County of San Bernardino General plan

Renewable Energy and Conservation Element – Background Report

REN-12-002

Prepared for

County of San Bernardino

Land Use Services Division
385 North Arrowhead Avenue, 1st Floor
San Bernardino, CA 92415-0182

Prepared by

PMC, a Michael Baker International Company
860 Walnut Street
San Luis Obispo, CA 93401

In association with

Aspen Environmental Group
5020 Chesebro Road, Suite 200
Agoura Hills, CA 91301

DRAFT
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This version of the Renewable Energy and Conservation Element is based on Phase 1 SPARC. Phase 2 will look more closely at costs and benefits of proposals before adoption of the Element. This draft will be updated prior to Element adoption by the County Board of Supervisors.

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List of Abbreviations

AB: Assembly Bill

BLM: Bureau of Land Management

Btu: British thermal unit

CAA: Clean Air Act

CAISO: California Independent System Operator

CCA: community choice aggregation

CDFW: California Department of Fish and Wildlife

CDP: census designated place

CEC: California Energy Commission

CEQA: California Environmental Quality Act

CPUC: California Public Utilities Commission

CPV: concentrated photovoltaic

CSA: county service area

CSI: California Solar Initiative

CSP: concentrated solar power

CUP: Conditional Use Permit

DOD: Department of Defense

DOE: Department of Energy

DOI: Department of the Interior

DRECP: Desert Renewable Energy Conservation Plan

DTSC: Department of Toxic Substances Control

ECR: Enhanced Community Renewables

EIA: Energy Information Administration

EPA: Environmental Protection Agency

ESA: Endangered Species Act

EV: electric vehicle

FEMA: Federal Emergency Management Agency

GHG: greenhouse gas

GPCD: gallons per capita per day

GTSR: Green Tariff Shared Renewables

GW: gigawatt

GWh: gigawatt-hour

HCP: habitat conservation plan

HERO: Home Energy Renovation Opportunity

HVAC: heating, ventilation, and air conditioning

IOU: investor-owned utility

IPP: independent power producer

ISEGS: Ivanpah Solar Electric Generating System

JPA: joint powers authority

kV: kilovolt

kW: kilowatt

kWh: kilowatt-hour

LADWP: Los Angeles Department of Water and Power

LCE: Lancaster Choice Energy

LCOE: levelized cost of energy

MCE: Marin Clean Energy

MOU: memorandum of understanding

MSP: Mojave Solar Project

MSW: municipal solid waste

MUP: Minor Use Permit

MW: megawatt

MWh: megawatt-hour

NEM: net energy metering

NOx: nitrous oxides

NREL: National Renewable Energy Laboratory

PACE: property assessed clean energy

PG&E: Pacific Gas and Electric Company

POU: publicly owned utility

PPA: power purchase agreement

PV: photovoltaic

RPS: Renewables Portfolio Standard

SANBAG: San Bernardino Associated Governments

SB: Senate Bill

SCAG: Southern California Association of Governments

SCE: Southern California Edison

SCG: Southern California Gas Company

SCP: Sonoma Clean Power

SEGS: Solar Electric Generating Systems

SUP: Special Use Permit

USFWS: US Fish and Wildlife Service

USGS: US Geological Survey

ZNE: zero net energ

I. Technical Background

This Technical Background chapter of the Appendix contains the following sections:

Energy Basics: A summary of the different forms of energy, the difference between energy and power, and the units used to measure energy and power.

Renewable Energy and Energy Storage Resources and Technologies: A detailed discussion of the three solar energy technology types (solar photovoltaic, solar thermal, and solar water heating), wind, bioenergy, and energy storage. This section includes how these technologies work, various forms and applications of these technologies, and how they have been used in a local or regional context. This section also discusses how renewable energy is defined, summarizes other types of renewable energy, and explains the difference between renewable energy and non-polluting energy.

Energy Generation and Consumption in California: An overview of how much energy California uses, the resources used to generate the energy used in California, and how the amount of electricity from various renewable sources in the state has changed over time.

Energy Generation and Consumption in San Bernardino County: A description of how much energy is used in San Bernardino County and how energy use varies in the different regions of the county, how the county's different climate zones affect energy use, and how home heating fuels are used in the county. This section also contains an overview of the power plants and rooftop solar energy installations in San Bernardino County.

Regulatory Framework: A detailed discussion of the federal and state agencies and laws/statutes that affect renewable energy development.

Energy Basics

"Energy," broadly speaking, is the ability to do work. The many forms of energy include kinetic (the energy of a moving object), chemical, electrical, thermal, and magnetic. While every object has some amount of energy (usually multiple types), it is not always in a form that is useful to people and so has to be converted into another form. For example, natural gas has a high amount of chemical energy, which can be converted to thermal energy by igniting it in the presence of oxygen (combustion). This thermal energy can be used directly for heating or cooking, or it may be converted into electrical energy by a steam turbine and electrical generator.

Electrical energy is often equated with power, although the two refer to disparate (but related) concepts. Power is the rate at which energy is generated or used and is measured in watts (W). It is used when discussing the amount of energy that is generated or used at any given second. For example, the wattage of a light bulb (e.g., a 60-watt bulb) refers to how much energy the bulb uses for each second that it is on. If the bulb is left on for one hour, it will have used 60 watts for each second that it is on, or 60 watt-hours (Wh). Energy is measured in watt-hours.[1]

Watts and watt-hours refer to relatively small amounts of power and energy, and so are usually expressed in multiples. These multiples are shown in **Table 1**.

Natural gas is usually measured in therms, which is the amount of thermal energy released by burning 100 cubic feet of gas. Energy from natural gas can be expressed in watt-hours (one therm is equal to 29.3 kWh), although this is rare.

