US Department of the Interior
Bureau of Land Management
Battle Mountain District, Nevada

Reasonably Foreseeable Development Scenario for Solar and Wind for the Battle Mountain District Resource Management Plan/Environmental Impact Statement

APRIL 2013

TABLE OF CONTENTS

Chapter Page

1. INTRODUCTION 1-1
- 1.1 Purpose of this Report 1-1
- 1.2 Renewable Energy-Related BLM Policies and Regulations 1-1
- 1.3 How to Read This Document 1-2

2. SOLAR ENERGY 2-1
- 2.1 What is Solar Energy? 2-1
- 2.2 How is Solar Energy Developed? 2-1
  - 2.2.1 Photovoltaic Systems 2-2
  - 2.2.2 Concentrating Solar Power Systems 2-3
  - 2.2.3 Power Tower Systems 2-4
  - 2.2.4 Emerging Technologies 2-4
- 2.3 What BLM Actions are Involved in Solar Energy Development? 2-4
- 2.4 How are Potential Levels Defined for Solar Energy? 2-5
- 2.5 Solar Potential 2-6
  - 2.5.1 Data Sources 2-6
  - 2.5.2 BLM/DOE Renewable Potential Energy Assessment 2-7
  - 2.5.3 Solar Energy Development Final Programmatic EIS 2-7
  - 2.5.4 Solar Potential Data Used in This Report 2-8
- 2.6 Potential Areas within the Battle Mountain District 2-8
- 2.7 Reasonable Foreseeable Development Scenario 2-9

3. WIND ENERGY 3-1
- 3.1 What is Wind Energy? 3-1
- 3.2 How is Wind Energy Developed? 3-1
- 3.3 What BLM Actions are Involved in Wind Energy Development? 3-2
- 3.4 How are Potential Levels Defined for Wind Energy? 3-3
- 3.5 Wind Potential 3-4
  - 3.5.1 Data Sources 3-4
  - 3.5.4 Wind Potential Data Used in this Report 3-6
- 3.6 Potential Areas within the BMD Area 3-6
- 3.7 Reasonable Foreseeable Development Scenario 3-6

4. REFERENCES 4-1

FIGURES

Page

1-1 BMD RMP Planning Area 1-3
2-1 Solar Energy Potential 2-10
3-1 Wind Potential 3-8

TABLES

Page

3-1 Classes of Wind Power Density at 10 Meters and 50 Meters 3-5

ACRONYMS AND ABBREVIATIONS

	Full Phrase
BLM	United States Department of the Interior, Bureau of Land Management
BMD	Battle Mountain District
CFR	Code of Federal Regulations
DOE	Department of Energy
EIS	Environmental Impact Statement
GIS	Geographic Information System
$kWh/m^2/day$	kilowatt-hour per square meter per day
MLFO	Mount Lewis Field Office
NREL	National Renewable Energy Laboratory
ROW	right-of-way
TFO	Tonopah Field Office
US	United States

CHAPTER 1
INTRODUCTION

1.1 PURPOSE OF THIS REPORT

The purpose of this report is to identify the reasonably foreseeable development for solar and wind for development and potential location of solar and wind energy on lands administered by the United States (US) Department of the Interior, Bureau of Land Management (BLM) within the Battle Mountain District (BMD) planning area. The planning area encompasses 10,500,000 acres of public (BLM-administered) land in four Nevada counties: Lander, Eureka, Esmeralda and Nye (**Figure 1-1**, BMD RMP Planning Area). Renewable energy addressed in this report includes solar and wind, and lands considered are all BLM-administered public lands in the planning area (10,500,000 acres). The Mount Lewis Field Office (MLFO) administers 4,500,000 acres and the Tonopah Field Office administers (TFO) 6,000,000.

1.2 RENEWABLE ENERGY-RELATED BLM POLICIES AND REGULATIONS

At the time of writing of this report, the BLM's solar and wind energy is directed by the regulations and executive orders listed below. The policies and procedures cited in this report are applicable at the time of writing but are expected to evolve over the timeframe of the RMP. The right-of-way (ROW) authorization process, which is required for solar and wind projects, is also expected to change over time.

As of 2013, the BLM's renewable energy policy is directed by the following regulations and executive orders:

- The Energy Policy Act of 2005 (Title II, Sec. 211), which requires the US Department of the Interior to approve at least 10,000 megawatts of renewable energy on public lands by 2015
- Executive Order 13212, Actions to Expedite Energy-Related Projects, which requires federal agencies to expedite review of energy project applications
- Secretarial Order 3285, which requires the US Department of the Interior to identify and prioritize specific locations best suited for large-scale renewable energy production

Additionally, the BLM has specific guidance for certain types of renewable energy. These are discussed in the respective energy-specific sections of this report. The main Instruction Memoranda are summarized here:

- Instruction Memorandum 2007-097, **Solar** Energy Development Policy (BLM 2007), establishes policy for the processing of ROW applications for solar energy development projects on BLM-administered lands and evaluating the feasibility of installing solar energy systems on BLM administrative facilities and projects.
- The Record of Decision for the Programmatic Environmental Impact Statement (EIS) on **Solar** Energy Development (BLM and DOE 2012) and processing ROW applications for solar energy projects on BLM-administered lands;
- Instruction Memorandum 2006-216, **Wind** Energy Development Policy (BLM 2006), provides guidance on implementing the Record of Decision for the Programmatic EIS on Wind Energy Development (BLM 2005) and processing ROW applications for wind energy projects on BLM-administered lands; Instruction Memorandum 2009-043, Wind Energy Development Policy (BLM 2009), provides updated guidance on processing ROW applications for wind energy projects on BLM-administered lands.

Solar and wind projects are authorized via the ROW process. ROW applications for development on BLM-administered lands must be accompanied by a processing fee as set forth in 43 CFR 2804.14. ROW applications are generally accepted and processed on a first-come, first-served basis. The ROW regulations (43 CFR 2804.23[c]) provide authority for offering public lands under competitive bidding procedures for ROW authorizations. The BLM initiates 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 procedures required by 43 CFR 2804.23(c).

1.3 How to Read This Document

This report contains separate chapters for the two types of renewable energy considered: solar and wind. Each chapter contains a flow of information designed to provide a basic understanding of the energy type, the technologies used to harness that energy, the process of developing (making use of) that energy, and the BLM action involved. Each chapter then describes how potential levels are commonly defined for each energy type, including an overview of scientific terminology and units. Each chapter explains the major resource assessments that are commonly used to assess potential within an area and defines which source data is used for conducting the assessment in this report. Each chapter provides an overview of the potential energy levels across planning area lands and estimates where development is likely to occur in the next 15 to 20 years through the presentation of a foreseeable development scenario.

