipment with higher access road requirements and the potential for extensive ground disturbance.

As the above paragraphs suggest, impacts from site characterization activities could range from insignificant to moderate, depending on what specifically needs to be accomplished. However, in most instances, and especially if the selected site meets the minimum slope requirements of the selected solar technology, site characterization will result in only small or negligible impacts. Site characterization is nevertheless critical to the overall success of the project in avoiding or minimizing adverse impacts. Surveys of existing ecosystems and identification of other important resources or features completed during site characterization provide data that are critical in supporting facility designs and development plans that minimize overall impacts.

3.2.2 Site Preparation and Construction

The components and activities required for construction are dependent on both the technology and the location. However, construction of any solar energy development project is likely to involve the following major actions: establishing site access; performing site grading; constructing laydown areas and an on-site road system; removing vegetation from the solar field and construction and laydown areas (primarily for fire safety); and constructing the solar field, power block area (for parabolic trough and power tower facilities), central control building, a weatherproof area for minor maintenance and for storage of equipment and parts (which may be separate or combined with the control building), electrical substations, and meteorological towers (if not done during site characterization). Additional activities may also be necessary at some facilities, including pile driving (for the type of foundation expected for individual dish engines), constructing a concrete batching plant, constructing sanitary facilities and temporary offices, and landscaping. Construction would generally be divided into two phases, which would include a site preparation phase of relatively short duration (e.g., a few months) followed by a much longer assembly, testing, and start-up phase.

Development strategies and construction schedules are also site dependent. Although smaller solar facilities in the range of 10 to 50 MW may be constructed in 1 year or less, larger facilities may have construction periods of several years and may be developed in phases. Developers would likely develop sites in accordance with economies of scale whenever possible. For example, where possible, similar activities would likely be completed at the same time throughout the entire site. Specialty crews could be brought to the site to complete all of their functions throughout the site, such as grading, excavating, installing foundations, or installing electrical equipment and substations, at one time.

3.2.2.1 Site Preparation

Site preparation consists of establishing site access, site clearing, and grading. Major heavy equipment that may be used in the site preparation phase would include bulldozers, graders, excavators, scrapers, front-end loaders, trucks, cranes, rock drills, chain saws, chippers, trenching machines, and equipment for blasting operations if required. Note that some construction techniques are available that minimize the land surface disturbance, such as disking and compacting, or leaving natural contours in place.

In general, the heavy equipment and materials needed for these activities are typical of road construction projects and would not pose unique transportation considerations for existing roads (see Section 3.4.1 for further details on transportation). However, off-site road construction or improvements may be required if local roads necessary for site access are not designed for gross vehicle weights of up to 80,000 lb (36,000 kg), the federal limit for tractor-trailer trucks on most U.S. highways. State-specific and local limits may also apply. Contact with local transportation authorities would be made to assure proper signage is placed to notify the public of traffic hazards.

Although some solar facilities could be accessed through gravel roads, in general the primary on-site access road(s) connected to the local road system would be a paved two-lane road because it would need to accommodate a large daily construction workforce and delivery traffic flow (as discussed in Section 5.9.1.2). Such an access road would reach as far as parking areas (paved or nonpaved) for construction workers, laydown areas for equipment and supplies, or other major site locations. On the basis of design standards for local roads and streets, these primary access roads may have lane widths of 10 ft (3 m), with graded 5-ft (1.5-m) shoulders as recommended for average daily traffic volumes greater than 400 vehicles (AASHTO 1994) for an overall road width of 30 ft (9 m). A ROW approximately twice the final width of an access road would be required. Therefore, if access road construction were required, the construction ROW width would likely be less than 60 ft (18 m), corresponding to a two-lane highway with 12-ft (3.7-m) lanes and 3-ft (1-m) shoulders. A 60-ft (18-m) ROW would result in a disturbed area of about 7 acres (0.03 km^2) per mile of road constructed. In contrast, the majority of the on-site roads are expected to be one-lane dirt or gravel roads that provide access to such areas as the locations of the individual solar facilities and transmission lines. Typically, these on-site access roads would be a minimum of 10 ft (3 m) wide (PBS&J 2002).

All ground disturbances would likely be confined to the ROW. Road specifications would be dictated by the weights of the heaviest components, for example, electrical transformers, or, in the case of parabolic trough or tower facilities, the STG. While straight-line access roads would minimize distance and cost, heavy loads may dictate a maximum grade of 10%, and while the areas for solar facilities are expected to be generally flat, access roads to the site may need to follow circuitous routes to meet grade requirements. Other factors, such as streams, areas of particular environmental sensitivities, and immovable obstacles, would also affect access road location. Nearby rail access may necessitate the establishment of a temporary equipment storage area at an off-site railhead, but it may also dramatically reduce truck transport requirements. Water transport is not expected to occur within the six-state study area; however, components constructed elsewhere may be brought to the vicinity by water transport.

Construction of the access road would require removing vegetative cover. Although most of the study area does not encompass forested areas, clearing the road path may involve tree removal in some locations. Depending on subsurface stratigraphy, surface soils may need to be excavated, and gravel and/or sand may need to be imported to establish a sufficiently stable road base. Topsoil should be removed and stockpiled for subsequent use to meet the needs of any identified or required interim reclamation. Access roads (other than the primary access road) would be expected to have all-weather capability but would not likely be paved. Aside from asphalt, compacted gravel is the most likely finishing material. In arid zones, compacted gravel roads may cause fugitive dust problems (e.g., PM_{10} and $PM_{2.5}$). Best management practices to mitigate road dust could include the application of soil palliatives. Engineered stormwater control may be necessary, and natural drainage patterns could be altered, at least on a local scale.

Vegetation must be cleared from electrical substation and power block areas to eliminate fire and electrical safety hazards. In addition, proposals for solar facilities generally specify vegetation removal for the entire solar field area, to reduce fire hazards and simplify construction. While some of the solar technologies could potentially be tolerant of native vegetation naturally re-establishing around or under the solar field components during the operating period, most current plans call for complete vegetation removal from the solar field and other industrial areas during construction.[8] The biomass removed during site and road clearing would require disposal; it could be burned on-site if applicable permits could be obtained. Controls regarding the disposition of biomass would be established on a site-specific basis.

While the scope of this PEIS analysis considers development on lands with less than 5% slope, in the near-term (e.g., the next 10 years), most solar energy projects probably would be located on ground with less than 1 to 2% slope to facilitate construction and simplify facility operations. Some localized grading might be necessary in limited portions of such solar sites.

Soils in certain portions of the solar facility sites would be expected to be compacted as a result of construction and vehicle traffic. It is possible that some areas cleared for construction

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8 Certain portions of the solar facility may be altered to the extent that revegetaion of native species would not naturally occur. A vegetation management program is likely to be needed throughout the operating period to control invasive species.

purposes could be revegetated with indigenous vegetation once construction is completed, although revegetation of desert areas is not readily achieved (see Section 5.10.1). Areas around control buildings and electrical substations would have to be maintained free of vegetation throughout the operating life of the solar facility for electrical safety and access purposes. These areas are likely to be covered in rock or gravel to ensure all-weather accessibility and proper drainage, and to reduce fugitive dust.

3.2.2.2 Site Construction (Assembly, Testing, and Start-Up)

The major equipment used in the construction phase would include cranes, front-end loaders, backhoes, bulldozers, trucks, and a temporary concrete batching plant if substantial amounts of concrete are needed and/or premixed concrete is unavailable from nearby vendors (e.g., for foundations for solar power towers or power block structures). In general, the vehicles, equipment, and materials needed for construction would not pose unique transportation considerations or impacts on existing roads.

3.2.2.2.1 Foundation Excavation and Installation. With the exception of towers at power tower facilities and the steam turbines at CSP facilities, the foundations required for permanent structures at solar facilities (e.g., control and administrative buildings and storage tanks) would require only slab-on-grade foundations. Wind loading and the structure weight of towers, and the weight and vibration of steam turbines, dictate more robust foundations that would typically require excavations to varying depths, depending on existing subsurface conditions. Foundations for towers and turbines would also likely utilize high-strength, steel-reinforced concrete, and extend to depths as great as 35 ft (11 m), depending on subsurface conditions; the diameter of the excavations would be approximately the same as that for the tower base. Geotechnical surveys involving numerous soil borings may be needed to establish foundation specifications. Depending on prevailing subsurface conditions, foundation excavations may also require drilling or blasting. Excavated materials would likely be stockpiled on site and re-applied in disturbed areas.

Most components of the solar field, such as parabolic troughs or PV panels, would require only minimal foundations, with many simply having preformed concrete feet resting on the ground surface. Dish engines are expected to rest on pile-driven foundations. Electrical transformers would require concrete pads.[9]

The concrete for foundations could be trucked to the site, or a temporary concrete batching plant could be constructed. Constituents of the concrete (aggregate, sand, cement, and water) would need to be hauled to the batching plant. Electrical power for the batching plant would likely be provided by a portable diesel engine/generator set (nominally, from 125- to 1,250-kW capacity). The land area required for a typical batching plant and associated material storage areas can be expected to be on the order of 10 acres (0.04 km^2) or less. Surface

[9] All but the largest of electrical equipment is expected to arrive on-site sealed and in a fully operational state. Larger transformers and equipment may need to be filled with dielectric fluid after placement on their pads.

vegetation would need to be removed, and some re-grading of surface soils in the batching plant area might be required. Soils would be expected to be heavily compacted as a result of batching plant activities and associated truck traffic. The batching plant and any excess concrete constituents would likely be removed at the end of the concrete-placing phase.

3.2.2.2.2 Other Construction Activities. Additional construction activities would include the construction of the control/electrical building, power block–related structures (including cooling towers, water treatment facilities, and evaporation ponds), placement of tanks, installation of electric substations, and trenching for power and signal cables. Conventional construction methods are expected to be sufficient for these activities.

Construction of the control building would involve either conventional construction techniques or the placement of a prefabricated building on a slab-on-grade concrete foundation. An additional storage building for parts and equipment might also be constructed. Some limited amount of maintenance or repair for solar array components might also be provided for, in conjunction with parts and equipment storage. Ambient conditions within the control building would need to be maintained to meet equipment operating requirements and/or to support the presence of facility personnel.

Power-conducting cables and signal cables would interconnect the power block or solar field (for dish engine and PV facilities) with the control building and the electrical substation. Where the soil mantle permits, the preferred method would involve burial of these cables to a nominal depth of 4 ft (1.2 m).[10] Standard trenching techniques are expected to be sufficient. However, on rocky sites where trenching is not possible or is too difficult, it may be necessary for the cables to be suspended in overhead cable trays.

No major maintenance is expected to be performed on-site on construction equipment; however, fluid levels would be maintained on-site for vehicles and equipment that are not roadworthy. Fuel for construction vehicles and equipment would be stored in portable aboveground tanks throughout the construction period. Lubricants to support equipment would likely be stored in portable containers inside the power block building or storage building.

During the construction phase, potable water and sanitary facilities would need to be established to support the construction crews. Potable water probably would be provided from off-site sources. Sanitary facilities would most likely be provided through portable latrines.