Table 1: Energy and Power Multiple Units

Number	Energy			Power		
	Unit	Abbreviation	Example Use	Unit	Abbreviation	Example Use
One thousand	Kilowatt-hour	kWh	The electrical energy use of a house	Kilowatt	kW	The power output of a rooftop solar panel
One million	Megawatt-hour	MWh	The electrical energy use of a large industrial building	Megawatt	MW	The power output of a power plant
One billion	Gigawatt-hour	GWh	The electrical energy use of a state	Gigawatt	GW	The power output of all power plants in a state

[1] In scientific applications, the standard unit for energy is the joule (J). This Element will measure energy in watt-hours and related units because they are more familiar to most people than the joule. One watt-hour is equal to 3,600 joules.

Renewable Energy and Energy Storage Resources and Technologies

Renewable energy refers to energy produced from a resource that is capable of replenishing itself through natural processes over a relatively short period of time. The term "rapidly renewable" is occasionally used to distinguish resources such as sunlight and wind from resources that are renewable but may take longer to regenerate (wood, for example). California law recognizes energy from the following resources and technologies as renewable (CEC 2013a):

- Certain types of bioenergy, including thermal conversion of plant or nonrecyclable paper, biogas or biomethane produced from organic waste, and biodiesel from specific waste products
- Fuel cells that use an eligible renewable resource (usually derived from biomass), or hydrogen produced from a non-fossil fuel source driven by electricity from renewable sources
- Geothermal
- Hydroelectric, if the power capacity of the system is less than 30 megawatt (MW) (or 40 MW if the system is part of a water supply or conveyance system and was under contract before 2006), or if it comes from efficiency improvements to facilities operational before 2007 and meeting specific requirements
- Municipal solid waste, if the waste is processed in very specific ways to produce a clean-burning gas or liquid fuel that is burned to generate electricity[2]
- Ocean wave
- Ocean thermal
- Solar, including both photovoltaic and thermal
- Tidal current
- Wind

Facilities that produce electricity from the above resources can submit a request to the California Energy Commission (CEC) to be certified as eligible renewable energy facilities. Energy storage facilities, which store surplus electricity for use at a later time, may also be certified as eligible facilities

[2] The Stanislaus Resource Recovery Facility south of Patterson does not meet these requirements but is specifically designated as an eligible renewable resource under California Public Utilities Code Section 399.12(e)(2) (CA PUC n.d.)

if they meet specific requirements (). Facilities that the CEC deems eligible can sell electricity that counts toward the goal of California's Renewables Portfolio Standard (RPS).

Renewable energy resources are commonly equated with nonpolluting, although this is not always the case. Biomass resources often produce some amount of air pollution and greenhouse gases (GHGs) when they are burned, although these unwanted emissions may be much lower than emissions from a comparable amount of fossil fuels. In a similar vein, not all nonpolluting energy resources are considered renewable. Nuclear fission, which uses a controlled reaction to split apart elements of a radioactive material (usually uranium), does not produce any air pollution or GHGs but is not considered a renewable energy technology because the radioactive material does not replenish itself. Large-scale hydroelectric facilities, while technically relying on a renewable resource (flowing water), are not considered renewable under state law.

Because eligible resources are defined by state law, they may vary among the 38 states with a standard or goal for renewable energy generation. The State of Pennsylvania, for example, allows facilities using certain types of coal or coal-derived energy sources to qualify for its version of RPS, called the Alternative Energy Portfolio Standard (DOE 2014a).

This Renewable Energy and Conservation Element focuses on solar, wind, and bioenergy technologies, as these are the renewable energy resources with the greatest potential in San Bernardino County. Energy generating facilities within the county may be able to use other types of renewable energy resources in a limited capacity.

Solar Energy

Solar energy technologies convert light from the sun into a usable form of energy. Although these technologies come in a number of forms, this element focuses on three: solar photovoltaic, solar thermal, and solar water heating.

Solar Photovoltaic

Solar photovoltaic (sometimes called solar PV or simply PV) technologies convert sunlight directly into electricity through devices called solar cells. Solar cells are built out of semiconducting materials, most commonly silicon, but occasionally they are made from more unusual materials such as cadmium telluride (CdTe) or copper indium gallium selenide (CIGS) among others; solar cells built of these more esoteric materials are mostly still in a research phase and have not yet achieved widespread commercialization (NREL 2011a).

Solar Photovoltaic

Photovoltaic (PV) technologies use panels composed of semiconducting materials that generate electricity when illuminated by sunlight. PV systems can range from small rooftop installations to solar farms covering hundreds or thousands of acres.

A typical silicon-based solar cell consists of a very thin layer of silicon that has been "doped" (intentionally and precisely contaminated) with phosphorus, sitting on top of a somewhat thicker layer of silicon doped with boron. The interaction of these materials creates an electric field between the two layers. When light strikes the cell, the energy in the light particles interacts with the electric field to create an electric current, which can be converted into the proper form and used (FSEC 2014). A typical solar panel consists of a number of these cells. While a lone solar cell or solar panel will produce electricity, most solar energy systems comprise a number of solar panels (collectively called an array).

A close-up of a crystalline solar cell (NREL 2011a)

Solar cells themselves come in three forms: crystalline, thin-film, and multijunction. Crystalline cells are by far the most common, comprising approximately 90% of all photovoltaic cells sold. The dominant form of a crystalline cell is called single-crystalline silicon, but other forms include hydrogenated amorphous silicon, microcrystalline, and multicrystaline (NREL 2014a). Thin-film cells, as the name implies, are thinner than conventional solar cells, which allows them to be integrated into surfaces where it would be infeasible to use the bulkier crystalline cells. This allows for unique applications, such as installing semitransparent thin-film solar cells between two layers of glass and installing the apparatus as a window in a building. Whereas crystalline cells are rigid, thin-film cells can be rigid or flexible (NREL 2011a). The most common form of thin-film cells is cadmium telluride, although many other types are available (ReportBuyer 2014). Multijunction solar cells are composed of at least three layers, creating multiple electric fields (in contrast to a traditional solar cell, which only has one field). They can be made from crystalline silicon as well as a number of other materials (NREL 2012a). The relatively high cost of these cells has limited their use thus far mostly to the aerospace industry, but research is under way to use them for more conventional energy generation purposes. One area that holds promise for multijunction solar cells is that of concentrated photovoltaics (CPV), where mirrors or lenses focus sunlight on a relatively small panel of cells (Kurtz 2012).