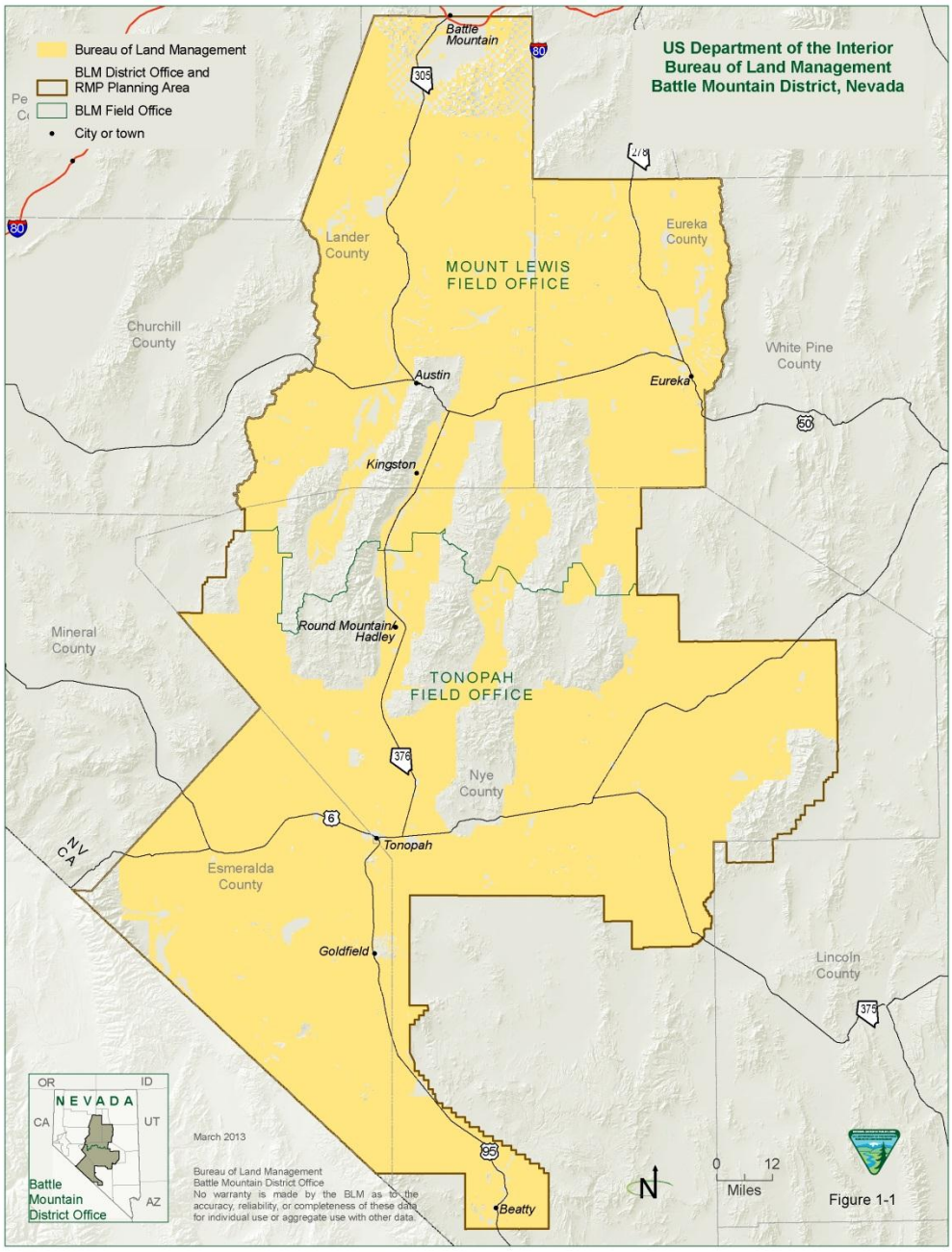

Figure 1-1 BMD RMP Planning Area

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CHAPTER 2
SOLAR ENERGY

2.1 WHAT IS SOLAR ENERGY?

Solar energy is the energy produced in the sun's core through nuclear fusion. This energy reaches the earth in form of electromagnetic radiation, mostly in the visible and near-visible (ultraviolet and near-infrared) bands. The intensity of radiation striking the top of earth's atmosphere is 1,367 watts per square meter. This value varies by plus or minus three percent as the earth orbits the sun on an elliptical orbit (University of Oregon 2002). The amount of solar radiation that reaches earth's surface is known as insolation or "incident solar radiation." Insolation values are affected by location (latitude and elevation), season, time of day, local landscape, and local weather.

As solar radiation passes through the atmosphere, some of it is scattered, absorbed, and reflected by air molecules, water vapor, clouds, ozone, and other agents in the atmosphere. On a clear day at noon, only about 25 percent or 1,000 watts per square meter of the incident direct radiation reaches the earth's surface. The solar radiation that reaches earth's surface directly without being scattered is called direct normal irradiance. The radiation that has been scattered before reaching the earth's surface is called diffuse solar radiation. The total solar radiation (sum of direct normal irradiance and diffuse solar radiation) projected onto a horizontal surface is called global radiation, which is sometimes referred to as global horizontal irradiance.

2.2 HOW IS SOLAR ENERGY DEVELOPED?

Solar radiation may be harnessed through various technologies and transformed to usable energy such as heat and electricity. Solar energy can be used for small-scale applications such as powering solar vehicles and generating electricity or heating water for residences. It may also be used for large-scale commercial applications such as generating electricity in solar power plants.

Two basic solar energy technologies that produce electrical power are photovoltaic systems and concentrating solar power systems. These can be combined with natural gas or other fossil-fueled power technologies to form hybrid systems.

2.2.1 Photovoltaic Systems

Photovoltaic systems use solar cells, which are semiconductor materials similar to those used in computer chips, to capture the energy in sunlight and convert it directly into electricity. Photovoltaic systems must be scaled over a very large area in order to be effective for utility-scale applications. Due to the high cost of photovoltaic cell productions, large photovoltaic electrical generating systems are less likely to be used in commercial utility application. Photovoltaic systems are generally used to provide power to individual homes and small buildings. They are also found in rural areas on communication towers, water pumps, and road and traffic signs.

The process by which a photovoltaic cell converts sunlight into electricity is called the photoelectric effect. Through this process, the sunlight absorbed by the semiconductor material knocks electrons loose from their atoms, allowing them to flow through the material and generate electric current.

There are three main types of materials used for solar cells. Traditional solar cells are made from silicon. These cells are usually flat-plate and are the most efficient. The second type is thin-film solar cells made from amorphous silicon or non-silicon materials such as cadmium telluride. The third and newest type of solar cells is made from a variety of new materials besides silicon, including solar inks, solar dyes, and conductive plastics. Some new solar cells use plastic lenses or mirrors to concentrate sunlight onto high-efficiency photovoltaic materials. These systems are cost effective for use in utility-scale applications because they use less of more-efficient and expensive materials (National Renewable Energy Laboratory [NREL] 2009a).