Throughout the construction phase, fugitive dust may have a significant impact on various resources (e.g., vegetation, wildlife, air quality, surface water, and visual resources). Fugitive dust may result from the disturbance of ground surfaces, removal of vegetative cover, vehicle traffic, and material handling (e.g., materials handled in an on-site concrete batching plant). Such impacts are typically mitigated by keeping disturbed surface areas to an absolute minimum and by the regular application of water or other approved dust palliatives to access

[10] Burying the cables can greatly reduce maintenance demands, reduce vandalism, eliminate obstructions for bird strikes, improve site safety, and virtually eliminate weather-related downtime.

roads and on-site roads and other disturbed areas throughout the construction phase. The water could be purchased from a nearby municipality and trucked daily to the site. Where no such sources are readily available, it is possible that water may be obtained from nearby surface water features or on-site wells. Surface drainage diverted to on-site impoundments and water excavated from deep foundations that intercept saturated subsurface zones are also potential sources of water for dust control. Precisely coordinated construction schedules, prompt installation of on-site roads, posted and enforced maximum on-site speed limits, and limitations on certain activities during windy periods could also be employed to mitigate the effects of fugitive dust from surface-disturbed areas. However, depending on the meteorological conditions at a site, fugitive dust generation during construction may be difficult to control because of the large areas to be cleared for solar fields.

Temporary construction facilities would be removed when no longer required, and the areas reclaimed. The footprints of solar energy development projects (solar field, power block if present, control buildings, transformer pads, electric substations, roads, and other ancillary structures) would encompass a large percentage of the sites, unless some areas are purposefully avoided or reserved as buffer areas. Proposals received to date indicate that the entire project area, including solar fields, would be fenced. In particular, electrical substations, power blocks, and control buildings would require fencing for security and safety. Various fence designs can be expected. High-hazard areas such as electrical substations may be enclosed with 8-ft (2-m) chain-link fence topped with barbed wire or razor wire to control unauthorized entry. Perimeter fencing may be low-maintenance barbed wire fencing or chain-link fencing, with some applications including fabric inserts. Some developers may install animal passages in their facility's perimeter fence to allow small animals that are not likely to cause damage to facility components to pass through. Temporary fences or barricades may need to be erected during some periods of the construction phase in accordance with applicable Occupational Safety and Health Administration (OSHA) regulations in Title 29, Part 1910.26 of the *Code of Federal Regulations* (29 CFR 1910.26) or as a result of the application of "safe work" practices in order to prevent unauthorized entry of individuals or animals into hazardous active construction zones and to provide for the safety of the construction workforce during periods when open excavations are present.

3.2.3 Operations

Operation of solar facilities would require varying numbers of on-site personnel, depending on the technology and the capacity of the facility. For example, some smaller PV facilities might require only one individual on-site daily to monitor controls and inspect equipment, or they could even be monitored remotely with no staff present on a daily basis. Larger facilities, particularly those with power block facilities utilizing steam cycles, would require an operations workforce on the order of 100 individuals (BrightSource Energy, Inc. 2007; SES Solar Two, LLC 2008). All facilities would require facility control staff to monitor solar array, power block, and substation operations. For "solar-only" facilities, such monitoring may be required only during daylight hours. For facilities with thermal storage or hybrid facilities that also involve a conventional fossil fuel–powered generation source, monitoring would need to occur whenever power is being generated.

A common maintenance requirement would be reflector/mirror washing. Some technologies require frequent washing to maintain energy conversion efficiency (e.g., parabolic trough), whereas others may require very infrequent washing (e.g., PV systems). In general, developers plan for at least annual washing. At large facilities, this would be a continuously ongoing operation. Dish engines also require periodic replacement of hydrogen that has leaked from the engine. The on-site electrolyzer that would be used for in situ production of this hydrogen, as well as high-pressure hydrogen storage tanks and distribution systems that could be used to deliver the hydrogen to the individual dish engines, would also require maintenance.

Facilities utilizing steam cycles and circulating both steam water and HTFs would have additional maintenance activities. Preventive maintenance on steam turbines, pumps, and compressors would result in the generation of spent lubricating fluids that would be expected to be stored on-site temporarily before transport to off-site treatment or disposal facilities. HTFs are not expected to require wholesale replacement during the facility's expected life; however, spills and leaks, or the repair and refurbishment of certain segments of the solar field may result in waste HTFs, all of which would be expected to be temporarily containerized and eventually sent to off-site treatment and disposal facilities. Spent lubricating oils and cleaning agents would be generated as a result of routine maintenance of the industrial plant. Spent lubricating oils, battery electrolytes, and coolants can also be expected to be generated from the preventive maintenance of emergency and backup power systems. Steam cycles would require continuous attention, including regular treatment of steam water to control total dissolved solids and prevent scale formation in the heat exchangers and other steam system components. Similar treatment of cooling water in recirculating closed-loop cooling systems would also be required, including the introduction of biocides to prevent algae formation in wet recirculating closed-loop cooling systems. Blowdown waters from the steam cycle and the cooling system may be disposed of on-site or containerized for eventual transport to off-site treatment or disposal facilities.

As with HTFs, dielectric fluids in electrical devices are expected to last the entire projected operating life of the facility. However, malfunctions, especially arcing in some devices, may necessitate drainage and replacement of dielectric materials.

3.2.4 Decommissioning/Reclamation

Decommissioning is expected to proceed in accordance with a pre-approved plan that would include removal of most if not all equipment, removal of permanent structures and improvements (including on-site and access roads), proper closure of all on-site wells, removal of all hazardous materials and wastes and closure of related storage areas according to applicable requirements (including a separate closure plan for hazardous waste storage areas), remediation of all spills or leaks of chemicals that may occur during emptying or dismantlement of components (e.g. removal of HTF from a parabolic trough solar field), closure of all off-site material storage areas, and return of the site to its native state to the greatest extent possible, including re-establishment of the native vegetative communities. All components of solar fields would be dismantled and recycled, sold for scrap, or disposed of off-site as solid waste after removal of fluids and hazardous constituents. During the facility decommissioning phase, Resource Conservation and Recovery Act of 1976 (RCRA) permits may be required to allow for on-site treatment to perform such tasks. PV panels are expected to be removed from the solar array and sent to special recycling facilities without further disassembly at the site. Inadvertent breakage of some PV panels during dismantlement may require remediation of hazardous constituents released to the environment. Electrical power management and conditioning equipment, including backup batteries, would be recycled or disposed of (in some cases as hazardous waste because of the heavy metals present). Transformers and electrical control devices would either be reused in other applications or sold as scrap after fluid removal. Belowground cable runs are expected to be left in place, provided their presence would not intrude on agreed-upon site revegetation plans.

The access road, on-site roads, rock or gravel in the electrical substations, transformer pads, and building foundations would be removed and recycled if no longer needed. Concrete slab foundations would be broken up. Broken concrete could be used by highway departments for road base or bank stabilization. Disturbed land areas covered in rock or gravel or building/tower footprints would be adjusted for their degrees of soil compaction, restored to original grade to the greatest extent possible, and reseeded or replanted with indigenous vegetation.

Dismantlement of electrical substations and storage buildings would be accompanied by inspection for and documentation of the presence of industrial contamination in the soil or surface water (if applicable) from minor spills or leaks, and decontamination as necessary. Soil testing and surface water testing should be conducted after decommissioning any site.

3.2.5 Transmission Lines

Construction and operation of transmission lines to tie solar energy facilities into the main power grid would be required for most new solar energy facilities. The length of transmission line required would depend on the distance from the site to existing lines having sufficient uncommitted capacity to accept power from the facility. An analysis of the distance from all eligible solar facility locations in the six-state study area to the existing transmission grid or to federally or locally designated transmission corridors showed that few locations are greater than 25 mi (40 km) from these existing lines or corridors[11] (see Appendix G). If transmission line construction is required to support solar facility development, the ROW width would likely be less than 250 ft (76 m), including additional width needed for construction (see Appendix F, Section F.4.2.1 for discussion of transmission ROW widths), which

[11] Subtitle F of the Energy Policy Act of 2005 required various federal agencies, led by the DOE and the BLM, to designate corridors for energy transmission in the 11 western states, including the six-state study area of this PEIS. Local BLM offices have also designated corridors under separate authorities. Both federally and locally designated corridors are addressed in the *Programmatic Environmental Impact Statement, Designation of Energy Corridors on Federal Land in the 11 Western States (Corridor PEIS)* (DOE and DOI 2008). The Corridor PEIS, as well as various state and regional initiatives, such as California's Renewable Energy Transmission Initiative (RETI) (see http://www.energy.ca.gov/reti/index.html and Appendix D of this PEIS), should help to facilitate solar development by creating corridors through which power from remotely located solar facilities can be efficiently delivered to customers with minimum adverse impacts.

corresponds to a disturbed area of about 30 acres (0.12 km^2) per mile of transmission line constructed.

The transmission analysis for this PEIS did not evaluate the available capacity on existing lines (i.e., the analysis assumed lines could be upgraded if needed).[12] Upgrading of existing lines would result in variable additional land disturbance, depending on the extent of upgrades needed. Upgrading existing lines would be advantageous to transmission operators because there would be no need to obtain new ROWs on federal, state, or private lands. Analysis of the impacts of transmission line construction and line upgrades is provided in Chapter 5. For the solar energy zone (SEZ)-specific PEIS analyses (Chapters 8 through 13), transmission construction land disturbance was analyzed for the distance from SEZs to existing transmission lines; if additional construction or line upgrades are necessary for specific solar projects within SEZs, developers will need to analyze those environmental impacts.

The voltage of transmission lines that would be built to connect solar facilities to the existing transmission grid is not known; however, transmission line ratings in the range of 230 to 500 kV would likely be used for interconnections from larger solar facilities or larger SEZs (500 kV is a predominant high voltage for transmission lines in the western states). Regardless of the voltage of the connecting transmission lines, the solar facility operator would be required to condition the electricity being produced by the facility with respect to voltage and phase so that it would be compatible with the conditions on that portion of the grid to which the facility is connected, and as directed by the transmission system operator. As stated previously, for SEZ-specific analyses, it was assumed that transmission line construction to connect to the nearest existing transmission line would be required and that a substation would be constructed at the point of interconnection of solar facility power.

Transmission line construction times are very much dependent on such factors as accessibility to the ROW, the need to build roads over difficult terrain, or the need to significantly amend topography for staging erection cranes and cable-pulling equipment.[13] For simple projects requiring minimal access road construction and ROW amendments (i.e., vegetation clearing and grade amendments would be the main activities), construction of 5 mi (8 km) of transmission line would likely require a minimum of 6 months, assuming the availability of multiple crews. Actual construction time could exceed 1 year for more constrained projects on steeply sloped lands.

A good description of the activities required for construction, operation, and decommissioning of transmission lines can be found in Appendix G of the West-Wide Energy

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[12] Site-specific upgrades and modifications to existing lines and substations to increase current carrying capacities (additional circuits, voltage upgrades, or both) or to otherwise accommodate power from solar facilities are not assessed in this PEIS because the locations and magnitude of such upgrades are unknown, the upgrades would not be controlled by solar facility developers, and the upgrades may not be solely connected to solar facilities. However, the potential impacts of line upgrades are discussed in Chapter 5.

[13] Given the terrain in the anticipated locations for solar facilities, it would likely be unusual that construction of a 25-mi (40-km) or less interconnecting line would encounter difficult terrain, and instances of significant grade amendments are expected to be rare.

Corridor PEIS (DOE and DOI 2008); this material is summarized in Appendix F (Section F.4) of this PEIS. The general sequence of activities for placing electricity transmission lines would involve surveying, site clearing, construction of access roads, drilling or excavation for support structures and concrete footings, and backfilling. Tower structures would be carried to the site by truck in sections, assembled in laydown areas, and lifted into place with a crane. Depending on environmental and/or logistical factors (e.g., rugged, mountainous terrain), helicopters could be used for tower transport and erection, which would significantly reduce the construction period. Towers would require from one to four or more concrete foundations, depending on the type of tower and the subsurface conditions.[14] Once towers were in place, truck-mounted cable-pulling equipment would be used to string the conductors onto the support structures. Although substantively more expensive, conductors can also be installed with helicopters, a technique especially suited to rugged or steeply sloped terrain.