The solar panels in this array have been tilted to face the sun directly (NREL 2007).

The amount of energy produced by a solar panel depends on its positioning and the efficiency of its solar cells. In the northern hemisphere, the sun is usually in the southern part of the sky,[3] allowing solar panels to produce the greatest amount of energy when facing south (such panels can be said to have a south-facing orientation).[4] Solar panels should also be tilted for maximum production, so as to

[3] For locations above the Tropic of Cancer (23.5 degrees above the equator), the sun is always in the southern part of the sky. The southernmost part of San Bernardino County is approximately 34 degrees north of the equator.

[4] Although panels produce the most amount of electricity when facing south, the period of peak production is usually around noon. By contrast, the period of peak electricity demand is in the afternoon, when the sun is in the western part of the sky. Solar panels with a west-facing orientation have their period of peak production in the afternoon, corresponding to the period

face the sun as directly as possible rather than at an angle. The optimal tilt angle for a solar panel increases the farther north or south from the equator that the solar panel is positioned. To improve production, some solar panels are fixed to mounts attached to electric motors, allowing them to adjust their positioning (tracking). Solar panels that can adjust their tilt or orientation (but not both) are called single-axis tracking panels, while panels that can adjust both are called double-axis tracking panels. Tracking is most common on ground-mounted solar panel arrays, although some roof-mounted arrays can also track.

The other component of a solar cell's energy production is efficiency, which is the amount of light striking the cell that can be converted to electricity. The efficiency of a typical commercially available solar panel is currently around 15%–20%, depending on the type of solar cell and the manufacturer (Kelly-Detwiler 2013), although some recently available models can exceed 20% (Maehlum 2014). The efficiency of solar panels is continually increasing and records are often broken multiple times a year, although it may take a long period of time for improvements in experimental solar cells to appear in commercial products. As of the end of 2014, the most efficient solar cells were multijunction cells with at least five layers with an efficiency of 44.7%. The highest known efficiency for crystalline solar cells was 27.6%, with an efficiency of 23.3% for the most efficient thin-film cell (NREL 2014b).

Solar Thermal

Solar thermal technologies, also called concentrated solar power (CSP), concentrated solar thermal, or solar thermoelectric, use sunlight to heat a fluid (known as a working fluid). In most solar thermal facilities, the working fluid is used to heat water to generate steam, which then spins a generator turbine to produce electricity; this is the same principle used in traditional fossil fuel or nuclear power plants, except the heat is produced by the sun rather than by burning fossil fuels or nuclear fission. Some solar thermal technologies use the heat to drive a chemical reaction to produce electricity, although these are still experimental (PNNL 2012).

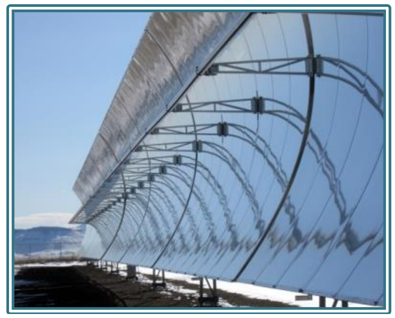
In all forms of solar thermal technologies, mirrors and lenses focus sunlight on a relatively small area. This concentration of solar energy produces high temperatures to heat the working fluid (in the same way that a magnifying glass can focus sunlight to high temperatures). The various types of solar thermal technologies depend on the configuration of the

Solar Thermal

Solar thermal technologies come in four configurations, but all use a system of mirrors to focus sunlight on a fluid, heating it to high temperatures. The heat from this fluid is converted to electricity, usually by a steam turbine. Solar thermal technologies are usually used in large, utility-scale installations.

of peak electricity demand. West-oriented panels may therefore be ideal in some circumstances, although their overall energy production is slightly lower than south-oriented panels (Itron 2011).

mirrors. There are four main types of solar thermal energy systems: parabolic trough, linear Fresnel, dish, and power tower (NREL 2014c).



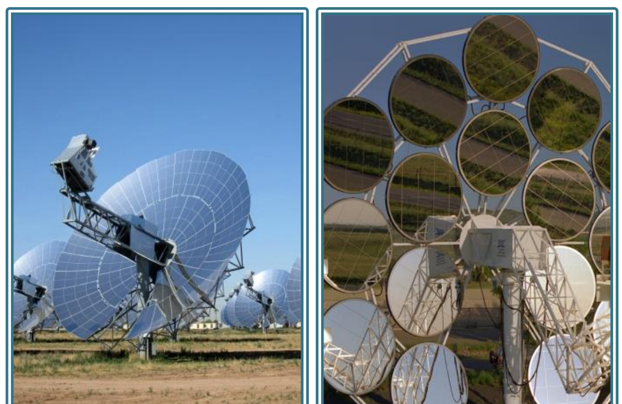
The curved mirrors of a parabolic trough system (NREL 2010a).

Parabolic trough systems consist of long rows of parabolic-shaped mirrors, with a slender tube containing the working fluid running above the mirrors. The tube is positioned above the mirrors at the focus point, where the reflected sunlight converges to create the high temperatures. Parabolic trough systems can adjust their tilt to maximize efficiencies (NREL 2014c).

The mirrors of a linear Fresnel system, each tilted at a slightly different angle to focus sunlight on the working fluid. (NREL 2010b).