Photovoltaic cells are connected together to form photovoltaic modules, which in turn are combined to make photovoltaic arrays. The size of an array depends on the amount of sunlight and the needs of the customer. For utility-scale electricity generation, hundreds of arrays are interconnected to form a single large system. Modules and arrays are often combined with other components such as those that convert the current within the cell material to usable electricity, batteries to store some of the electricity, and mounting structures that point them toward the sun. These components, referred to as the balance-of-system components, combined with modules and arrays create a complete photovoltaic system. There are two types of photovoltaic systems in use today: flat-plate systems and concentrated photovoltaic systems.

Flat-plate Photovoltaic Systems

The most common array designs use flat-plate photovoltaic panels, which can either be fixed in place or allowed to track the sun. These panels respond to both diffuse and direct solar radiation, making them useful even on cloudy days when the diffuse radiation accounts for nearly 100 percent of the total radiation. On a sunny day, an estimated 10 to 20 percent of the total solar radiation comes from the diffuse component of sunlight.

Generally, flat-plate photovoltaic panels are mounted on stationary structures with a tilt at a fixed angle determined by the latitude of the site, the requirement of the load, and the availability of sunlight. The fixed arrays are advantageous in that they are simple, inexpensive, and lightweight. However, because their orientation to the sun is fixed and at an angle often less than optimal, they receive less energy per unit area compared with a tracking array. The flat-

plate tracking arrays are primarily mounted on one-axis tracking structures, which are designed to track the sun from east to west.

Concentrated Photovoltaic Systems

Concentrated photovoltaic systems use lenses or mirrors to concentrate sunlight on solar cells. The concentration of sunlight allows for greater efficiency and reduction in size and number of cells. These systems must track the sun to keep light focused on the photovoltaic cells. They are primarily mounted on two-axis tracking structures, which are designed to track the sun's daily and seasonal course. One-axis tracking systems are also sometimes used.

Both reflectors and lenses have been used to concentrate light for photovoltaic systems. The most promising lens for concentrated photovoltaic application is the Fresnel lens, which uses a miniature sawtooth design to focus incoming light. The best lenses, however, can transmit only 90 to 95 percent (and, in practice, even less) of incident light. In addition, lenses cannot focus diffuse sunlight, which makes up nearly 10 to 20 percent of the radiation on a clear day.

While concentrated photovoltaic systems lower costs by reducing photovoltaic material needs, they require sophisticated tracking devices and expensive concentrating optics. High concentration ratios also introduce an excessive heat, which can decrease cell efficiencies and damage solar cells.

2.2.2 Concentrating Solar Power Systems

Concentrating solar power technologies use mirrors to concentrate sunlight onto receivers that convert it to heat. The thermal energy is then used to drive a generator via a steam turbine or heat engine to produce electricity. Concentrating solar power technologies are the most suitable solar technologies for large utility-scale applications. The three main types of concentrating solar power technologies are linear concentrator, dish/engine, and power tower systems.

Linear Concentrator Systems

Linear concentrating solar power systems use a large field of long, rectangular, U-shaped mirrors tilted toward the sun that capture and focus solar energy onto linear receiver tubes that run along the length of the mirrors. The receiver contains a fluid (oil or water/steam) that is heated by the sunlight and used to boil water in a steam-turbine generator to produce electricity.

The two major types of linear concentrating solar power systems are parabolic trough systems and linear Fresnel reflector systems. Parabolic trough systems are the predominant concentrating solar power systems currently in operation in the US. They use collectors in which the receiver tube is positioned along the focal line of each parabolic mirror. Currently the largest individual trough systems generate 80 megawatts of electricity.

In linear Fresnel reflector systems, the receiver tube is positioned above several flat or slightly curved mirrors that are mounted on tracking structures. Sometimes a small parabolic mirror may be added atop the receiver to further focus the sun's rays.

Dish/Engine Systems

The dish/engine system produces relatively small amounts of electricity (3 to 25 kilowatts) compared with other types of concentrating solar power technologies. It uses a parabolic mirrored dish similar to a large satellite to concentrate sunlight onto a thermal receiver. The thermal receiver, mounted at the focal point of the dish, absorbs and transfers the heat to an engine or generator. The most common type of heat engine used today in dish/engine systems is the Stirling engine. A Stirling engine uses the fluid heated by the receiver to move pistons and create mechanical power. Mechanical work turns a crankshaft, which drives a generator and produces electricity. To maximize the amount of solar energy captured by the dish/engine collectors, the dish assembly is mounted on a tracking structure that follows the sun across the sky.

2.2.3 Power Tower Systems

Power tower systems use a large field of flat, sun-tracking mirrors, known as heliostats, to focus sunlight onto a receiver, which is located atop a tower. A fluid in the receiver, either water/steam or molten nitrate salt, is heated and used to generate steam, which, in turn, is used in a conventional turbine generator to produce electricity. The molten nitrate salt has heat-transfer and energy-storage capabilities, which allows for production of electricity during cloudy weather and at night.

Thermal Energy Storage

Sunlight is an intermittent resource. No solar radiation is available at night, and cloud cover, smog, or haze can further limit generation from a solar power plant. In a concentrating solar power system, fossil fuel hybridizations provide a means to produce power during periods of low or non-existent solar radiation. In addition, heat energy storage is viable for power tower and parabolic trough technologies in which oil or molten salt is used as the heat-transfer medium.

Thermal energy storage technologies include two-tank indirect systems, two-tank direct systems, and single-tank thermocline systems. A two-tank direct thermal energy storage system stores the thermal energy in the same fluid that was used to collect it. A two-tank indirect thermal energy storage system uses different fluids to collect and store the heat. Both systems store the fluid in two separate tanks—one at high temperature and the other at low temperature. A single-tank thermocline system stores the thermal energy in a solid medium, most commonly silica sand, located in a single tank.

2.2.4 Emerging Technologies

The technologies described above are those that are in use at the time of this writing. Leading up to 2012, private entities and government agencies have invested substantially in the development of new solar technologies to allow for the cheaper and more efficient capture of solar energy. It is expected that further technological advancements will be made.

2.3 WHAT BLM ACTIONS ARE INVOLVED IN SOLAR ENERGY DEVELOPMENT?

Solar energy development on BLM-administered lands is managed through ROW authorization under Title V of the Federal Land Policy and Management Act of 1976, 43 CFR 2800, and current applicable BLM Instruction Memoranda. This guidance is expected to change over time and new Instruction Memoranda are expected to be developed.

A ROW grant is an authorization that allows for specific use of a piece of public land for a certain project. A solar energy development ROW authorizes all facilities on public lands including solar collectors, tower, turbine generator, fossil-fuel fired generator for hybrid systems, thermal storage, access roads, electrical and transmission facilities, and other testing and support facilities. Installation of a photovoltaic system as part of another authorized facility or use does not require a separate authorization. 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. In addition, an approved plan of development for construction and operation of the solar facility must be completed prior to beginning construction.