Construction of transmission lines would also require the establishment of tower assembly areas, laydown areas, and temporary roads. These areas would be reclaimed at the end of the construction period.

During the operation of transmission lines, inspection and maintenance of the cables and towers would be required. Inspections may be accomplished by personnel walking or driving the ROW and/or by aircraft. In addition, to prevent ground faulting, vegetation management using a combination of herbicides and physical clearing could be required along the ROW; however, in the semiarid environments in which solar facilities and their transmission grid interconnections would be located, tall vegetation that would threaten the operability of the transmission line is not likely to exist, so neither herbicides nor physical clearing would likely be necessary.

Decommissioning of transmission lines and substations would include removal of all equipment and permanent structures, remediation of all spills or leaks of chemicals, and return of the ROW to its native state to the greatest extent possible, including re-establishment of native vegetative communities. Metal and wooden tower components and conductors could be reclaimed for similar use, or recycled if appropriate recycling facilities could be identified.

3.3 LAWS AND EXECUTIVE ORDERS POTENTIALLY APPLICABLE TO SOLAR ENERGY AND TRANSMISSION LINE PROJECTS

This section discusses in very general terms the existing major laws, Executive Orders (E.O.s), and policies that may impose environmental protection and compliance requirements on the siting, construction, operation, and decommissioning phases of utility-scale solar energy and transmission line projects. Because solar energy and transmission line projects may vary on the basis of design, size, specific activities, and location, the requirements described here may not apply to all projects. Lists of specific E.O.s, federal and state laws, and county ordinances that may be applicable are provided in Appendix H.

[14] Concrete footings would not be required in all instances; some towers can be directly buried when subsurface soil conditions are acceptable.

With respect to solar energy projects located on BLM-administered lands, the BLM conducts its operations in accordance with the Federal Land Policy and Management Act (FLPMA) and numerous statutes, regulations, and standards related to environmental protection, hazardous materials transportation, ecological resource requirements, and cultural and paleontological resource requirements. The BLM also conducts its operations in compliance with other applicable land use laws, including the Wild and Scenic Rivers Act of 1968, the National Trails System Act of 1968, the Wilderness Act of 1964, and the National Park Service Organic Act of 1916.

In addition to these federal laws, state laws and county ordinances may also be applicable to solar energy and transmission line projects. States may have simply adopted federal laws as their own or they may have modified them somewhat. States and counties may also have developed laws or ordinances to address concerns specific to their locations and resources.

The potentially applicable laws have been divided into general categories, as described below. Although several of the following descriptions only cite federal laws, state laws and county ordinances also fall into these categories. Appendix H provides a list of federal and state laws, E.O.s, and county ordinances in the following categories:

- *Air quality*—Air emissions from a solar energy and transmission line development project are subject to the requirements of the Clean Air Act of 1990 (CAA), as amended (typically, air emissions of most concern for solar facilities would be particulate matter emissions, of most concern during construction but also of potential concern during operations; see Section 5.11). The CAA provides that each state must develop and submit for approval to the U.S. Environmental Protection Agency (EPA) a State Implementation Plan (SIP) for controlling air pollution and air quality in that state, and that each state must develop its own regulations to monitor, permit, and control air emissions within its boundaries. The CAA also requires that federal actions conform to the appropriate SIPs. Under Section 112(r) of the CAA, owners and operators of facilities that produce, process, handle, or store specific hazardous substances above threshold quantities must meet certain requirements for planning and reporting and risk-management planning requirements. Depending upon their annual greenhouse gas (GHG) emissions, stationary sources may be required to obtain CAA permits. Solar energy facilities would not exceed the threshold limits for such permits.

- *Cultural resources*—Cultural resources that may be affected by federal undertakings such as issuing ROWs are subject to various requirements under Section 106 of the National Historic Preservation Act, as amended for identification and consideration, in consultation with Tribal, state, and/or federal entities. Mitigation actions may be required.

- *Ecological resources*—Development located on BLM-administered or other federal land must be conducted in accordance with requirements for the protection and improvement of habitat for all federally listed species, BLM-designated sensitive species (i.e., the list published by the BLM state office of species occurring on public lands whose populations or habitats are rare or in significant decline), state-listed species, and wild horse and burro herds. The Endangered Species Act, Migratory Bird Treaty Act, and Bald and Golden Eagle Protection Act are among the nation's ecological resource protection laws.

- *Energy projects*—Siting, constructing, operating, and decommissioning solar energy and transmission line projects may require approvals from energy and environmental permitting authorities.

- *Floodplains and wetlands*—If solar energy and transmission line project facilities are located in or adjacent to wetland areas or other water bodies, they would be subject to all applicable statutory requirements, such as Section 404 of the Clean Water Act of 1997 (CWA), and associated regulations.

- *Groundwater, drinking water, surface water, and water rights*—The provision of drinking water from wells or surface water to a transient non-community water system at project facilities would require compliance with the Safe Drinking Water Act of 1972 (SDWA). Alterations of jurisdictional waters of the United States and discharges of stormwater and wastewater require compliance with the CWA. In addition, the withdrawal and use of groundwater for industrial, including power plant cooling, or drinking water purposes may require approvals or permits.

- *Hazardous materials and toxic substances*—Hazardous materials or toxic substances may be used in the construction and operation of a project. Storage and use of fuels, petroleum, oils, lubricants, and other hazardous materials or toxic substances at project facilities during construction, operation, and decommissioning phases are subject to numerous federal and state regulations.

- *Hazardous waste*—Hazardous wastes generated during the construction, operation, and decommissioning of solar energy and transmission line projects (e.g., used solvents and paints) must be accumulated, collected, transported, and disposed of in accordance with the RCRA and other applicable hazardous waste laws.

- *Land use*—Depending on the location of solar energy projects and transmission lines, special land use determinations may need to be made, particularly if projects or transmission lines are sited in or affecting environmentally sensitive or protected areas.

- *Noise*—The EPA issued guidelines for outdoor noise levels that are consistent with the protection of human health and welfare against hearing loss, annoyance, and activity interference. The guidelines state that annoyance and undue interference with activity will not occur if outdoor levels of noise are maintained below an energy equivalent of 55 decibels (dB). However, these levels are not legally enforceable standards.

- *Paleontological resources*—Fossils of scientific value could be affected through project construction, operation, and decommissioning. The FLPMA prohibits the collection of significant vertebrate and invertebrate fossils without a valid permit. Fossils on federal land are managed and protected pursuant to the Paleontological Resources Preservation Act of 2009, which allows for prosecution of theft and damage of federal paleontological resources.

- *Pesticides and noxious weeds*—Pesticide and insecticide application during project construction and operation must comply with the Federal Insecticide, Fungicide, and Rodenticide Act of 1974 and equivalent state requirements or bans. In addition, sites would be subject to federal provisions to control noxious weeds and invasive species and may be subject to regulations governing state-established control areas.

- *Solid waste*—Solid wastes generated during the construction, operation, and decommissioning of solar energy and transmission line projects must be managed in accordance with the Solid Waste Disposal Act of 1976 and all state and local requirements for solid waste accumulation, collection, transportation, and disposal.

- *Source water protection*—Under Part C of the SDWA, Protection of Underground Sources of Drinking Water, each state is to establish a wellhead protection program to delineate wellhead protection areas, identify potential sources of contamination, and establish control measures to prevent contamination of drinking water sources. If hazardous chemicals or materials are used during the construction or operation of a project that is located within a wellhead protection area, reporting or control measures may apply.

- *Water bodies and wastewater*—The discharge of wastewater (e.g., sanitary wastewater treatment systems or rinse/test waters) from the construction or operation of a project into waters of the United States or waters of a state will require a National Pollutant Discharge Elimination System (NPDES) permit or the state equivalent. According to administrative and judicial interpretation, the scope of the federal CWA jurisdiction over waters of the United States depends on technical, site-specific factors. Regulated bodies of water could include, but are not limited to, interstate and intrastate lakes, rivers, and streams, and certain wetlands, playa lakes, prairie potholes, mudflats, intermittent streams, and wet meadows. In addition, the CWA requires an NPDES permit or the state equivalent for certain stormwater discharges. Spill prevention, control, and countermeasure plans may also be required to prevent oil spills from reaching regulated waters, adjoining shorelines, intermittent streams, or wet meadows, but only if they are hydrologically connected to the navigable waters of the United States. States may have their own planning requirements for other waters. Discharges of dredged or fill material into waters of the United States or any work in, over, or under regulated waters would require a Section 404 or Section 10 permit, respectively, from the U.S. Army Corps of Engineers.

In addition to these categories, the construction and operation of a solar energy and transmission line project on public land that has valid mining claims must not materially interfere with the claimants' rights to mine, remove, or sell the minerals from the claim (*United States Code*, Title 30, Chapter 2 [30 USC Chapter 2]). Solar energy projects and their associated transmission projects may also be subject to the health and safety standards of OSHA. The Federal Aviation Act may also apply.

Requirements to consider the impacts of issuing ROWs on local populations, pursuant to E.O. 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (*Federal Register*, Volume 59, page 76297, Feb. 11, 1994), and E.O. 13045, "Protection of Children from Environmental Health Risks and Safety Risks" (*Federal Register*, Volume 62, page 19885, April 23, 1997) may arise, depending on the activities, locations, and other circumstances of the project.

3.4 TRANSPORTATION CONSIDERATIONS

Solar energy development would require a variety of transportation operations over the lifetime of a project. The majority of transportation operations would involve movement of workers, material, and equipment to the site during the construction phase. The types and amounts of material and equipment required for construction of the solar energy development project would depend on site characteristics as well as the design selected. During solar plant operations, worker commutes and deliveries of supplies would be supported. Decommissioning activities would be expected to result in activities similar to construction. The following discussion provides a general overview of the expected transportation requirements during construction, operations, and decommissioning.

3.4.1 Construction

Construction activities are expected to occur over a period of 1 or more years depending on the size of a solar energy project, with anticipated daily workforces possibly reaching 1,000. The number of workers required during different phases of development would vary, but increased commuter traffic in the vicinity of the project may require road improvements or other measures to alleviate congestion or traffic hazards. Depending on the relative locations of the worker population and the site, the use of carpools and shuttle buses may be options for reducing the number of vehicles entering or departing the site during the morning and evening rush hours.

As stated in Section 3.2.2.1, the heavy equipment and materials needed for site access, site preparation, and solar array foundation construction are typical of road construction projects and do not pose unique transportation considerations. Road improvements could be required if local roads necessary for site access were not designed for gross vehicle weights of up to 80,000 lb (36,000 kg). State-specific and local limits may also apply. The types of heavy equipment required would include bulldozers, graders, excavators, front-end loaders, compactors, and dump trucks. Typically, the equipment would be moved to the site by flatbed combination truck and would remain on-site through the duration of construction activities. Typical construction materials hauled to the site would include gravel, sand, and water, which are generally available locally. Ready-mix concrete might also be transported to the site, if available. Concrete batch plants may also be set up on-site. Peak truck deliveries of materials and supplies, including solar array components, might be expected to be on the order of 50 trucks per day. Construction wastes (such as excess concrete) would be shipped from the solar energy facility.