Linear Fresnel systems are similar in many ways to parabolic trough systems, but the rows comprise multiple columns of flat mirrors rather than a single column of parabolic mirrors. Each mirror can adjust its tilt independently of the others to reflect sunlight on a tube of working fluid running above the rows (NREL 2014c).

Dish solar thermal systems rely on a large dish (similar in shape to a satellite dish) covered in mirrors. A receiver unit is mounted on an arm at the focal point of the dish; this receiver unit holds the working fluid at the optimal distance to be heated by the dish's mirrors. Each dish acts as an independent double-axis tracking system, adjusting both tilt and orientation for maximum production (NREL 2014c). A variation on this design, known as the dish Stirling, uses the working fluid to directly power a turbine, rather than creating steam. Dish systems have the highest efficiency among the solar thermal technologies (Sandia National Laboratory 2008).



Two variations of a dish solar thermal system (left: NREL 2010c; right: NREL 1996).

Solar power tower facilities use a large circular array of flat mirrors called heliostats, each of which acts as a double-axis tracking system. In the middle of the array is a tall tower, supporting the receiver unit that contains the working fluid. The heliostats adjust their tilt and orientation independently of each other to reflect sunlight onto the receiver unit (NREL 2014c). Because all sunlight collected by a solar power tower's mirrors is focused on a single receiver unit (unlike the other solar thermal technologies), power tower systems produce the highest temperatures, up to over 1,800°F (Martin and Goswami 2005).

The tower-mounted receiver units of a power tower system, surrounded by heliostats (NREL 2010d).

Parabolic trough and solar power tower systems are the two solar thermal technologies being used for widespread commercial energy production; linear Fresnel and dish systems are currently only used in a limited capacity, often for demonstration projects. San Bernardino County is home to examples of both systems. The Ivanpah Solar Electric Generating System (ISEGS) solar power tower facility, located near the unincorporated community of Nipton close to the Nevada border, is the largest solar thermal facility in the world as measured by capacity. The Solar Energy Generating System (SEGS), a parabolic trough system consisting of nine units in three locations, is the world's largest parabolic trough facility and the second largest solar thermal facility.

Unlike PV technologies, solar thermal technologies are almost exclusively used in large utility-scale electricity generating facilities. Solar thermal technologies are much less economically feasible at small scales, although there are no technical barriers that prevent small, distributed generation solar thermal facilities (UKDOE and UKDID 2013). Due to their size and complexity, solar thermal systems are virtually always ground-mounted.

Solar Water Heating

Solar water heating panels on the roof of a school (NREL 2011b).

Solar water heating technologies are used to supplement or replace conventional water heaters (usually powered by natural gas or electricity) in homes and nonresidential buildings. There are a number of different solar water heater designs, but all incorporate a receiver unit to collect the sun's energy and heat the water. A common design for homes uses a sheet of dark metal in an insulated box as a collector, positioned on the roof of the home in an area with high exposure to sunlight. Some systems, particularly those for large institutional or industrial use, use an arrangement of parabolic mirrors with a collector tube running above the mirrors (very similar to a parabolic trough solar thermal system). Other systems may use dark metal tubes as the collector unit, or even use the hot water tank itself as a collector unit.

Solar water heating systems can be categorized by the fluid in the collector unit. In a direct system, water circulates through the collector unit, allowing it to be directly heated by the sun. Indirect systems heat a working fluid, which then passes on the heat to the water inside of a hot water tank. Solar water heating technologies can also be categorized by how the water or working fluid moves through the system. In an active system, a pump is used to keep the water or working fluid moving, whereas passive systems rely on convection currents (a phenomenon wherein the different temperatures of the water or working fluid in different parts of the system keep it circulating). Each system has its own advantages and disadvantages based on cost, efficiency, and reliability.

Solar water heating systems are usually mounted on the roof of a building, although larger systems may be ground-mounted. On average a water heater can supply about two-thirds of a home's hot water needs (ICLEI USA n.d.), although this may vary widely given the home's hot water demand, the climate, and the technology and size of the solar water heater. In California, solar water heaters are often used to keep swimming pools at a comfortable temperature. These pool heating systems are capable of meeting 100% of the swimming pool's heating needs, particularly if the pool is only used during warmer months (DOE 2003).

Solar Water Heating

Solar water heaters use the heat from the sun to heat water for buildings, supplementing or replacing traditional water heaters. While they come in various forms, the most common type of system uses roof-mounted panels connected to the building's plumbing.

Other Solar Energy Technologies

Many other technologies use solar energy but are not addressed in this Element. Passive solar design is a method of using the placement, design, and materials of a building to minimize the amount of heating or cooling needed from devices such as furnaces or air conditioners, instead of relying on solar energy to create a comfortable indoor temperature. Solar cooking uses mirrors to concentrate solar energy in an enclosed space, creating high enough temperatures to cook food. Additionally, some emerging technologies create usable energy from chemical reactions driven either directly by sunlight (photochemical) or by the sun's heat (thermochemical).

Wind Energy

Wind energy technologies convert the energy of moving air into usable energy. Historically wind energy has been used for a number of mechanical purposes, such as pumping water and grinding grain, although the main current application of wind energy technology and the focus of this Element is to generate electricity. A single wind energy device is called a wind turbine, which is composed of three parts. The first part, the rotor assembly, consists of blades mounted to a central rotor. The blades are shaped and angled in such a way so that they spin when the wind hits them, causing the rotor to revolve. The second part of a wind turbine is called the nacelle, which houses the generator and various other mechanical and electrical systems. The rotor assembly is attached to the nacelle, and the generator in the nacelle converts the movement of the rotor into electricity. The rotor assembly and nacelle are mounted on a tower or pole, which is the third component of the turbine (BLM 2014).

Wind Energy Systems

Wind energy systems use an array of blades, in various configurations. The force of the wind causes the blades to spin, powering a generator to produce electricity. Wind energy systems can be small roof-mounted installations or sprawling wind farms with turbines hundreds of feet tall.