ROW applications for solar energy development projects are identified as a high-priority BLM Field Office workload, consistent with the President's National Energy Policy of 2001 and the Energy Policy Act of 2005. The term length of the authorization is not limited by regulation (43 CFR 2805.10[a][3]); however, it should recognize the overall costs and useful life of solar energy facilities (43 CFR 2805.11[b][3]). The term of the solar energy authorization for a commercial facility should not exceed the design life of the project, typically 30 years. The authorization may be renewed consistent with the provisions of the regulations (43 CFR 2807.22[a]). Other compatible uses may be authorized but are unlikely due to the intensive use of the site for photovoltaic or concentrating solar power facility equipment. All solar energy ROW authorizations are subject to annual rent, as established by the BLM, unless they are specifically exempt from rent by statute or regulation.

In addition, the solar energy development policy requires that all solar energy project ROW applications be subjected to environmental review in accordance with the requirements of the National Environmental Policy Act of 1969. The scope of the National Environmental Policy Act analysis and compliance requirements of the Endangered Species Act, Migratory Bird Treaty Act, National Historic Preservation Act, and other laws for a solar energy development ROW application should address the installation, maintenance and reclamation 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, electrical inverters, and transmission facilities.

2.4 How are Potential Levels Defined for Solar Energy?

Solar energy potential is determined using solar insolation values measured in kilowatt-hours per square meter per day (kWh/m^2/day). Concentrating solar power solar resource potential is based on direct normal solar radiation values. Photovoltaic solar insolation values represent the resource available to a flat-plate collector, oriented due south, at an angle from horizontal equal to the latitude of the collector location.

In addition to solar insolation values, factors such as slope of the land, proximity to roads, transmission lines, water resources, and population centers, as well as average wind speeds and vegetation concentration must be considered when determining a site's potential for solar development.

2.5 SOLAR POTENTIAL

2.5.1 Data Sources

The main source of solar potential data in the US is available through the US Department of Energy's (DOE) National Renewable Energy Laboratory (NREL). The NREL offers national 10-kilometer and 40-kilometer resolution maps of photovoltaic and concentrating solar power resources. The maps provide annual and monthly average daily totals for each resource type. For photovoltaic solar radiation, the insolation values represent the resource available to a flat-plate collector, oriented due south, at an angle from horizontal equal to the latitude of the collector location. The concentrating solar power solar radiation maps represent direct normal radiation values for receptors that track the sun throughout the day. In addition to direct normal irradiance maps (typical for concentrating solar power) and latitude tilt maps (typical for photovoltaic solar), NREL provides global horizontal irradiance data, which represents total solar radiation (the sum of direct, diffuse, and ground-reflected radiation).

The 10-kilometer resolution maps are based on the State University of New York data, which use a model that incorporates hourly radiance images from geostationary weather satellites, daily snow cover data, and monthly averages of atmospheric water vapor, trace gases, and the amount of aerosols in the atmosphere to calculate the hourly total insolation falling on a horizontal surface. The 40-kilometer resolution maps are based on the Climatological Solar Radiation model, which used information on cloud cover, atmospheric water vapor and trace gasses, and the amount of aerosols in the atmosphere to calculate daily total insolation falling on a horizontal surface.

NREL also provides a Dynamic Solar Atlas that provides resource information for any location in the US. It provides access to spreadsheets giving average monthly radiation values for 14 different types of solar collectors. Data for individual collectors are also available for fixed, flat-plate photovoltaic collectors on five different orientations. The dynamic map also accesses the monthly average photovoltaic watts calculator, a software program that calculates electrical energy produced by grid-connected photovoltaic systems.

NREL provides additional concentrating solar power resource maps for the southwest on its Concentrating Solar Power Research page of its website (NREL 2010a). These maps of direct-normal solar radiation are filtered by solar resource and land availability and identify the most economically suitable lands available for deployment of large-scale concentrating solar power plants. There are two types of maps provided for each state: maps that exclude lands with slopes greater than one percent and those that exclude lands with slopes greater than three percent. Major urban areas, potentially sensitive environmental lands, water features, and areas with less than one square kilometer are excluded from these maps.

The 10-kilometer resolution maps provide a higher level of detail on solar irradiance than the 40-kilometer resolution maps. Given the size of the planning area being considered in this assessment, a higher resolution data set was considered more appropriate. Thus, the 10-kilometer State University of New York data were used for this analysis.

There are two major existing BLM assessments addressing solar resource potential on public lands in the US that utilize the NREL solar potential data: the BLM and DOE's Renewable

Potential Energy Assessment (BLM and DOE 2003) and the Solar Energy Development Programmatic EIS (BLM and DOE 2012).

2.5.2 BLM/DOE Renewable Potential Energy Assessment

In 2003, the BLM, in collaboration with NREL, conducted an assessment of renewable energy resources including solar, biomass, geothermal, water, and wind energy on BLM-administered lands in the western US (BLM and DOE 2003). The objective of this assessment was to identify BLM-administered lands with highest potential for renewable energy development.

This assessment used NREL 40-kilometer resolution solar data and developed screening criteria in order to analyze and assess the potential solar energy resources on public lands. The screening criteria for the concentrating solar power central generation technology were (in order of importance):

- Direct normal radiation of at least 5 kWh/m^2/day
- Slope of the land less than 5 percent
- Transmission availability within 50 miles (within the 69- to 435-kilovolt range) and transmission capacity availability
- Minimum parcel size of 40 acres
- Within 50 miles of roads or railroads
- BLM-compatible land use

The screening criteria for large-scale photovoltaic development included:

- Direct normal radiation of at least 5 kWh/m^2/day
- Transmission availability within 50 miles of transmission lines within the 115- to 345-kilovolt capacity range
- BLM-compatible land use

2.5.3 Solar Energy Development Final Programmatic EIS

The Solar Energy Development Programmatic EIS (BLM and DOE 2012) was prepared by the DOE's Energy Efficiency and Renewable Energy Program and the BLM to assess environmental impacts associated with the development of utility-scale solar energy in six western states (Arizona, California, Colorado, New Mexico, Nevada, and Utah). The Programmatic EIS analyzed potential impacts associated with utility-scale solar projects that can generate 10 megawatts or more of electricity to be put directly into the transmission grid. Trough, dish, and tower concentrating solar power, as well as flat-panel and concentrating photovoltaic technologies, were included in the Programmatic EIS analysis.

Maps representing low, moderate, and high potential for concentrating and photovoltaic solar resources on BLM-administered lands for the six states included in the analysis are included. The data for this analysis was obtained from the NREL 10-kilometer resolution database.

In the Programmatic EIS, lands with excellent solar resources, suitable slope, proximity to roads and transmission lines, and containing at least 2,000 acres of BLM-administered lands were considered for solar energy study areas. Sensitive lands, wilderness, and other high-conservation-value lands, as well as lands with conflicting uses, were excluded. Solar energy study areas in the BMD include Millers and Gold Point; both solar energy study areas are located within the TFO.