Once the foundations are in place, construction of the different types of solar projects would be similar with respect to transportation needs. Solar collectors would be assembled on-site, and materials would be delivered to the project location by regular truck shipments without the need for oversize or overweight permits. The total number of shipments over the course of the construction period would be dependent on the type of solar technology and the size of the facility. Oversize exceptions would include the delivery of STGs and main transformers. Such equipment is typically shipped by rail to the nearest intermodal facility where transfer to specially designed tractor trailers would occur for transport to the project location. These latter shipments may require times of more than 1 day, escorts, temporary road closings, and transport during off-peak hours, but they would be one-time events.

3.4.2 Operations

Transportation activities during solar energy production would involve commuting workers, material shipments to and from the facility, and on-site work and travel. Larger facilities, particularly those with power block facilities, would require an operations workforce on the order of 100 individuals. Generally, a few daily truck shipments to or from a site would be expected. With facility sizes on the order of thousands of acres (tens of kilometers), on-site operations would include travel to various locations for repairs and maintenance, including dust suppression and cleaning operations. If on-site water is not available for these latter operations, shipments of water to the facility location would be required. Deliveries of materials during operations could also include hazardous materials such as fuels or ammonia. Shipments from facilities would include wastes for disposal.

3.4.3 Decommissioning/Reclamation

With some exceptions, transportation activities during site decommissioning would be similar to those during site development and construction. Heavy equipment and cranes would be required for dismantling solar arrays, breaking up array foundations, and re-grading and re-contouring the site to the original grade. Oversized and/or overweight shipments are not expected during decommissioning activities because the major steam turbine components can be disassembled, segmented, or size-reduced prior to shipment.

3.5 HAZARDOUS MATERIALS AND WASTES ASSOCIATED WITH SOLAR ENERGY FACILITIES

The following sections discuss the types and estimate the quantities of hazardous materials and wastes associated with the construction, operation, and decommissioning of a solar energy facility. Component manufacturing or assembly facilities are not within the scope of this assessment and are not addressed (see Section 2.5.3). Similarly, facilities that support the solar facility by supplying necessary chemicals and materials to support operations, or by providing treatment and disposal of facility-related wastes, are not addressed.

3.5.1 Construction

3.5.1.1 Hazardous Materials

Except for some notable differences, construction activities among the various solar energy technologies are generally similar, as are the array of hazardous materials and wastes associated with such activities.

Hazardous materials associated with the construction of solar energy facilities would be generally similar in nature to the hazardous materials associated with construction of any major industrial facility. However, hazardous materials unique to the CSP solar energy technology selected (e.g., HTFs, TES media, and water treatment chemicals) would also be present near the completion of the construction phase as assembled components containing such hazardous materials are filled. Table 3.5-1 lists the major types of hazardous materials expected to be present on-site during the construction phase.

3.5.1.2 Construction Wastes

Wastes associated with the construction of renewable energy facilities would be similar to wastes resulting from the construction of any large industrial facility. Wastes are likely to include both hazardous and nonhazardous industrial solid wastes as well as nonhazardous domestic solid wastes and both industrial and sanitary wastewaters. Potentially hazardous industrial solid wastes might include wastes resulting from the use of listed solvents[15] and

[15] Spent solvents listed in federal regulations at 40 CFR 261.31 are, by definition, hazardous waste. EPA-authorized state hazardous waste regulatory programs adopt the federal listings by reference and may, in some cases, add additional solvents to the state's hazardous waste list.

TABLE 3.5-1 Hazardous Materials Used during Construction of Solar Energy Facilities

Material	Purpose	Remarks
Vehicle and equipment fuels, including diesel fuel, gasoline, kerosene, and propane[a]	Fuel for off-road construction vehicles and various construction equipment	• Diesel fuel and gasoline are expected to be stored in manufactured aboveground storage tanks with capacities of 2,000 gal (7,600 L) or less. • Propane stored in aboveground pressure tanks, 2,000 gal (7,600 L) or less. • Removed after completion of the construction phase.
Propane	Comfort heating of temporary buildings and trailers	• Expected to be stored in aboveground pressure tanks of 2,000 gal (7,600 L) or less. • Excess removed after completion of the construction phase.
Vehicle and equipment fluids, including lubricating oils, hydraulic fluids, brake fluids, glycol-based coolants, battery electrolyte, and dielectric fluids	Maintenance and support of construction vehicles and equipment, including compressors and emergency/ standby generators	• Expected to be present in minimal quantities only sufficient to maintain fluid levels of construction vehicles and equipment, primarily in container sizes of 55 gal (210 L) or less. • Excess removed after completion of the construction phase.
Compressed gases: oxygen, acetylene, and nitrogen	Welding, cutting, brazing, and purging	• Expected to be removed after completion of the construction phase.
Solvents, chemical cleaning agents	Cleaning of equipment after assembly, preparation of surfaces for application of paints or other corrosion control coatings	• Expected to be present in minimally necessary quantities only, primarily in container sizes of 55 gal (210 L) or less.
Paints, primers, thinners, and corrosion control coatings; sealants and adhesives	Weatherproofing equipment and superstructures; component assembly	• Expected to be used throughout the construction phase; likely to be present in container sizes of 55 gal (210 L) or less. • Components are expected to arrive on-site with final coatings applied; only field dressing after assembly will likely be necessary. • Excess hazardous materials removed after completion of the construction phase. • Some materials may exhibit hazardous characteristics (e.g., flammability) or contain toxic ingredients (e.g., chromium in certain paints and primers).

TABLE 3.5-1 (Cont.)

Material	Purpose	Remarks
Pesticides and herbicides	Vegetation and insect control	• Expected to be limited to EPA- and state-approved commercial products, present only in minimally necessary quantities. • Wholesale applications of pesticides (e.g., for vegetation control over the active construction zone) may be performed by a contractor, with no pesticides stored on-site.
Technology-specific hazardous materials	HTF, TES, water treatment chemicals, etc.	• See the discussion in Section 5.20 and Table 3.5-2 for more details.

[a] Depending on the site, fueling of construction vehicles and equipment may be accomplished directly from a vendor's fuel delivery truck, thus eliminating the need for on-site storage of some fuels.

corrosion control coatings, spent vehicle and equipment fluids and components (e.g., used oil,[16] used hydraulic fluids, spent filters, oily rags and wipes, and spent lead acid or nickel-cadmium batteries and battery electrolyte), and hazardous materials containers that do not meet the federal or state regulatory definition of "empty." All such hazardous waste is expected to be generated in limited quantities and would likely be accumulated in portable containers of 55-gal (210-L) capacity or less on-site for brief periods before being transported by a registered transporter to off-site permitted hazardous waste treatment, storage, or disposal facilities (TSDFs). Energy recovery or recycling opportunities may also be identified for some hazardous industrial wastes.

Nonhazardous industrial solid wastes would include waste packaging and dunnage (scrap wood, steel, glass, plastic, paper, and empty metal containers) as well as excess concrete, broken equipment, or components. There may be recycling or energy recovery opportunities for some of this material, provided adequate segregation is practiced. Otherwise, disposal of all such wastes would likely be in properly permitted off-site landfills.

Nonhazardous domestic solid wastes would be generated as a result of on-site administrative activities and in support of the workforce and would primarily include such materials typically found in office waste streams, including wastepaper and food scraps.[17] All such wastes are expected to be containerized until removal by local solid waste contractors to permitted sanitary landfills or recycling centers (when such options exist).

[16] Used oil is not categorically a hazardous waste in federal regulations but may be characterized as such because of the presence of certain contaminants. Also, used oil may be categorized as hazardous waste in EPA-authorized state-level hazardous waste programs.

[17] When the facility utilizes an on-site treatment system for domestic sewage, the sludge resulting from that activity would also qualify as a nonhazardous domestic solid waste.

Industrial wastewaters resulting from equipment and component cleaning and system purging activities would be containerized and transported to properly permitted wastewater treatment or disposal facilities. Plumbing and system components that would contain fluids are also expected to undergo one-time hydrostatic testing for system integrity once assembly is completed. The wastewaters from such tests may contain small amounts of contaminants from system assembly, and some may also exhibit hazardous characteristics.[18] Other wastewaters may include stormwater contaminated with sediment, which would be managed in accordance with a stormwater pollution prevention permit, and excavation dewatering waste streams that may be allowed to be discharged to surface drainage in the absence of contamination or allowed to evaporate in lined on-site impoundments. Water from dewatering operations may also be used for control of fugitive dust on unpaved access and on-site roads.[19] If on-site wells were installed to supply water for industrial processes, some small amounts of well development fluids and borehole cuttings would be produced. Drilling muds are likely to be captured in temporary lined impoundments near the drilling site and ultimately recovered for re-use.[20] Drill cuttings would likely be disposed of on the surface in areas adjacent to the wells (provided no prior contamination was encountered). Small amounts of wastewater from equipment washing associated with concrete production are likely to be produced if an on-site concrete batching plant is used. Such wastewaters would typically be discharged to the ground surface. Sanitary wastewaters resulting from workforce support may either be containerized in portable facilities before being removed to off-site sewage treatment facilities or disposed of on-site in septic systems under the auspices of appropriate permits when local soil and subsurface conditions allow.

3.5.2 Operations

3.5.2.1 Hazardous Materials

The amounts and variety of hazardous materials present on-site would depend on numerous factors, including the operational demands of the solar energy technology employed, the size and power-producing capacity of the facility, and the remoteness of the facility's location from commercial suppliers. Reasonable estimates of hazardous materials volumes are provided in the following discussions; however, those volumes can vary greatly on the basis of the aforementioned factors.

Hazardous materials required for routine maintenance of components and support equipment would be generally the same for both CSP (i.e., parabolic trough, power tower, and

[18] Similar hydrostatic testing wastes may also be generated periodically during the operation phase before fluid-containing systems that have been disassembled for repair or replacement are put back into service.

[19] Except in the case of a solar power tower, excavations for foundations, footings, and cable trenches are expected to be relatively shallow and not likely to intercept groundwater; in most instances, dewatering of excavations would be unnecessary.

[20] If closed-loop drilling systems were used, surface impoundments would not be necessary.

dish engine facilities) and PV facilities. All facilities that use water for washing reflecting surfaces or PV panels would need to use demineralized water which, in most cases, would require some on-site water treatment capability, probably involving ion-exchange resins or reverse osmosis. CSP technologies utilizing a steam cycle can be expected to have more extensive on-site water treatment capabilities for both the steam cycle and the cooling system (if a wet recirculating or hybrid wet-dry system is used), which would result in large quantities of hazardous chemicals stored on-site. Cooling system and steam cycle blowdown water is expected to be discharged to lined surface impoundments. It may be necessary to remove salts accumulating in these impoundments during the period of facility operations. At the end of facility operation, water and any precipitated salts would be removed, containerized, and delivered to appropriate off-site treatment or disposal facilities and the surface impoundment closed. Wastewaters and salts from blowdown impoundments are not expected to exhibit any hazardous character, but must nevertheless be appropriately managed to avoid adverse environmental impacts. All technologies can also be expected to have large amounts of dielectric fluids (mineral oils and/or sulfur hexafluoride gas) contained in electrical equipment in the PCS and management systems. In general, larger quantities and a greater variety of hazardous materials are required to support the operation of parabolic trough and power tower CSP facilities than are needed for any type of PV technologies. Hazardous materials needed for solar dish facilities are unique from all other solar technologies, due to the unique operational requirements of the Stirling engine. Parabolic trough and power tower CSP facilities would have large volumes of HTFs and TES materials present in addition to the lubricants and chemicals needed to maintain STGs, combustion turbine generators (CTGs) (when present), and steam and cooling water cycles. Tables 3.5-2 and 3.5-3 display the major hazardous materials present in CSP facilities and PV facilities, respectively.[21, 22]

3.5.2.2 Operations Wastes

3.5.2.2.1 CSP Facilities. Solid wastes generated during operation of CSP facilities would include both nonhazardous and potentially hazardous industrial wastes and nonhazardous domestic wastes. Industrial wastes might include metal scraps, machine parts, defective or broken electrical equipment, and other miscellaneous components that have been taken out of service. Industrial wastes would also include wastes resulting from general facility maintenance and repair, such as spent cleaning agents, paints, corrosion control coatings, oily rags, spent solvent wipes, and spent fluids and components from the preventive maintenance or repair of

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21 Very hazardous materials (toxic heavy metals) are contained in the semiconductor materials of some solar cells. However, although their presence is acknowledged, hazardous semiconductor materials arrive at the facility contained in fully fabricated, sealed solar cells that present no potential for hazardous materials release to the environment or exposure to the workforce or the public, unless the integrity of the cell is compromised. Even in such events, the amounts of hazardous materials present in individual solar cells would be very limited. Consequently, hazardous semiconductor materials are not explicitly listed or discussed here.