The two main types of wind turbines are horizontal axis wind turbines (HAWT) and vertical axis wind turbines (VAWT). The HAWT design is by far the most popular. As the name implies, the rotor in a HAWT system is horizontal, with blades extending outward from the rotor in a manner similar to an aircraft propeller. Most HAWT designs use three blades, although some use two and a few designs use one or more than three. The blades themselves are often long and narrow, constructed of lightweight and sturdy materials. Most HAWT systems position the rotor assembly upwind (in front of) the tower, as this design minimizes stress on the blades, although some designs position the blades downwind (behind) the tower. HAWT systems must be facing into the wind to generate energy; upwind systems have a motor (or in the case of small systems, a wind vane) to turn the rotor assembly and nacelle as needed, while the force of the wind is sufficient to properly position downwind systems (DOE 2014b).

Left: A rooftop Darrieus VAWT (Sandberg 2009).
Right: A three-tier Savonius VAWT (Oimatsu 2006).

VAWT designs are much less common and have not yet achieved widespread commercial use. These systems have a vertical rotor with the blades extending out horizontally along part of the rotor's length. The two primary VAWT designs are the Darrieus and Savonius designs, both named after their respective inventors. The Darrieus design and related variations use slender blades, either curved or straight. The blades of a Savonius system are wide (resembling panels rather than a conventional blade) and may either be straight or may curve outwards from the rotor in a spiral shape. VAWT designs operate regardless of wind direction and so do not need to be turned like HAWT systems. The nacelle of a VAWT system can also be placed nearer the ground, making it easier to access. However, VAWT designs are generally less efficient than HAWT systems (DOE 2014b, 2014c).

A wind farm of typical HAWT-design turbines (DOE 2008).

A number of unconventional wind energy technologies are generally either experimental or only exist conceptually. Some are based on the HAWT or VAWT designs, while others are entirely different (Renewable Energy World 2009; Goudarzi and Zhu 2013). One of the more familiar of these designs is the "airborne" or "kite" wind energy system, a tethered system light enough to float over 30,000 feet high, allowing it to tap into winds of the high-altitude jet streams (Blackman 2009).

Wind turbines range widely in size and the amount of power they can produce. Some may be only a few feet tall with an output of 500 watts or less and are small enough to be mounted relatively unobtrusively on the roof of a building. Other systems are larger (12–20 feet tall, not including the tower) with an output of a few kilowatts and are usually mounted on a relatively short pole (just high enough to be above nearby buildings and trees) (Hurst 2008). At the opposite end of the scale, wind turbines can be extremely large. A 1.5 MW turbine, among the most common type of large-scale turbine, generally stands around 250 to 300 feet tall or more (NREL 2009). The world's tallest wind turbines reach heights of 722 feet and can produce up to 8 MW of power (Wittrup 2014).

BIOENERGY

This Vermont power plant uses wood chips as a fuel source (NREL 1998).

Bioenergy energy technologies, sometimes called biopower, generate energy using organic matter (biomass). The material used to produce the energy is known as the feedstock and may consist of agricultural or livestock operation wastes, crops grown intentionally for energy production, residues from food processing facilities, waste products from forestry or wood processing facilities, and even waste from a landfill or wastewater treatment plant (CEC 2006a). Bioenergy is one of the oldest energy technologies, dating to when early humans burned wood or plant matter for heat and light. It currently provides a full 10% of the world's energy needs, more than any other renewable source (IEA 2014a).

Bioenergy Systems

Bioenergy technologies convert organic material, known as biomass, into usable energy. Multiple types of biomass may be used, but waste products are the most common. Bioenergy systems produce some amount of pollution and GHGs, and only some types are considered renewable under California law.

Feedstock is converted into usable energy through one of three types of processes: thermal, biochemical, and chemical. Thermal processes convert the feedstock into heat, which may be used directly (burning wood in a stove for space heating, for example) or indirectly (for example, using the heat to create steam to spin an electric generating turbine). The most familiar thermal process is combustion, which involves exposing the feedstock to high enough temperatures in the presence of oxygen so that it burns (i.e., setting fire to it). An alternative process, called pyrolysis, occurs when the feedstock is exposed to high temperatures in the virtual absence of oxygen (DOE 2015a). This is the same technique used to produce charcoal and also occurs when food is charred or burnt (Myhrvold 2013). Thermal conversion also includes gasification, a very high-heat process that uses a carefully controlled amount of oxygen or air. In addition to producing heat energy, gasification also produces a gaseous material called syngas, which itself can be used as a source of energy (DOE 2015a).

Biochemical processes subject the feedstock to chemical reactions created by a living creature, usually bacteria or other microbes (in other words, decomposition). The most common biochemical process is anaerobic digestion, which occurs when microorganisms break down the feedstock in an oxygen-free environment. Waste from landfills, wastewater treatment plants, and agricultural and livestock operations are often treated using anaerobic digestion. This process often happens naturally within a landfill but can also be created by placing the material in a vessel called a digester. In the absence of oxygen, the microbes convert the feedstock into a methane-rich gas called biogas. The biogas can be burned, either for heat or to generate electricity, or may instead be processed and refined to create a substance called biomethane, which is pure enough to be used as a substitute for commercially available natural gas (CEC 2015a). A different biochemical process, fermentation, can be used to convert dedicated energy crops into biofuels that can power vehicles.

The third conversion process, chemical conversion, breaks down the feedstock chemically but by using dedicated chemicals rather than biological organisms. Various chemical processes can convert the feedstock into biofuels for vehicles or may produce gases that can be burned for heat or to generate electricity. These technologies have often been used to create electricity and vehicle fuels during times of scarcity, including war. In the United States, chemical conversion is used for industrial purposes, but it is not used as a widespread means of commercial energy production (CEC 2012).