The Programmatic EIS has also committed to analyze lands with solar insolation levels greater than 6.5 kWh/m^2/day and slopes of less than 5 percent that exclude Wilderness Study Areas, National Conservation Areas, Areas of Critical Environmental Concern, and other sensitive lands. These areas must also be larger than one square kilometer to be considered for solar energy development.

2.5.4 Solar Potential Data Used in This Report

All of the available assessments on solar radiation, including the Solar Programmatic EIS, used either the 10-kilometer resolution State University of New York data or the 40-kilometer resolution Climatological Solar Radiation model data, are available through the NREL GIS database. Both data sets include maps of resource potentials for photovoltaic and concentrating solar power solar radiation nationwide, which were integrated into the US Atlas of Renewable Resources (NREL 2010b). In this interactive resource map, layers representing 10-kilometer resource data from 1998 through 2005 for Direct Normal, Global Horizontal, and Latitude Tilt data are available. The 40-kilometer resolution solar layer representing data sets gathered from 1961 to 1990 only for flat-plate tilted south at latitude are available.

This report uses 10-kilometer resolution data, direct normal for concentrating solar power and Latitude Tilt for photovoltaic available in NREL's GIS database.

2.6 POTENTIAL AREAS WITHIN THE BATTLE MOUNTAIN DISTRICT

As shown in **Figure 2-1**, Solar Energy Potential, on BLM-administered lands within the BMD area, 3,806,845 acres have good to excellent concentrating solar power resource potential (6.5 to 8 kWh/m^2/day) in variance areas. The identified high-potential variance areas for both concentrating solar power and photovoltaic solar resources are predominantly found in the TFO with minimal resources in the MLFO area.

A variance area is defined by the BLM as an area that may be available for a utility-scale solar energy ROW with special stipulations or considerations (see avoidance area in the Land Use Planning Handbook, Appendix C, page 21, Part E.9). The BLM is identifying all lands outside of exclusion areas and solar energy zones (SEZs) as variance areas for utility-scale solar energy development. The BLM will consider ROW applications for utility-scale solar energy development in variance areas on a case-by-case basis based on environmental considerations; coordination with appropriate federal, state, and local agencies and tribes; and public outreach. The responsibility for demonstrating to the BLM and other coordinating parties that a proposal in a variance area will avoid, minimize, or mitigate, as necessary, sensitive resources will rest with the applicant.

2.7 REASONABLE FORESEEABLE DEVELOPMENT SCENARIO

Two SEZs, within the TFO, were analyzed in the Solar Programmatic Environmental Impact Statement. The Millers SEZ is located approximately fifteen miles north of Tonopah, NV and is 16,787 acres. The Gold Point SEZ is located approximately twenty-five miles southwest of Goldfield, Nevada, and is 2,824 acres. There were no SEZs identified within the MLFO.

One solar project has been permitted by the TFO; this project is referred to as the Crescent Dunes project. It is currently under construction during the development of this reasonable foreseeable development and is anticipated to be producing power before January 1, 2014. The Crescent Dunes solar project is permitted to produce 110 megawatts of power and includes approximately 1,750 acres of surface disturbance.

Prior to approving the Crescent Dunes Solar project there was several applications in the TFO. The Crescent Dunes Solar project permitting created an environment that caused other applications to withdrew because of transmission capacity within the Tonopah area. Transmission capacity is a major factor in the feasibility and success of solar energy projects, particularly in remote areas such as the TFO. Without existing adequate transmission capacity, the likelihood of large-scale solar energy development in the TFO is low. It is anticipated that there will not be additional applications until the transmission capability has improved. However, the BMD has been encouraging proponents to include solar energy opportunities as a component of their plans of development for their projects. This has been encouraged for two reasons: 1) the development of solar energy within their operational boundary would reduce the amount of electricity needed from the grid, reducing the cost of production; and 2) if a solar energy component is part of the development plan, additional solar capacity could be developed during the reclamation of the project, which could provide power to the community and reduce the cost for reclamation.

The Gibillini Mining Project has included in its plan of operation the development of solar energy on a small scale of approximately 10 megawatts. The Gibillini Mining project is in early stages of its application but demonstrates the potential for utilizing small-scale solar energy production as a part of its development projects. Within the next 20 to 30 years, there is a reasonable expectation that the BMD will have similar small scale solar energy production components as part of future plan of operation submittals. These anticipated small solar developments would be developed as part of the plans of operations for mines and would be within the plan of operation boundaries, resulting in minimal additional surface disturbance

The TFO has the capability to produce a large amount of power if transmission capability is improved.