22 Depending on the nature, volume, and frequency of the operational wastes being generated at a solar facility and the management strategy for that waste, federal RCRA or state hazardous waste regulations would apply to the storage, treatment, shipment, and/or disposal of those wastes.

TABLE 3.5-2 Hazardous Materials Associated with the Operation of CSP Facilities

Material	Purpose	Remarks[a]
Therminol or Dowtherm	HTF	• Synthetic oil typically composed of a mixture of biphenyl and diphenyl oxide. • Depending on the size of the solar array and its location relative to the steam heat exchanger, volumes of HTF may be in excess of 1.3 million gal (4.9 million L), depending on the size of the solar field and facility configuration. (HTF systems are not expected to include a reservoir and are not expected to be supported by external, separate on-site storage of HTF.)
Molten salt TES medium	TES (for facilities so equipped), HTF	• Most typically, a mixture of sodium nitrate and potassium nitrate. • Depending on the design basis for hours of TES capacity, amounts present could be substantial.
Operating fluids for ICEs and miscellaneous equipment: lubricating oil, transmission oil, hydraulic fluid, and glycol-based coolant	Preventive maintenance of diesel engine(s) on emergency generator(s) and other equipment using ICEs	• Amounts on-site only sufficient to maintain fluid levels and perform preventive maintenance. • Expected volumes on hand to support maintenance may range from 500 to 2,000 gal (1,900 to 7,600 L), depending on system and component designs and recommended maintenance intervals.
Fluids in STGs, CTGs, compressors, pumps, and other support equipment: lubricating oils, glycol coolants, compressor oils, hydraulic fluids, and hydrogen	Internal component lubrication, heat rejection, cooling, replacement of working fluid lost through leaks	• Most fluids replaced periodically in preventive maintenance. • Some power generators may be cooled by hydrogen (in a closed-loop system). • For Stirling dish facilities, a central facility would produce hydrogen by electrolysis for distribution to each solar dish engine to replace hydrogen working fluid that escapes from the external heat engines through leaks.[b] • Stirling dish engines are also supported by a closed-loop glycol coolant system. • The volume of lubricating oil to support each turbine/generator can exceed 10,000 gal (38,000 L).[c]
Hydrogen gas	On-site generation by electrolysis in a central location and distributed to each dish engine	• Required to replace hydrogen working fluid lost to leakage in Stirling dish engines.[b]

TABLE 3.5-2 (Cont.)

Material	Purpose	Remarks[a]
Compressed gases	Instrument and equipment purge, calibration gases; equipment repair (welding, brazing, and soldering), comfort heating, fire control, and cooling/refrigeration	• Nitrogen, air, oxygen, and argon for instrument purge and calibration. • Acetylene, MAPP gas[d] for welding, heating, cutting, brazing, soldering, etc. • Propane for comfort heating. • CO_2 for portable and installed fire extinguishers. • EPA-approved non-ozone-depleting compound refrigerants are expected to be used in building heating, ventilation, and air-conditioning (HVAC) systems.
Vehicle and equipment fuels and fluids: diesel, gasoline, kerosene, propane,[e] natural gas, lubricating oil, hydraulic fluid, and glycol-based coolants	Fuel for emergency generators, emergency fire-water pumps, air compressors, and other equipment containing ICEs, and on-site vehicles	• Fuel is likely to be stored in and dispensed from aboveground tanks with capacities in the range of 500 to 2,000 gal (1,900 to 7,600 L). • Natural gas would be obtained through pipelines. • Lubricating oil in equipment may total >10,000 gal (>38,000 L) with as much as an additional 5 to 10% in on-site storage in 55-gal (210-L) drums.[f]
Battery electrolyte	Backup power source for DC loads and maintenance of vehicle and equipment batteries	• Majority contained in lead-acid batteries in vehicles and equipment. • Only sufficient quantities of electrolyte will be on hand to maintain fluid levels in lead acid storage batteries.
Steam cycle and cooling system water treatment chemicals, including surfactants, concentrated mineral acids and bases for pH control, and ion-exchange resins; brines that are a by-product of the water purification process	Maintain chemical quality of water in steam cycle and wet open-loop cooling system; control scale and biological organisms in recirculating cooling water	• Types and amounts of chemicals needed would depend on the quality of the raw water introduced into the cooling system and the rate of loss due to evaporation and drift. • Chemicals most typically used include sodium hydroxide (>8,500 gal [>32,000 L]; 50% solution), sodium hypochloride (>16,000 gal [>61,000 L]; 10 to 20% solution), cyclohexylamine, monoethanolamine, methoxypropylamine, phosphoric acid (30% to 100% solution), sodium bromide, and sulfuric acid (>17,000 gal [>64,000 L]; 93% solution). • Other chemicals might include ammonium hydroxide, calcium oxide, ferric sulfate, magnesium chloride, organic phosphate inhibitor, and trisodium phosphate.[g] • Brines may be treated on-site, sent to on-site lined evaporation ponds for volume reduction, or containerized and transported to off-site treatment facilities.

TABLE 3.5-2 (Cont.)

Material	Purpose	Remarks[a]
Miscellaneous cleaning agents and solvents,[h] HVAC refrigerants (chlorofluorocarbons)	Equipment cleaning and maintenance, scale control on heat exchangers and cooling systems, building maintenance	• Typical janitorial supplies; minimal quantities would be present on-site. • Work may be performed periodically by an outside contractor, with no cleaning agents stored on-site.
Paints, primers, thinners, and corrosion control coatings	Protection of equipment and superstructures against corrosion	• Expected to be used throughout the operations phase on an as-needed basis; likely to be present in container sizes of 55 gal (210 L) or less. • Some materials may exhibit hazardous characteristics (e.g., flammability) or contain toxic ingredients (e.g., chromium in certain paints and primers).
Pesticides and herbicides, fertilizers	Vegetation and insect control, control of biological organisms in cooling water	• Expected to be limited to EPA- and state-approved commercial products, present only in minimally necessary quantities. • Wholesale applications of pesticides (e.g., for vegetation control over the active industrial zone) or fertilizers may be performed by a contractor, with no pesticides stored on-site.
Dielectric fluids	Electrical insulating fluid for electrical devices such as transformers, switches, capacitors, and bushings	• Large transformers may contain >1,000 gal (>3,800 L) of dielectric fluid. • Dielectric fluids are expected to be free of polychlorinated biphenyls (PCBs). • Some devices may contain sulfur hexafluoride gas as a dielectric medium. • Dielectric fluids typically last the life of the electrical device but may need to be replaced if electrical arcing occurs to a significant degree inside the device due to a malfunction or failure. • Total volume of dielectric fluids in electrical equipment can range from 32,000[f] to 50,000 gal (120,000 to 190,000 L)[i] to >100,000 gal (>380,000 L),[j] depending on system configurations and facility nameplate capacity.
Laboratory reagents	Chemical quality analysis of steam water and cooling water	• Limited quantities (<1 gal [<3.8 L] in all cases) are expected be present on-site.

Footnotes on next page.

TABLE 3.5-2 (Cont.)

[a] Although the amounts listed are representative, the volumes can vary dramatically depending on system design requirements. Quantities cited are those derived from Kelly (2006) as well as from Applications for Certification submitted to the California Energy Commission (SES Solar Two, LLC 2008; Beacon Solar, LLC 2008; BrightSource Energy, Inc. 2007; Inland Energy, Inc. 2007). Volumes and types of water treatment chemicals would be dictated by the chemical quality of the raw water initially introduced into the steam cycle and cooling systems.

[b] In its initial Application for Certification submitted to the California Energy Commission, SES Solar Two, LLC, initially proposed a compressed gas cylinder of hydrogen would be located at each dish engine. However, in a supplement submitted to the California Energy Commission on June 12, 2009 (SES Solar Two, LLC 2009), modifications were proposed that now involve in-situ generation of hydrogen by electrolysis with distribution to each dish engine. The electrolyzer will have a capacity of 1,065 ft^3 (30 m^3) of hydrogen per hour and is likely to operate at off-peak times using power from the grid. The electrolyzer will also consume 184 gal (697 L) of water per day.

[c] For example, a two-stage turbine rated at 265 MW would be supported by a turbine oil system that includes a reservoir of more than 10,000 gal (38,000 L) (Kelly 2006).

[d] MAPP gas, a stabilized mixture consisting primarily of methylacetylene and propadiene with lesser amounts of propane and other low–molecular weight flammable organic gases, enjoys widespread industrial applications for heating, cutting, soldering, and brazing. MAPP gas is not suitable for welding, however. A Material Safety Data Sheet (MSDS) exists for a typical commercially available formulation (Airgas 1999).

[e] Fossil fuel external combustion devices that may be used to augment steam or power production or HTF lines during downtime (e.g., boilers or CTGs) would most likely use natural gas that would be supplied by a commercial vendor via a pipeline.

[f] See, for example, the Beacon Solar Energy Project's Application for Certification to the California Energy Commission (Beacon Solar, LLC 2008).

[g] See, for example the Application for Certification submitted to the California Energy Commission for the Victorville 2 Hybrid Power Project (Inland Energy, Inc. 2007).

[h] A wide variety of cleaning agents could be used for such activities as reflector and equipment washing. Aqueous detergent solutions are the likely choice. Their use would result in wastewaters high in dissolved and suspended solids with pH values ranging between 5.0 and 8.0, depending on the detergent selected.

[i] See, for example, the Imperial Valley Application for Certification submitted by Stirling Energy Systems to the California Energy Commission (SES Solar Two, LLC 2008).

[j] See, for example, the Ivanpah Solar Electric Generating System Application for Certification submitted by BrightSource Energy, Inc., to the California Energy Commission (BrightSource Energy, Inc. 2007).

internal combustion engines (ICEs) (e.g., used oil and filters, used hydraulic and transmission fluids, spent glycol-based coolants, spent battery electrolyte, and spent lead-acid batteries). Preventive maintenance of solar dish engines would also produce used oil and filters and spent glycol-based coolants. Industrial wastes would also result from the maintenance of STGs and CTGs, and the operation of steam and cooling water systems. Domestic solid wastes would include administrative wastes (primarily wastepaper) and wastes associated with workforce support (e.g., aluminum cans, food scraps, cardboard, glass, plastic containers, and other nonhazardous solid wastes).