Combustion and anaerobic digestion are the two most common methods to generate electricity using bioenergy technologies. As of 2007, approximately 65% of California's bioenergy facilities used combustion. Waste product from forests and wood processing facilities were the most common feedstocks, followed by food processing residues and municipal solid waste (MSW, or trash).[5] The next most common bioenergy technology is anaerobic digestion from landfills. In these systems, specially designed pipes and other equipment capture the biogas as it is produced in the landfill and burn it for electricity; approximately 28% of bioenergy in California is generated this way. Approximately 6% of the state's bioenergy comes from anaerobic digestion of residue from wastewater treatment plants, while anaerobic digestion of animal and food waste comprises the final 1% (CEC 2015b).

Unlike solar and wind energy, biomass energy technologies do produce some amount of pollution and GHGs from the combustion of biomass or any byproducts of a conversion technology (e.g., biogas). These technologies are usually cleaner than traditional fossil fuels, and bioenergy resources replenish themselves over a reasonable time frame (unlike fossil fuels). **Table 2** compares emissions per megawatt-hour (MWh) for four bioenergy resources, coal, and natural gas for three emission types: nitrous oxides (NOx), which can create smog and cause respiratory ailments; sulfur dioxide (SO2), a toxic gas with widespread health impacts; and GHGs measured in carbon dioxide equivalent (CO2e). The numbers in the table are for power plants connected to the California electricity grid.

[5] MSW is only treated as a renewable resource in specific instances, as it is a mixture of organic and inorganic material.

Table 2: Comparison of Emissions per MWh Generated for California Bioenergy and Fossil Fuel Technologies

Technology	NO_x lbs/MWh	SO_2 lbs/MWh	CO_2e lbs/MWh
Digester gas	0.18	0.0039	104.76
Landfill gas	0.12	0.0002	6.57
Solid wood combustion	1.68	0.1813	67.39
MSW combustion	3.71	2.8478	4,025.60
Coal	3.52	2.0907	1,979.29
Natural gas	0.21	0.0097	861.10

Source: EPA 2013A

California state law treats electricity from bioenergy resources as eligible renewable resources for compliance with the RPS if the electricity is produced from one of four types of energy resources:

- From biodiesel (a liquid fuel that can be used as a substitute for petroleum-derived diesel), if it is produced from agricultural crops/wastes or from MSW using certain approved processes (CEC 2013a).
- From eligible plant waste, tree waste, or nonrecyclable paper products, process using combustion or another thermal conversion process (CA PRC 2013; CEC 2013a).
- From biogas (including biogas refined into biomethane) produced in a digester or naturally in a landfill (CEC 2013a).
- From MSW, only if the process is "clean burning" and meets a number of specific requirements (CEC 2013a).

Electricity produced by a fuel cell using a biomass feedstock is also eligible to assist compliance with the RPS. Bioenergy fuel cells use a feedstock that has been mixed with a catalyst, which breaks down the biomass. In the presence of the other materials in the fuel cell, this creates an electric current. The catalyst in these fuel cells can be chemical compounds that activate when exposed to light or heat, or biologic compounds called enzymes (such devices are called enzymatic biofuel cells). Bioenergy fuel cells are currently a research technology and are not being used commercially (Atanassov et al. 2007; Liu et al. 2014).

Other Renewable Energy Technologies


A 48 MW geothermal plant in Imperial County (NREL 2015).

As noted previously, California recognizes a number of other renewable energy technologies. These technologies are generally not feasible in San Bernardino County due to a lack of the necessary resources.

- Geothermal energy technologies, which use the high temperatures far underground for heating and electrical generation. Geothermal technologies are widely used throughout California, especially in The Geysers north of the San Francisco Bay Area. San Bernardino County has one known geothermal resource area (the Randsburg area in the northwest part of the county), but its capacity is limited and does not appear commercially viable (CEC 2005a).

- Hydroelectric technologies use the force of moving water to spin an electric generating turbine (these facilities are only considered renewable in limited circumstances) (CEC 2013a). There are a small number of hydroelectric facilities in the southwestern part of the county (CEC 2014a), but limited resources are likely to prevent further installation of hydroelectric technologies to any significant degree.

- Ocean wave technologies are a largely experimental variety of renewable energy system that uses the force from waves breaking on the shore to generate electricity. As San Bernardino County does not have any coastlines, these technologies are not feasible for the county.

- Ocean thermal technologies (sometimes called ocean thermal energy conversion, or OTEC) use the temperature difference between the ocean surface and the deep ocean to produce heat. San Bernardino County is not adjacent to the ocean; thus, this technology is not feasible.

- Tidal current technologies use the force of tides as they regularly rise and fall. These technologies cannot be used in San Bernardino County, as the county lacks a tidally influenced coastline.

Energy Storage

In a traditional electricity grid, the electricity must be used quickly once it has been generated or it is lost, as electricity cannot be stored in the wires of the grid (Denker 2005). In order to avoid wasting resources generating electricity that will not be used, large-scale power facilities and balancing authorities such as the California Independent System Operator (CAISO) must carefully balance the amount of electricity generated with the demand for power. Some types of renewable energy facilities can complicate this process because electrical generation is dependent on a factor outside of human control (e.g., whether the sun is shining or the wind is blowing) and these facilities may not generate power during time of peak demand; this is known as intermittency. Distributed generation facilities may pose an increased challenge as they become more common. While large-scale power facilities have dedicated equipment and staff to match generation with demand, distributed generation facilities rarely have such control, and an increase in the amount of electricity produced from distributed generation systems may create further difficulties for balancing the grid.

Energy storage systems are a solution to this problem. These technologies store excess electricity during the time when supply exceeds demand and can release the electricity back into the grid when demand rises. Energy storage technologies can be built into any scale of power plant, ranging from utility-scale facilities producing hundreds of MW of power to a small solar array on the roof of a house. These technologies can also be used independent of any electricity generating system, installed in a private building or connected to the grid.