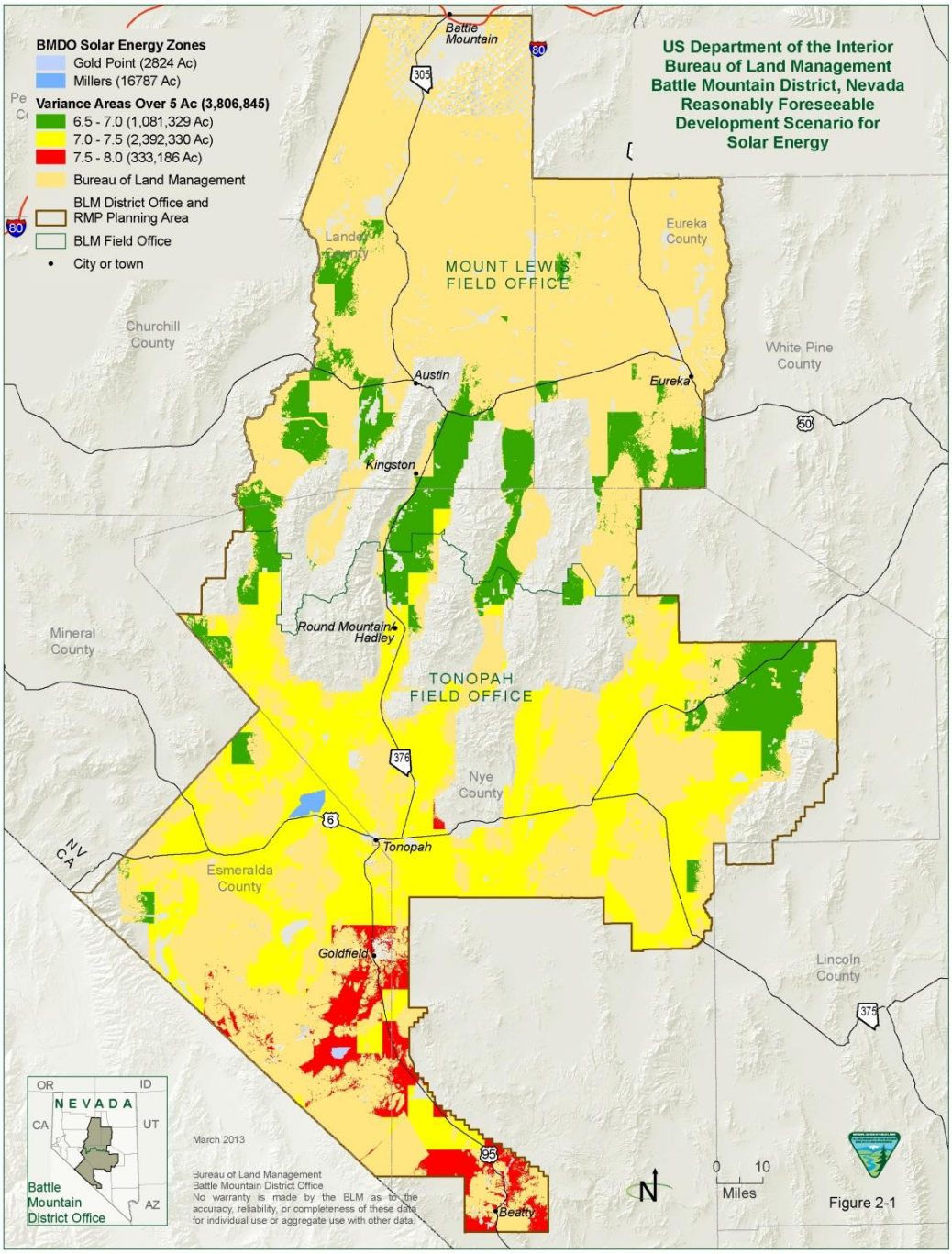

Figure 2-1 Solar Energy Potential

CHAPTER 3
WIND ENERGY

3.1 WHAT IS WIND ENERGY?

Wind is a form of solar energy. Solar radiation causes uneven heating of the atmosphere, producing regions of high and low pressure. This pressure gradient results in movement of air from high-pressure to low-pressure regions, creating wind. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetative cover. This wind flow when harvested by modern wind turbines can be used to generate electricity.

The terms wind energy and wind power describe the process by which the wind is used to generate mechanical power or electricity. Because air has mass, moving air carries with it kinetic energy. Wind turbines convert the wind's kinetic energy into mechanical power. This mechanical power can be used for specific tasks such as grinding grain, pumping water, or producing electricity.

3.2 HOW IS WIND ENERGY DEVELOPED?

A wind turbine is a mechanical assembly that converts the energy of wind into electricity. A wind turbine consists of a blade or rotor, a drive train (usually including a gearbox and a generator), a tower, and other equipment including controls, electrical cables, ground support equipment, and interconnection equipment. The blades turn in the moving air and power an electric generator that supplies an electric current. The blades act much like an airplane wing. When the wind blows, a pocket of low-pressure air forms on the downwind side of the blade, causing the blade to be pulled toward that pocket. This force causes the rotor to spin like a propeller and turn a shaft. The rotational energy of the shaft turns the generator and makes electricity. Wind turbines are mounted on a tower to enable them to capture the most energy. Tower height affects the amount of power that can be extracted by a given wind turbine. At 30 meters or more above ground, wind turbines can take advantage of the faster and less-turbulent wind.

Wind turbines fall into two basic groups, which include the horizontal-axis variety (propeller-style) like traditional farm windmills and the vertical-axis design like the eggbeater-style Darrieus model. The horizontal-axis type turbines are the most common, constituting nearly all the

utility-scale turbines. These typically have either two or three blades. The three-blade turbines are operated upwind with their blades facing into the wind.

Wind turbines are available in a variety of sizes and power ratings. Utility-scale wind turbines for land-based wind farms have rotor diameters ranging from 40 to about 120 meters, and towers of roughly 40 to 130 meters high.

Utility-scale turbines range in power rating from 100 kilowatts to as large as several megawatts. Larger turbines are grouped together into wind farms, which provide bulk power to a utility power grid. Wind power plants are modular, which means they consist of small individual modules (turbines) and, depending on electricity demand, can easily be made larger or smaller.

Single small turbines, below 100 kilowatts, are used for homes, telecommunications, or water pumping. Small wind systems also have potential as distributed energy resources. These systems, called hybrid wind systems, operate in connection with diesel generators, batteries, and photovoltaic systems in remote, off-grid locations where a connection to the utility grid is not available.

3.3 WHAT BLM ACTIONS ARE INVOLVED IN WIND ENERGY DEVELOPMENT?

Wind energy development on BLM-administered lands is managed through ROW authorization in accordance with the terms and conditions of BLM's Wind Energy Development Policy (Instruction Memorandum 2009-043 [BLM 2009]). This guidance is expected to change over time.

The BLM's Wind Energy Development Policy provides guidance on processing ROW applications for wind energy site testing and monitoring facilities, as well as applications for wind energy development projects on BLM-administered lands. Under this policy, all wind energy applications are processed in accordance with the requirements of Title V of the Federal Land Policy and Management Act of 1976 and 43 CFR 2800, "Right-of-Way under the Federal Land Policy Management Act." Under this policy, developers may apply for the following three types of wind energy ROW grants:

- A site-specific grant for testing and monitoring
- A project-area grant for testing and monitoring
- A development grant

A site-specific grant is used to authorize individual meteorological towers and instrumentation facilities. The area authorized for these facilities is the minimum area required for construction and maintenance of the temporary facility (including access roads). Under the current guidance, the term of this grant is limited to three years from the date of issuance and may not be renewed. The BLM may allocate numerous site-specific grants to various ROW holders in the same area without any exclusive rights regarding future wind energy development. In addition, the BLM retains the right to authorize other compatible uses of public lands in the area.

A project-area grant with provisions for renewal beyond the three-year term authorizes wind energy site testing and monitoring facilities for a project area. The project area describes an area

of land where wind resource information is being collected to determine the area's wind energy resource potential. The holder of the project area grant retains an interest in the site testing and monitoring project area, which precludes other wind energy ROW applications during the three-year term of the grant. However, for any future wind energy development proposals, the holder of the grant is required to submit a separate ROW application and plan of development to the BLM for review.

A development grant authorizes all facilities related to a commercial wind energy development project on public lands. This authorization includes the wind turbine facilities, onsite access roads, electrical and distribution facilities, and other support facilities authorized by the wind energy development ROW grant. The lands involved in the development grant are defined by aliquot legal land descriptions and configured to minimize the amount of land involved, while still allowing an adequate distance between turbine positions and reasonable ROW boundaries. In the absence of any specific local zoning and management issues, no turbine will be positioned closer than five rotor-diameters from the center of the wind turbine to the ROW boundary in the dominant upwind or downwind direction to avoid potential wind turbulence interference issues with adjacent wind energy facilities, unless it can be demonstrated that site conditions, such as topography, natural features, or other conditions (e.g., offsets of turbine locations) warrant a lesser distance. Further, for safety reasons, no turbine on public land will be positioned closer than 1.5 times the total height of the wind turbine to the ROW boundary.