TABLE 3.5-3 Hazardous Materials Associated with the Operation of PV Facilities

Material	Purpose	Remarks
Compressed gases	Instrument and equipment purge, calibration gases; equipment repair (welding, brazing, and soldering), comfort heating, fire control	• Nitrogen, air, oxygen, and argon for instrument purge and calibration. • Acetylene, MAPP gas[a] for welding, heating, cutting, brazing, soldering, etc. • Propane for comfort heating. • CO_2 for portable and installed fire extinguishers.
Vehicle and equipment fuels: diesel, gasoline, kerosene, and propane[b]	Fuel for emergency generators, emergency fire-water pumps, air compressors, and other equipment containing ICEs, and on-site vehicles	• Fuel is likely to be stored in and dispensed from aboveground tanks with capacities in the range of 500 to 2,000 gal (1,900 to 7,600 L).
Fluids required to support equipment and vehicles with ICEs: lubricating oil, transmission oil, hydraulic fluids, and glycol-based coolant	Preventive maintenance of diesel engine(s) on emergency generator(s) and other equipment using ICEs	• Amounts on-site only sufficient to maintain fluid levels and perform preventive maintenance.
Battery electrolyte	Contained in vehicle and equipment batteries and in batteries that compose the backup power source for DC loads	• Majority contained in lead-acid batteries that are in service. • Only sufficient quantities of electrolyte will be on hand to maintain fluid levels in lead acid storage batteries.
Water treatment chemicals	Demineralize water used for panel washing	• Most probably ion-exchange resins.
Miscellaneous cleaning agents and solvents	Equipment cleaning and maintenance, scale control on heat exchangers and cooling systems.	• Minimal quantities would be present on-site. • Work may be performed periodically by an outside contractor, with no cleaning agents stored on-site.
Paints, primers, thinners, and corrosion control coatings	Protection of equipment and superstructures against corrosion	• Expected to be used throughout the operations phase on an as-needed basis; likely to be present in container sizes of 55 gal (210 L) or less. • Some materials may exhibit hazardous characteristics (e.g., flammability) or contain toxic ingredients (e.g., chromium in certain paints and primers).

TABLE 3.5-3 (Cont.)

Material	Purpose	Remarks
Pesticides and herbicides, fertilizers	Vegetation and insect control	• Expected to be limited to EPA- and state-approved commercial products, present only in minimally necessary quantities. • Wholesale applications of pesticides (e.g., for vegetation control over the active industrial zone) may be performed by a contractor, with no pesticides stored on-site.
Dielectric fluids	Electrical insulating fluid for electrical devices such as transformers, switches, capacitors, and bushings	• Large transformers may contain >1,000 gal (>3,800 L) of dielectric fluid. • Depending on power conditioning equipment present and facility power production capacity, >100,000 gal (>380,000 L) of dielectric fluid may be present. • Dielectric fluids will be PCB-free. • Dielectric fluids typically last the life of the electrical device but may need to be replaced if electrical arcing occurs to a significant degree inside the device due to a malfunction or failure.[c]

[a] MAPP gas, a stabilized mixture consisting primarily of methylacetylene and propadiene with lesser amounts of propane and other low-molecular weight flammable organic gases, enjoys widespread industrial applications for heating, cutting, soldering, and brazing. MAPP gas is not suitable for welding, however. An MSDS exists for a typical commercially available formulation (Airgas 1999).

[b] Fossil fuel external combustion devices that may be used to augment steam or power production or heat HTF lines during downtime (e.g., boilers or CTGs) would most likely use natural gas that would be supplied by a commercial vendor via a pipeline.

[c] See, for example, the original Conditional Use Permit application submitted by Optisolar to the County of San Luis Obispo, California, for its Topaz Solar Farm (Topaz Solar Farms, LLC 2008) and revisions to portions of the original application (Hoffman 2008).

All industrial solid wastes would be containerized and undergo characterization before being transported to off-site properly permitted disposal or recycling facilities. Domestic solid waste would be containerized and collected by a waste hauler for delivery to permitted sanitary landfills or segregated during on-site accumulation to facilitate delivery to recycling centers when such options exist. Some industrial solid wastes, such as spent lubricating oils, spent fluorescent lightbulbs, spent corrosive cleaning agents (both strongly acidic and strongly alkaline), and spent cleaning solvents, may be federally or state-listed hazardous wastes or display hazardous characteristics, requiring them to be managed as hazardous wastes in accordance with prevailing regulations. Although critical fluids such as HTFs, TES media (e.g., molten salts), and dielectric fluids would be present in substantial quantities, they are expected to last the life of the facility or the component in which they are installed. However, repairs and replacements of system components, as well as spills and leaks, may result in the generation of some wastes consisting of these fluids.

Wastewaters would include wastes from industrial activities (spent aqueous cleaning/washing solutions, cooling system and steam cycle blowdowns, brines from water treatment, and spent glycol coolants), sanitary wastewaters from support of the workforce, and stormwater runoff from industrial areas. Industrial wastewaters such as blowdown from steam cycles and cooling systems and brines from water softening may be treated on-site, sent to on-site lined evaporation ponds for volume reduction, or containerized and transported to off-site treatment facilities. Because the workforce during operation is expected to be small, sanitary wastewaters are likely to be containerized and ultimately removed by a contractor to wastewater treatment facilities. In some instances, sanitary wastewater may be managed on-site through approved septic systems[23] or delivered to on-site packaged treatment plants. Stormwater runoff is expected to be managed in accordance with a site-wide stormwater pollution prevention permit but may require special handling if contaminated by contact with spilled chemicals.

3.5.2.2.2 PV Facilities. Some wastes associated with the operation of PV facilities would be analogous to wastes generated during CSP facility operation. However, not all CSP wastes would have PV analogs. Wastes related to the cleaning and maintenance of major PV system components and support equipment would be similar to wastes of such origins resulting from CSP facility operation. Spent solvents and aqueous cleaning solutions, spent oils, hydraulic fluids, and coolants, and wastes typical of building maintenance would all be generated, as well as domestic solid wastes from administrative activities and sanitary wastewaters associated with workforce support. However, PV facilities would not generate any wastes associated with the operation and maintenance of a steam cycle or cooling water systems. Management protocols for PV wastes are expected to be similar to those used for similar wastes generated at CSP facilities discussed previously.

Finally, routine operation of a PV facility should not result in waste solar panels. However, malfunctions or damage sustained in accidents or as a result of weather extremes may result in some panels needing to be replaced. In those instances, if the integrity of the panel is compromised, semiconductor material containing hazardous components may be released and would have to be managed as hazardous waste. The release of cadmium (Cd) and other heavy metals from broken modules (especially cadmium telluride [CdTe], copper-indium-diselenide [CIS], and copper-indium gallium selenide [CIGS]) and during fires constitutes an

[23] See, for example, the Conditional Use Permit Application for the Topaz Solar Farm, submitted to San Luis Obispo County, California (Topaz Solar Farms, LLC 2008).

area of concern (Nieuwlaar and Alsema 1997; EPRI and CEC 2003; Fthenakis and Zweible 2003).[24] Otherwise, it is anticipated that malfunctioning or damaged panels would be sent to recycling facilities where semiconductor material would be recovered, and the nonhazardous portions of the panel would be disposed of as solid waste.

3.5.3 Decommissioning Wastes

Decommissioning of a facility, whether it occurs prematurely or at the end of the facility's planned active life would be addressed in detail in an approved closure plan. Approved decommissioning is expected to include complete dismantlement of the facility and recycling of the individual equipment and components to the greatest extent practical. Equipment laydown areas established initially for facility construction may be reactivated during decommissioning to provide for interim storage of equipment and components awaiting recycling. Fluids removed from equipment would be characterized to determine appropriate disposal or evaluated for potential reuse. In either case, containerization and brief on-site storage would occur before ultimate disposition. Some pieces of equipment (e.g., large electrical equipment containing dielectric fluids), although recyclable, may need to be emptied of fluids before being moved; however, the fluids removed may be re-introduced into the equipment after evaluation for quality and contamination when that equipment is put into service at a different location. After emptying, components would be purged and cleaned with appropriate cleaning agents, and the resulting wastes characterized and disposed of in off-site facilities. Wastes associated with component cleaning and dismantlement include preventive maintenance wastes for the various construction equipment employed during decommissioning. Decommissioning wastes would also include contaminated soils and spent absorption media resulting from recovery and remediation of spills and leaks that occurred during facility operation or as a result of dismantlement activities. Such remediation wastes would be containerized and characterized for disposal in appropriately permitted off-site facilities. Road-building materials (sand gravel, clean fill) and removed concrete foundations and pads would be stockpiled for recycling, most likely for road building or fill operations elsewhere.

It is reasonable to expect that buried components would be removed to sufficient depths to facilitate revegetation of the site in accordance with a BLM-approved revegetation plan. Components at greater depths may be cleaned (when necessary) and abandoned in place. Buried pipes would be evacuated and cleaned and pipe segments capped before abandonment in place.

Special care must be exercised in the disposal of PV cells composed of high-performance solar cell materials that contain toxic metals (Fthenakis and Zweibel 2003; EPRI and CEC 2003). Where possible, those solar panels would be dismantled and delivered intact to off-site recycling facilities where the hazardous constituents would be removed and reprocessed. Damaged or broken panels that could not be recycled would need to be containerized and characterized for

[24] See Section 5.20 (Health and Safety) for more detailed discussions regarding the hazards associated with some semiconductor materials used in high-performance solar panels.

proper disposal, and areas surrounding their installed locations surveyed and remediated, if necessary, of any toxic metal contamination.

If lined surface impoundments are used during operation, remaining liquids, accumulated sludge, and any synthetic liner materials would be removed, containerized, and characterized for proper disposal, and the impoundment area re-graded with indigenous soils.

3.6 HEALTH AND SAFETY ASPECTS OF SOLAR ENERGY PROJECTS

Potential human health and safety issues related to solar energy projects are summarized in this section and discussed in greater detail in Section 5.21. Physical hazards to workers and potential safety and health issues for the general public are discussed. The potential for elevated exposures to electromagnetic fields is also discussed.

3.6.1 Occupational Hazards

Occupational health and safety programs associated with construction, operations, and decommissioning of solar facilities and associated transmission lines are regulated under the federal Occupational Safety and Health Act (29 USC 651 et seq.). A special consideration at solar facilities would be protection of vision from potentially damaging glare from the solar field; this would be addressed in the facility Health and Safety plan. Occupational noise exposure standards for workers must comply with the regulatory requirements of 29 CFR1910.95. The States may have additional laws and regulations that build on that law. Workers at any solar facility are subject to risks of injuries and fatalities from physical hazards. These occupational hazards can be minimized when workers adhere to safety standards and use appropriate protective equipment. However, fatalities and injuries from on-the-job accidents can still occur. Detailed project-specific health and safety plans and adequate worker training would minimize the likelihood of injuries and fatalities.

Most of the occupational hazards associated with solar energy projects are similar to those of the heavy construction and electric power industries. There is additional hazard associated with the fact that many construction activities would take place outdoors in remote locations. Accident rates have been tabulated for most types of work, and risks can be calculated on the basis of historical industry-wide statistics. The National Safety Council (NSC) maintains statistics on the annual number of injuries and fatalities by industry type (NSC 2006). The expected annual number of worker fatalities and injuries for specific industry types can be calculated on the basis of NSC rate data and the number of annual fulltime equivalent workers required for construction and operations activities at a solar energy project (see Section 5.21).

The risk of occupational heat stress or stroke is likely to be high during construction of solar facilities and associated transmission lines, given the desert location of much of the study area. Health and safety plans will need to address this risk. Chemical exposures during construction and operation of a typical solar energy project are expected to be routine and minimal and mitigated by using personal protective equipment (PPE) and/or engineering controls to comply with OSHA permissible exposure limits (U.S. Department of Labor 1997) that are applicable for construction activities.