The most familiar form of energy storage technology is a battery, which uses chemical reactions between two types of materials to create an electrical current. In a rechargeable battery, connecting the battery to an external source of power reverses the chemical reaction, allowing it to be used thousands or even millions of times; disposable batteries can only be used once (the chemical reaction cannot be reversed) and are not suitable for storing excess energy in the grid. There are a number of battery technologies, including lead-acid (commonly used for vehicle batteries in gasoline-powered cars), lithium ion (found in most portable electronics such as cell phones, tablets, and laptops, and also used in modern electric vehicles), and sodium-sulfur (a large-scale technology suitable primarily for nonmobile uses) (IEA 2014b). A large array of modern batteries can hold a significant charge; the Golden Valley Cooperative Project in Alaska uses 13,760 batteries to store 40 MW of power (CEC 2005b).

Pumped hydro storage technologies are essentially refillable reservoirs. In these facilities, electricity is used to pump water uphill into a reservoir where there is an excess of power in the system. When the electricity is needed, the water in the reservoir is allowed to flow downhill through a powerhouse to spin a generator, as in a traditional hydroelectric power plant. These technologies currently have more power storage capacity than any other form of grid-connected energy storage, although the ability to build more is limited by the same factors that limit other large-scale hydroelectric facilities: limited availability of suitable terrain and concern about the environmental impacts of dam construction, among others (IEA 2014b). The world's largest pumped hydro storage facility, the Bath County Pumped Storage Station in Virginia, has a capacity of over 3,000 MW (Dominion Energy 2015).

Flywheel storage technologies use excess electricity to spin a wheel at high speeds, converting electrical energy to rotational energy. When the flywheel is slowed down, the rotational energy can be converted back into electricity. The use of low-friction materials in flywheel systems helps to limit energy loss over long periods of time (IEA 2014b). The amount of energy a flywheel can store is dependent on, among other things, the mass of the flywheel itself and the speed at which it spins. Traditionally, flywheels have been built out of materials such as steel, which have high mass but fail at higher rotational speeds. Most modern flywheels are made of composite materials, which can be spun at higher speeds and thus store more energy than traditional flywheels despite their lower mass (Castelvecchi 2007).

Thermal energy storage technologies convert excess electricity to heat, storing it in materials that have a high heat capacity (the ability to store large amounts of thermal energy). The heat can be transferred from the storage materials and used to generate electricity (by powering a steam turbine, for example). The materials used in thermal storage technologies can include tanks of water, rocks or concrete, or molten salt. These technologies show particular promise for solar thermal power facilities, which use high heat capacity materials as a working fluid to generate electricity. A solar thermal facility with a storage system can reserve excess working fluid in insulated tanks, releasing it to generate electricity at a later time. Such systems can allow these facilities to produce electricity at night, unlike solar PV or conventional solar thermal facilities (IEA 2014b). The Solana Solar Generating Plant, a parabolic trough solar thermal facility in Arizona, uses molten salt to store enough heat to allow the facility to produce its peak output (280 MW) for six hours (Sandia National Laboratory 2015).

A number of other technologies are also being developed or explored. Excess electricity can compress air and store it in tanks, and the pressure of the compressed air can be released to spin generator turbines. Excess electricity can split water molecules apart to produce hydrogen (a process called electrolysis), which can be combined in a fuel cell with oxygen from the air to generate electricity during times of high demand. Another technology converts electrical energy to a magnetic field, using special materials and very cold temperatures. These technologies are largely in a research phase (IEA 2014b).

In addition to providing storage for excess electricity in the grid, energy storage technologies are an integral component of a microgrid, along with a distributed generation renewable energy system. Typically, a distributed generation renewable energy system will only produce power if the grid is active (e.g., there is no power outage). For example, a rooftop solar PV array will not generate power for the house during a blackout, even if the array can generate more power than the house needs. A microgrid functions as a backup power grid at a smaller scale (for an individual building, a campus, a neighborhood, or even a whole community). Power from the main electrical grid and/or a distributed generation system supplies the electrical demand for all buildings on the microgrid and stores excess electricity in an energy storage device. If the main electrical grid goes down, the energy storage device can supply power to the microgrid, supplemented as needed by the distributed generation facilities.

Because energy storage technologies can store electricity from any resource, including fossil fuels, energy storage is not considered inherently renewable. However, an energy storage device can be treated as a renewable energy resource for compliance with the RPS if it meets specific criteria (CEC 2013a).

California has 165 energy storage facilities that are operational, under construction, or planned. The largest of these, the Eagle Mountain Pumped Storage Hydroelectric Project, is currently planned and will provide 1,300 MW of power for up to 18.5 hours when complete (Eagle Crest Energy Company

2014). **Table 3** lists energy storage facilities in California, not including those that have been decommissioned or are nonoperational.

Table 3: Operating, Under Construction, or Planned Energy Storage in California

Technology	Number of Facilities	Total Capacity (MW)	Average Capacity per Facility (MW)
Battery	Planned: 15 Under construction: 25 Operational: 50 Total: 90	173.1	1.9
Flywheel	Planned: 1 Operational: 4 Total: 5	9.5	1.9
Compressed air	Planned: 1	300	300
Pumped hydro	Planned: 2 Operational: 7 Total: 9	5,767	640.8
Thermal	Planned: 1 Under construction: 1 Operational: 51 Total: 53	179.6	3.4

Source: Sandia National Laboratory 2015

Energy Storage Case Study

Energy storage technologies help address the challenge that renewable energy poses to the reliability of the electrical grid. Traditionally, electricity produced by energy generating facilities is "lost" if it is not used quickly (Denker 2005). Some renewable energy resources, such as solar and wind, produce power intermittently at times that may not match the periods of high electrical demand. For example, solar PV and wind energy conversion facilities produce energy when the sun is shining or the wind is blowing, but energy production may not be constant. Distributed generation facilities often lack the controls of large-scale power facilities, creating further challenges for grid integration. Energy storage technologies can address the challenge of renewable energy reliability and grid integration by storing electricity when there is an excess supply and then releasing it to the grid as demand requires. New technologies are entering the market or are in active development. These technologies can be deployed in small or large installations and can be integrated into buildings or power plants or can operate as stand-alone facilities.