In addition, the wind energy development policy requires that all wind energy project ROW applications, whether for site testing and monitoring or for commercial development, be subjected to environmental review in accordance with the requirements of National Environmental Policy Act of 1969 and that such development be in compliance with the requirements of the Endangered Species Act, Migratory Bird Treaty Act, National Historic Preservation Act, and other appropriate laws.

3.4 HOW ARE POTENTIAL LEVELS DEFINED FOR WIND ENERGY?

Wind speed is a crucial element in projecting turbine performance, and a site's wind speed is measured through wind resource assessment prior to a wind system's construction. The power available in the wind is proportional to the cube of its speed, which means that a slightly higher wind speeds will produce a significantly higher power. Generally, an annual average wind speed greater than four meters per second (nine miles per hour) is required for small wind electric turbines. Less wind is required for water-pumping operations. Utility-scale wind power plants require minimum average wind speeds of 6 meters per second (13 miles per hour). Wind resources are characterized by wind power density classes, which range from Class 1 (the lowest) to Class 7 (the highest).

While the technical characteristics of the wind in a specific location are very important, many other factors also contribute to siting decisions. A location far removed from the power transmission grid might be uneconomic, as new transmission lines would be required to connect the wind farm to the grid. Soil conditions and the terrain must be suitable for the construction of the towers' foundations. Surface roughness is another determining factor because it determines the amount of turbulence a turbine will experience. Turbulent winds put greater stresses on the rotor and tower, reducing the turbine's lifespan as a result.

3.5 WIND POTENTIAL

3.5.1 Data Sources

The main source of data on wind potential in the US is available through the DOE's NREL. The NREL's GIS offers a national wind resource assessment of the US as well as high-resolution wind data. The national wind resource assessment was developed in 1986 for the DOE by the Pacific Northwest Laboratory, which is documented in the Wind Energy Resource Atlas of the US (DOE 1986). The NREL website (NREL 2009b) provides a dynamic map based on the Wind Energy Resource Atlas of the US (NREL 2010c). In this assessment, the conterminous US was divided into grid cells one quarter of a degree of latitude by one third of a degree of longitude. Each grid cell was assigned a wind power class ranging from Class 1 (the lowest) to Class 7 (the highest), representative of the range of wind power densities. The wind power density limits for each wind power class are shown in **Table 3-1**, Classes of Wind Power Density at 10 Meters and 50 Meters, below.

In **Table 3-1**, Classes of Wind Power Density at 10 Meters and 50 Meters, the wind power classes represent different wind power densities at different heights above ground (10 and 50 meters). The data depicted in the NREL's wind resource potential map represents wind power densities at 50 meters above ground, which is typical for utility-scale wind turbine application. Estimates at the 30-meter level are useful for identifying small wind turbine opportunities; however, such data are yet to be developed. In the NREL's assessment, areas designated Class 3 or greater are considered suitable for utility-scale applications, while Class 2 areas are marginal, and Class 1 areas are generally not suitable for utility-scale uses. According to the NREL's assessment, wind power Class 2 may be suitable for rural applications, and wind power Class 1 in locations such as exposed hilltops may be adequate for wind turbine applications.

High-resolution data are separated into two groups: NREL-produced and TrueWind-produced/NREL validated. The NREL-produced map data apply to areas of low surface roughness (e.g., grasslands) and areas with slopes less than 20 percent, while the TrueWind-produced estimates factor in surface roughness and include all slopes. The data produced by TrueWind were obtained in cooperation with the DOE's Wind Powering America program and have been validated by NREL and other wind energy meteorological consultants.

The Wind Powering America program provides a nationwide wind resource map, which is a combination of high-resolution and low-resolution databases for the US. The map shows the annual average wind power estimates at a height of 50 meters. The areas unlikely to be developed onshore due to land use or environmental issues have been excluded from this assessment. Only moderate- and high-potential areas (wind power Class 3 and above) are represented in this assessment.

Table 3-1
Classes of Wind Power Density at 10 Meters and 50 Meters

Wind Power Class	Resource Potential (Utility Scale)	Wind Power Density (watts per square meter) at 10 Meters Above Ground	Speed (miles per hour) at 10 Meters Above Ground	Wind Power Density (watts per square meter) at 50 Meters Above Ground	Speed (miles per hour) at 50 Meters Above Ground
1	Poor	0–100	0–9.8	0–200	0–12.5
2	Marginal	100–150	9.8–11.5	200–300	12.5–14.3
3	Moderate	150–200	11.5–12.5	300–400	14.3–15.7
4	Good	200–250	12.5–13.4	400–500	15.7–16.8
5	Excellent	250–300	13.4–14.3	500–600	16.8–17.9
6	Outstanding	300–400	14.3–15.7	600–800	17.9–19.7
7	Superb	400–1000	15.7–21.1	800–2000	19.7–26.6

Source: NREL 2009b

The Wind Powering America program also provides high-resolution data at 50 meters for individual states (when such data are available). The data represent low-, moderate-, and high-potential areas for wind development. According to this assessment, wind power Class 4 or higher is sufficient for generating wind power with utility-scale turbines. Particular locations in Class 3 areas could have higher wind power class values at 80 meters than at 50 meters.

There are two major existing BLM assessments addressing wind resource potential on public lands that utilize the NREL wind potential data. These include the BLM/DOE Renewable Potential Energy Assessment (BLM and DOE 2003) and the Wind Energy Development Programmatic Environmental Impact Statement (BLM 2005).

3.5.2 BLM/DOE Renewable Potential Energy Assessment

In 2003, the BLM, in collaboration with the NREL, conducted an assessment (BLM and DOE 2003) of renewable energy resources including solar, biomass, geothermal, water, and wind energy on BLM-administered lands in the western US. The objective of this assessment was to identify BLM-administered lands in the western US with highest potential for renewable energy development. The assessment used NREL's high-resolution data, when such data were available, and the 1987 low-resolution data, also available through the NREL. The following screening criteria (in order of importance) were developed for targeting high-potential wind resource potential areas:

- Wind power Class 3 and above
- Within 25 miles of transmission lines with capacity in the range of 69 to 345 kilovolts
- Within 50 miles of a major road or railroad

- BLM-compatible land use

3.5.3 Wind Energy Development Final Programmatic EIS

The Wind Energy Development Final Programmatic EIS (BLM 2005) evaluates the potential impacts associated with wind energy development on BLM-administered lands in the western US, excluding Alaska. For this Programmatic EIS, NREL developed a maximum potential development scenario in order to define the potential for future wind energy development on BLM-administered lands. NREL utilized the same methodology and screening criteria that was employed in the BLM's 2003 Renewable Potential Energy Assessment (BLM and DOE 2003) discussed above. In addition to the maximum potential development scenario, the NREL used a different model (the Wind Deployment System) to project the amount of wind power that might be generated over the next 20 years in the study area.