At PV facilities, infrequent damage to solar panels could result in the accidental release of small quantities of hazardous metal compounds to the ground surface. Cleanup procedures for these accidental releases would require the use of PPE; thus actual worker exposures to these substances would be low.

3.6.2 Public Safety

A potential public safety issue is unauthorized or illegal access to solar facilities. During such unauthorized access, individuals could disturb electrical equipment (e.g., attempt to open electrical panels, which could result in electrocution) or encounter other hazards. Such access is minimized through the use of fencing around the entire site and around electrical equipment, but it may still occur occasionally.

There is some potential for members of the general public to be exposed to reflected light from solar facility mirrors at an intensity that could cause eye injury, particularly for brief periods when mirrors are being rotated. Measures to prevent such exposures would be established during project-specific planning.

Dry vegetation and/or high winds may cause a potential fire hazard around solar facilities and transmission lines. Under these conditions, fires could start for a variety of reasons, such as electrical shorts, insufficient equipment maintenance, contact with power lines, and lightning. A potential impact from construction and operation of solar facilities and transmission lines could include an increased risk of fires because of the use of flammable fuels and hazardous materials, as well as the operation of internal combustion sources (e.g., vehicle engines) and external combustion sources (e.g., boilers) during the construction and decommissioning phases and, to a lesser extent, during operations.

The clearing of native vegetation that is subsequently replaced by invasive species in a ROW could also increase the risks of both initiation and spread of fires. For example, if invasive annual grasses were allowed to invade and populate a ROW, the risk of fires in that ROW might be more than the risks in the undisturbed ROW. However, clearing and maintaining a ROW could also result in the creation of a man-made firebreak. Clearing mainline ROWs and certain functional areas, such as electrical substations and pump and compressor stations, for operational safety can also reduce the amount of fuel available within the ROW for fires.

Fire risks might increase because of the presence of certain structures associated with transmission lines. Tall electricity transmission towers represent an increased potential for lightning strikes (however, standard practice would require that all such structures be grounded). Ground faults or arcing from energized electricity conductors and substation equipment also represent increased potential for fire.[25] Fire-fighting personnel face increased risk of electrocution where high-voltage lines are present. The transmission lines and their support towers could represent obstacles to safe staging of firefighting equipment (including air tankers). However, maintenance access roads along transmission lines often provide critical access points for effective firefighting.

Because smoke increases the conductivity of the air, smoke from wildfires can cause flashover between conductors. Damage to towers or power conductors due to exposure to intense heat from an adjacent fire could cause wholesale failure of the transmission system, involving electrical arcing to ground that would jeopardize firefighting personnel and equipment in the immediate vicinity. For this reason, high-voltage lines near active wildfires are often de-energized. Lines are almost always de-energized before fires actually reach the transmission facilities themselves.

3.6.3 Electric and Magnetic Fields

Power lines and electrical equipment generate both electric and magnetic fields. Because of the presence of electrical substations at solar energy facilities, and the transmission lines associated with these facilities, the potential hazards to human health and safety from electric and magnetic fields (EMFs) must be considered. Wherever electric currents flow, EMFs are produced. These fields rapidly decrease in strength with distance from the source. Electric field strengths directly beneath high-voltage power lines can reach up to several thousand volts per meter (V/m); typical electric field strengths in homes associated with the 60-Hz AC sources used in the United States range from about 0 to 10 V/m (NIEHS 2002). The electric field strength along the edge of the ROW for a 230-kV transmission line is about 1.5 kV/m. The potential for adverse health effects from magnetic fields has been the focus of research because a few studies have shown associations between magnetic field exposure and some types of cancers (further discussed below). No such associations have been observed for electric fields. A voluntary occupational exposure guideline of 8.3 kV/m and a general public exposure guideline of 4.3 kV/m for electric fields have been developed by the International Commission on Non-Ionizing Radiation Protection (as cited in NIEHS 2002).

Sources of magnetic fields include aboveground and underground power lines. At the edge of a 150-ft (45-m), 230-kV aboveground transmission line ROW, the magnetic field strength is about 20 milligauss (mG); at 300 ft (91 m) from the centerline, the magnetic field strength is about 0.8 mG (BPA 1993), which is the approximate background level. For a 500-kV aboveground transmission line ROW, the magnetic field strength is about 29 mG at 150 ft (45 m) and 1.4 mG at 300 ft (91 m). The actual field strengths depend on line design and current levels.

For comparison, magnetic fields associated with electrical appliances are highly variable, typically ranging from less than 10 mG up to about 1,000 mG, at about 0.5 ft (0.2 m) from an

[25] Most high-voltage transmission lines have static lines or shielding cables strung above the conductors to deflect lightning strikes to grounds on the structures. In addition, ground faults will automatically cause line lock-outs until the fault is investigated and repaired. These procedures limit risks of fire or electrocution.

operating electrical appliance such as a can opener (EPA 1992). At 4 ft (1.2 m) from the source, almost all magnetic field strengths associated with electrical appliances drop to 10 mG or less.

Exposures of the general population are most accurately measured as 24-hour averages, using personal exposure meters. Most people in the United States are exposed to 24-hour average magnetic field strengths of less than 2 mG (Zaffanella and Kalton 1998). Some types of work lead to increases in magnetic field exposures, especially for electrical workers, persons working near machines with electric motors, and welders. Time-weighted average exposures for these workers range from about 1 to 40 mG (NIEHS 1999).

Acute exposure to high-level external extremely low frequency (ELF) magnetic fields induces electric fields and currents in individuals, causing nerve and muscle stimulation and changes in the central nervous system (WHO 2007). These effects occur at magnetic field levels above 1,000 mG.

Concern in the United States over possible adverse health effects associated with exposure to low-level magnetic fields started in 1979, with a publication showing an association between childhood leukemia and proximity of homes to power lines (Wertheimer and Leeper 1979). Since then, hundreds of epidemiological and laboratory studies have been conducted. Closeness to power lines has not been found to be a valid risk factor for increased childhood leukemia. However, a weak association, based on epidemiological studies, has been found between measured magnetic field exposures and both childhood and adult leukemia. In 1999, the National Institute of Environmental Health Sciences (NIEHS) completed a review of the data and concluded that there was weak scientific evidence that exposure to ELF EMFs could pose a leukemia hazard (NIEHS 1999). In 2002, the International Agency for Research on Cancer (IARC) classified ELF magnetic fields as possibly carcinogenic to humans (IARC 2002). A 2002 California Department of Health Services report also classified exposure to magnetic fields as possibly carcinogenic to humans, as well as possibly causative in adult brain cancer, amyotrophic lateral sclerosis, and miscarriage (Neutra et al. 2002).

Electrical workers, with their higher 24-hour average magnetic field exposures, might be expected to have an elevated rate of leukemia, brain cancer, or other cancers if magnetic fields cause cancer. Many large epidemiological studies, including tens of thousands of electrical workers, have been conducted. Of five large studies discussed in a NIEHS (2002) report, only one reported a small but statistically significant increase of lung cancer and all cancers combined for electrical workers. The other four studies showed no consistent association between magnetic field exposures and cancer.

Because of the inconclusive nature of the association between cancer and exposure to magnetic fields, there are no United States standards applicable for long-term, low-level exposures of the general public or workers. Given the uncertainties, the World Health Organization states that the adoption of arbitrary low exposure limits is not warranted, but recommends that simple and low-cost ways of reducing exposure when constructing new facilities should be implemented.

3.7 EXISTING AGENCY PROCESSES AND GUIDANCE

3.7.1 Current BLM Process for Issuing Solar Development ROWs

The BLM's existing Solar Energy Policies (BLM 2007; 2010a,b) are presented in their entirety in Appendix A, Section A.1. Applications for commercial solar energy facilities, both PV and CSP, are processed as ROW authorizations under Title V of FLPMA and 43 CFR Part 2804. Applicants must submit a complete and acceptable application and provide a cost-recovery payment before the BLM will initiate processing of a ROW application.

The application process begins with a pre-application meeting with a BLM authorized officer. During this meeting, potential issues and land use conflicts affecting the BLM's decision to issue or not issue the ROW authorization can be identified. The pre-application process identifies any environmental or cultural resource studies that may be needed, assesses public interest and concerns, identifies other authorized uses within or near the area, allows consideration of potential alternative site locations, and outlines arrangements for paying the costs associated with processing a ROW.

The ROW authorization contains appropriate stipulations relating to all aspects of project development, including, but not limited to, road construction and maintenance; vegetation removal; natural, cultural, and biological resources mitigation and monitoring; and site reclamation. When a ROW is issued, the ROW holder is encouraged, through terms and conditions of the ROW authorization, to work with the BLM to increase public acceptance and awareness of the benefits of solar energy development by providing information and public viewing areas at safe locations near the development. Other compatible uses for the ROW area may be authorized by the BLM but are unlikely due to the intensive use of the site for PV or CSP facility equipment.

An approved Plan of Development for construction and operation of a solar facility must be completed prior to beginning construction. When possible, the ROW authorization and the Plan of Development are processed simultaneously. A bond is also required for solar energy development ROWs to ensure compliance with the terms and conditions of the authorization and the requirements of the regulations, including reclamation. The reclamation provisions within the Plan of Development include removal of solar collectors and other structures, and the reclamation of access roads and disturbed areas.

The term length of authorizations would typically be 30 years, which is the general design life of utility-scale solar facilities. The authorization could be renewed consistent with the regulations (43 CFR 2807.22(a)); the ROW would be renewed if the applicant showed compliance with the terms, conditions, and stipulations of the original ROW and with applicable laws and regulations. Under the current ROW authorization process, the holder of a ROW authorization pays an annual rent established by the BLM on the basis of an established Rental Schedule (as described in BLM's interim rental policy issued in June 2010 [BLM 2010a]). Under this policy, the rental payment reflects the full use of the public land for solar facilities, similar to a lease for industrial purposes. A portion of the rental payment will be phased in over a 5-year period once the facility begins generating electricity.

ROW applications for solar energy development are generally accepted and processed on a first-come, first-served basis. The BLM discourages applicants from holding ROW authorizations for the purposes of speculating, controlling, or hindering development of solar energy on public lands, through ensuring that applicants meet qualification requirements, including providing information on their technical and financial capabilities to construct, operate, maintain, and terminate the solar energy facilities. The regulations provide the authority to deny an application if the applicant cannot demonstrate adequate technical ability to construct, operate, and maintain the solar energy facilities. The BLM may also deny an application if the applicant does not provide, in a timely manner, additional information requested by the BLM to process an application or the required cost recovery funds.

Solar energy development ROW authorizations include a due diligence requirement for installation of facilities consistent with an approved Plan of Development, with construction to begin within 2 years of the ROW being issued. If construction has not been started within this time frame, the ROW holder must provide the BLM good cause as to the nature of any delay, evidence of progress toward beginning construction, and the anticipated date of start-up operations, or the authorization may be terminated.

Environmental analyses are required for solar energy development projects in accordance with the National Environmental Policy Act of 1969 (NEPA) and must address potential direct, indirect, and cumulative effects of the project. The scope of the NEPA analysis must include the installation and maintenance of solar collectors, water for steam generation and cooling purposes, oil or gas used by backup generators, thermal or electrical storage, turbines or engines, access roads and electrical inverters, and transmission facilities. The NEPA analysis must also include assessment of land disturbance, water use, and potential impacts on natural, cultural, and biological resources.