Maps depicting BLM-administered lands with low, medium, and high potential for wind energy development are available for 11 western states (BLM 2005). Wilderness Areas, Wilderness Study Areas, National Monuments, and National Conservation Areas were excluded from the maps. Lands categorized as having low potential fall in wind power Classes 1 and 2. Lands with wind power Class 3 are considered medium potential, while wind resources of Class 4 and above are economically developable with current technology. Most of the BLM-administered lands in the BMD have only low potential for wind energy development.

3.5.4 Wind Potential Data Used in this Report

For this analysis, the available high-resolution data created by TrueWind Solutions were used, as was done in the Wind Energy Development Final Programmatic EIS (BLM 2005). The data have been verified by the NREL and are also utilized in the assessment done by the Wind Powering America program.

3.6 POTENTIAL AREAS WITHIN THE BMD AREA

Within the BMD area, wind potential is generally marginal to poor with approximately 90 percent of the planning area in these classes. Outstanding to superb wind potential areas (Classes 6 and 7) have been identified on 4,706 acres, while 10,404 acres have excellent (Class 5) wind potential, and 38,902 acres have good (Class 4) wind potential. The identified high-potential areas are shown with these potential classes in **Figure 3-1**, Wind Potential.

3.7 REASONABLE FORESEEABLE DEVELOPMENT SCENARIO

The likelihood of future development of wind projects in the BMD area can be estimated by considering the quality of wind resources, existing wind projects in the area, the number of pending ROW applications within the BMD, the quality of wind resources in the BMD compared with other areas in the region, and expressions of interest by wind companies.

As previously outlined, wind energy potential is generally marginal to poor in the planning area, and only small areas have been identified as having high potential (Class 4 or higher) for wind energy development.

Over the past four years there have been up to six meteorological towers constructed within the BMD for wind testing. The testing was conducted in both the TFO and the MLFO at four different locations. Wind meteorological tower projects can be conducted for up to three years

with an option to extend if it is proven that the need for additional testing is essential. All meteorological tower projects have been removed and reclamation was conducted by the proponents. Currently, there are no wind projects within the BMD. Additionally, there are no existing wind ROWs and there have not been any applications received to proceed with either a wind testing or a wind development project within the BMD. Similar to what was outlined in the solar energy reasonable foreseeable development, transmission capacity is a major factor in the feasibility and success of wind energy projects, particularly in remote areas such as the BMD. Without existing, adequate transmission capacity the likelihood of wind energy development in the BMD is low. There are no current transmission ROW applications nor has there been any interest expressed for future transmission ROWs within the BMD.

The closest ROW authorization for a wind energy development project is located near Ely, Nevada.

Due to the limited size of plots of BLM-administered land with good-quality wind resources, the lack of wind projects in the BMD, the lack of pending ROW applications in the BMD, lack of transmission capabilities and transmission ROWs application interest, and the fact that much better wind resources occur in other parts of the state, it is not expected that commercial-scale wind energy projects would be developed within the planning area by year 2030.

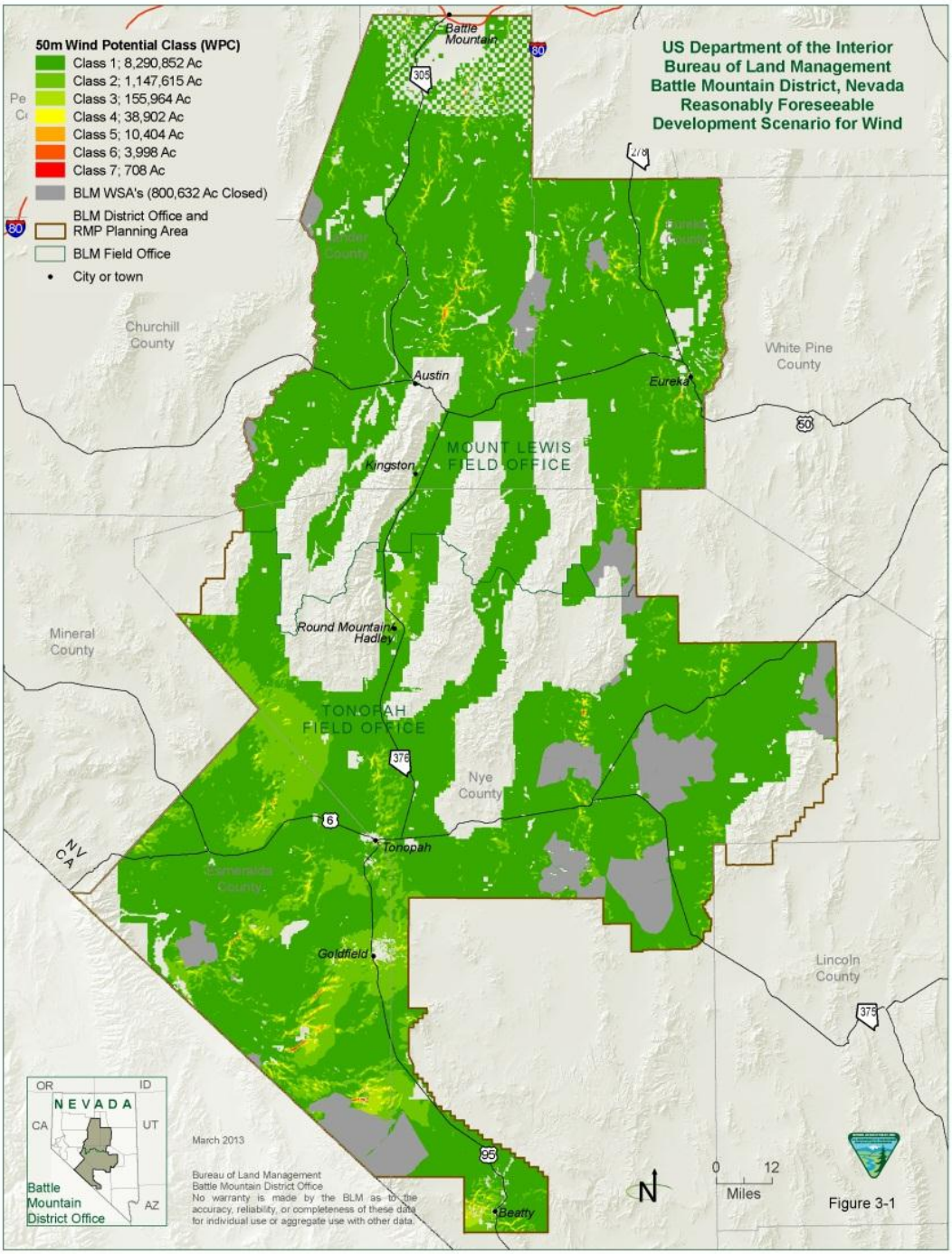

Figure 3-1 Wind Potential

CHAPTER 4
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