The BLM is using the 2007 Solar Energy Development Policy as updated by instruction memoranda issued in 2010 (BLM 2010a,b) to continue processing applications while this PEIS is being developed. As of December 1, 2010, the BLM had approved eight utility-scale ROW authorizations in the six-state study area under these policies.

3.7.2 Options for ROW Processing

As stated previously, ROW applications for solar energy development are generally accepted and processed on a first-come, first-served basis. However, the ROW regulations in 43 CFR 2804.23(c) provide authority for offering public lands under competitive bidding procedures for solar energy ROW authorizations. The BLM can initiate a competitive process if a land use planning decision has specifically identified an area for competitive leasing. The BLM may also consider other public interest and technical factors in determining whether to offer lands for competitive leasing. Competitive bidding follows the procedures required by 43 CFR 2804.23(c).

Another option for facilitating solar energy development would be a land withdrawal, under which a tract of land would be withdrawn to establish a solar energy zone. The withdrawal of land for a solar energy zone could be for BLM administration[26] or for administration by another federal agency, bureau, or department. Withdrawals are governed by regulations issued under the FLPMA, contained in 43 CFR Part 2300. A withdrawal is defined as

> "…withholding an area of Federal land from settlement, sale, location, or entry under some or all of the general land laws, for the purpose of limiting activities under those laws in order to maintain other public values in the area or reserving the area for a particular public purpose or program; or transferring jurisdiction over an area of Federal land, other than property governed by the Federal Property and Administrative Services Act (40 U.S.C. 472), from one department, bureau or agency to another department, bureau or agency" (see 43 CFR 2300.0-5[h]).

The FLPMA gives the Secretary of the Interior the authority to make, modify, extend, or revoke certain land withdrawal actions. Withdrawal proposals exceeding 5,000 acres (20 km^2), however, are subject to congressional consideration and review. To effect a land withdrawal, the agency receiving jurisdiction must follow a series of steps involving detailed initial consultation with the BLM, comprehensive environmental impact reviews (e.g., NEPA analyses), and consultations with other federal, state, and local agencies as well as other stakeholders. Ultimately, the process would result in issuance of either a public land order that would implement the land withdrawal, or a denial. The withdrawal application process can take several years. The lands would be set aside (segregated) from sale or other claims for a period of 2 years once the withdrawal application was accepted by the Secretary. This segregation would protect the land from being committed to other, competing uses; however, actions proposed as part of the withdrawal application could not be implemented during this time.

The BLM could also decide to dispose of land that could then be used for solar energy development. Land disposals can be exchanges or sales of BLM-administered lands with or to state government, local government, or private entities. The BLM must confirm that the lands being considered for exchange or sale have been identified as potentially suitable for disposal in an approved land use plan or plan amendment (BLM 2008a). If the lands have not been identified for potential disposal in an existing land use plan, the BLM has the discretion of completing a plan amendment to assess and determine whether disposal of the land would be in the public interest. The BLM must coordinate disposal actions with the appropriate state and local governmental entities, authorized users, adjoining land owners, and other parties that have expressed an interest. In most cases, this coordination occurs at the beginning stages of a proposed land disposal action, and again at the conclusion when a Notice of Realty Action is published and presented to the appropriate governing authorities. The BLM must also complete an environmental analysis to assess the potential impacts of a proposed disposal action. If the analysis concludes that disposal of the land would result in impacts on resources and/or existing uses that cannot be properly mitigated, the lands would not be made available for exchange or sale.

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[26] See the BLM's Notice of Proposed Withdrawal (Volume 73, page 31308 of the *Federal Register* [73 FR 31308]) to protect and preserve solar energy study areas for future solar energy development.

3.7.3 Existing Mitigation Guidance Relevant or Applicable to Solar Energy Development

Federal agencies with jurisdiction over proposed projects often utilize mitigation measures, best management practices (BMPs), guidelines, or stipulations to keep the impacts of specific activities on the surrounding environment to a minimum. For utility-scale solar facilities, some guidance has already been developed by the BLM and by other agencies. In the development of mitigation measures for inclusion in BLM's proposed Solar Energy Program and DOE's proposed guidance, existing agency guidelines have been reviewed (Engelhard 2009; Scofield 2009; CEC, CDFG, BLM, and USFWS 2009), and relevant and appropriate elements have been incorporated. While some existing guidelines have been incorporated into the proposed BLM Program, the specific requirements have been defined on the basis of reviews and analyses conducted in the course of this PEIS and, therefore, may vary from those put forth by other organizations.

While some of the potential impacts associated with solar energy development projects described in Chapter 5 are unique to this type of activity, several of the potential impacts (e.g., road construction and habitat fragmentation) are common to other types of development activities, and the BLM has existing guidance for the environmentally sound conduct of these activities. Such existing BLM guidance and planning documents established for other types of development activities have also been reviewed and considered for inclusion as proposed guidance and mitigation measures for solar energy development.

3.7.3.1 BLM Guidance

The BLM has developed many program-specific guidance documents that establish mitigation requirements for a variety of activities. This guidance comes in many forms—manuals, handbooks, instruction memoranda (IMs), environmental memoranda, technical references, BMPs, standards, directives, land use plans, and other such documents. The existing Solar Energy Development Policy (BLM 2007) (Appendix A) directly addresses solar energy development and was summarized in Section 3.7.1. The BLM's proposed Solar Energy Program, developed in this PEIS, includes policies and design features requiring that relevant BLM mitigation guidance be incorporated into individual solar energy development project Plans of Development, as appropriate, to address site-specific issues.

Two BLM guidance documents have been identified that contain mitigation guidance for solar energy development projects: the first is the BLM's Revised Wind Energy Policy IM (BLM 2008b), and the second is the BLM's IM for Compensatory Management (BLM 2008c). In addition, BLM land use plans may contain stipulations that are relevant to solar energy development. These items are discussed below.

The Wind Energy Development PEIS (BLM 2005) developed a wind energy program for the BLM, similar to the proposed BLM program for solar energy development provided in this PEIS. The wind program was updated somewhat with the release of the BLM's revised Wind Energy Development Policy, IM 2009-043 (BLM 2008b) in December 2008. The Wind Energy Development Policy established new policies specific to wind energy development, including requirements to avoid National Landscape Conservation System lands; consult with appropriate federal, state, and local agencies and Tribal governments; amend land use plans to address wind energy development; provide a Plan of Development for each project incorporating all appropriate BMPs; obtain bonds for projects; consider habitat conservation; consider visual resource values; and incorporate adaptive management strategies and monitoring programs for wind energy projects. The BMPs include requirements for Plan of Development content (specifying, for example, use of existing roads and infrastructure as much as possible and inclusion of monitoring programs); protection of wildlife, other ecological resources, cultural, paleontological, and visual resources; control of noise, hazardous materials and waste, and noxious weeds; and protection of water resources and human health and safety. BMPs are specified for the siting, construction, operations, and decommissioning phases of project development. These policies and BMPs were considered for applicability in establishing the proposed Solar Energy Program for BLM and for the DOE's proposed guidance (Section 2.2).

The BLM has also issued IM 2008-204, Interim Offsite Compensatory Mitigation for Oil, Gas, Geothermal and Energy Rights-of-Way Authorizations, which outlines policy for the use of off-site mitigation for authorizations issued by the BLM (this IM replaces IM WO-2005-069), including solar energy development (BLM 2008c). Compensatory mitigation is defined in the memorandum as mitigation actions that are undertaken off-site to compensate for an impact by replacing or providing substitute resources or environments. This off-site mitigation can be immediately adjacent to the area affected but can also be located anywhere in the same general geographic area.

The BLM's land use plans are planning and management documents that define how resources will be managed within a specific planning area, and they establish restrictions on activities to be undertaken in that planning area. The land use planning process is the key tool that the BLM uses to protect resources and designate uses on federal lands that it manages. These plans help ensure that public lands are managed in accordance with applicable laws and regulations under the principles of multiple use and sustained yield. The BLM develops land use plans in accordance with federal requirements and BLM regulations and planning policies. Depending on when a land use plan was written or last revised, it may exist as a Management Framework Plan, the original format, or as a newer Resource Management Plan. Land use plans are typically organized according to the resources present in the planning area. For each identified resource (e.g., wildlife, minerals, or recreation areas), the plan will identify management objectives and management actions. Often the management actions establish restrictions or stipulations regarding the use or development of the given resource. Many resources are common to virtually all BLM planning areas, and the corresponding land use plans establish management actions to ensure appropriate resource management. Many of these are resources that might be affected by solar energy development projects: wildlife (including federally and state-protected species), wildlife habitat, soils, water resources, cultural and historic resources, visual resources, recreation areas, and forestry resources. In addition, many land use plans establish restrictions or stipulations specific to relevant management issues, such as hazardous materials management, fire management, and wild horse management.

Stipulations from individual land use plans have not been incorporated into the guidance, policies, and required mitigation measures presented as BLM's Solar Energy Development

Program in this PEIS. However, stipulations from the applicable land use plans will be addressed at the time of site-specific NEPA reviews for individual solar energy facilities.

Finally, the BLM has issued many program-specific documents addressing environmental issues relevant to solar energy projects. The topics covered by these documents that can reasonably be identified as relevant include the NEPA, visual resource management, road construction and maintenance, wildlife management (including special status species, Endangered Species Act of 1972 [ESA] species, threatened and endangered species, and sage-grouse management), Areas of Critical Environmental Concern; hazardous materials and waste management, cultural resource management, Native American consultations, pesticide use and integrated pest management, and occupational health and safety. Relevant BLM program-specific mitigation documents were used and referenced in developing design features applicable for solar energy development (see Appendix A, Section A.2.2). Readers may obtain the complete guidance documents if they wish to obtain more information. Electronic copies of some of the BLM regulations, manuals, handbooks, IMs, and bulletins are available at http://www.blm.gov/wo/st/en/national_page/site_maps/site_map_index/washington_office.html.

3.7.3.2 DOE Guidance

Guidance is available for developers seeking aid through DOE's Loan Guarantee Program regarding the types of projects that would require NEPA documentation, and the level of documentation required (DOE 2010). In addition, the Western Area Power Administration has developed standards (Western 2008) that would be relevant for the construction and operation of transmission interconnects built in association with solar energy facilities. These standards address many potential impacts, including the management and disposal of hazardous materials and wastes, landscape preservation, noxious weed control, prevention of air and water pollution, and the protection of habitat. These standards have been considered for applicability in establishing the proposed Solar Energy Program for BLM and for DOE's proposed guidance (Section 2.2).

3.7.3.3 Other Guidance

The United Nations Environmental Programme (UNEP) has developed environmental due diligence guidelines for solar thermal energy systems (UNEP undated-a) and for solar PV energy systems (UNEP undated-b). These guidelines discuss the potential for soil and groundwater contamination, biodiversity protection, visual impacts, land use, and public health and occupational hazards associated with the technologies, and were reviewed for applicability to the proposed Solar Energy Program for BLM and for DOE's proposed guidance.

State wildlife agencies have also developed guidelines for avoidance and mitigation for wildlife impacts. State Wildlife Action Plans can be used as guidance to help avoid impacts on wildlife resources. In addition, State Heritage Data Management Systems are available to identify wildlife species status and distribution. For the SEZ-specific PEIS analyses (Chapters 8 through 13), state-specific guidelines for avoidance and mitigation of wildlife impacts have been considered and referenced, as applicable.

3.8 REFERENCES

Note to Reader: This list of references identifies Web pages and associated URLs where reference data were obtained for the analyses presented in this PEIS. It is likely that at the time of publication of this PEIS, some of these Web pages may no longer be available or their URL addresses may have changed. The original information has been retained and is available through the Public Information Docket for this PEIS.

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