The University of California, San Diego (UCSD) is a key Southern California example of energy storage technologies. It is home to one of the most advanced microgrids in the nation, complete with an energy storage component. A microgrid is a small-scale energy distribution network that allows buildings connected to it to continue to operate when the main electrical grid fails. Microgrids can incorporate energy storage, which allows them to use on-site renewable energy facilities to supply the microgrid and purchase low-cost power from the grid as needed. Microgrids are discussed further in the **Access** chapter (Benefits: Resiliency section) of this **Appendix**.

UCSD is using a mixture of technologies, including ultracapacitor-based storage, cogeneration and thermal energy storage, experimental recycled vehicle battery storage, and a total of 7.5 MW of battery-system integration. The microgrid and energy storage project strengthens the regional reliability of the electrical grid, balancing energy demand and helping to reduce UCSD's energy demand on the grid. UCSD's microgrid produces approximately 42 MW, or 92% of the university's power, and incorporates wind, solar, and other conventional technologies (Margoni 2014). The 5 MWh storage capacity allows the microgrid to provide electricity to the campus during times of reduced energy production.

The UCSD energy storage component of its microgrid illustrates the feasibility and benefits of such technologies. The system saves an estimated $900,000 annually in energy costs (UCSD 2015).Yet the UCSD system also acts as a reserve for the large community grid. By reducing campus energy use and releasing stored energy, the microgrid can provide net positive 7 MW to the larger distribution grid, which can be the difference between blackouts and a functioning grid for millions of people. This example also indicates the importance of grant money to spur such projects. The project received over $4 million in funding from the California Energy Commission (CEC) and the California Public Utilities Commission (CPUC) (Choudhury 2013; Margoni 2014). More details about energy storage installations are in the **Energy Storage Case Studies** chapter of this **Appendix**.

Energy Generation and Consumption in California

California's electricity use comes from a variety of sources, with natural gas making up the largest component. Approximately two-thirds of the electricity used in the state is generated in California, with a smaller amount of electricity imported from southwestern and northwestern states. In 2013, the state used approximately 296,630 gigawatt-hours (GWh) of electricity (CEC 2014b). California's 2013 sources of electricity are shown in **Table 4**.

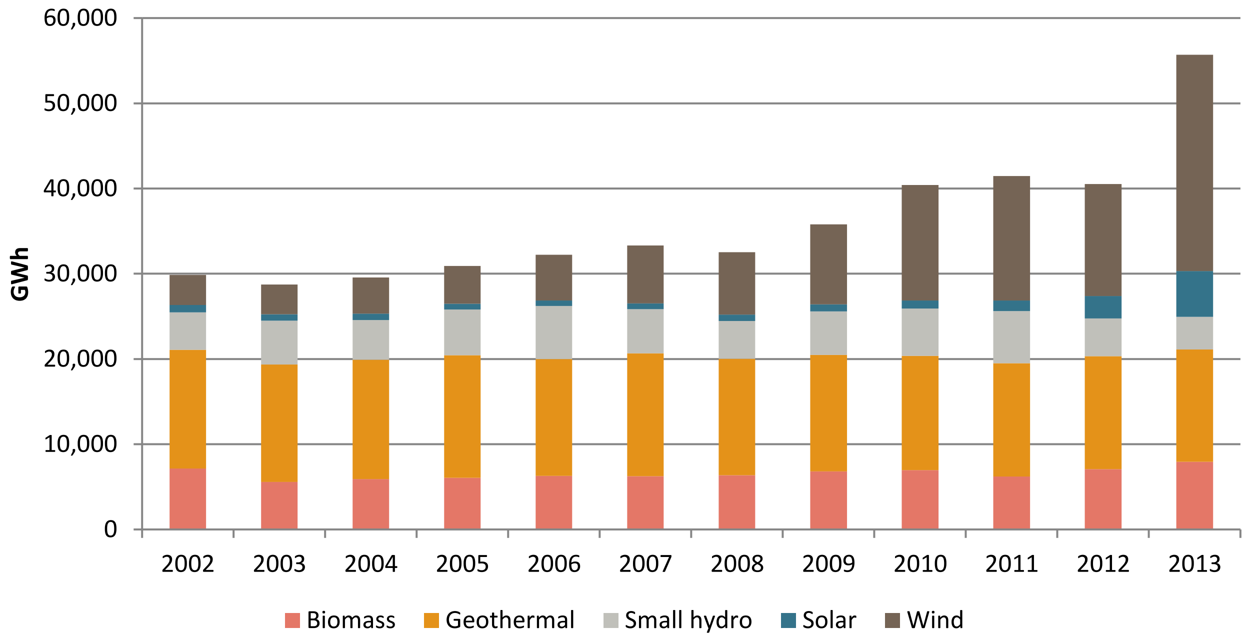
Table 4: California Sources of Electricity, 2013

Source	Electricity (GWh)	Percentage
Coal	23,190	7.82%
Natural gas	131,420	44.31%
Oil	40	0.01%
All fossil fuels	154,650	52.13%
Nuclear	26,220	8.84%
Large hydro	23,010	7.76%
All nonrenewable non-fossil fuels	49,230	16.60%
Bioenergy	7,930	2.67%
Geothermal	13,190	4.45%
Small hydro	3,810	1.29%
Solar	5,390	1.82%
Wind	25,360	8.55%
All renewables	55,680	18.77%
Other	10	<0.01%
Unspecified	37,060	12.49%
Total	**296,630**	**100%**

Source: CEC 2014b

While renewable energy resources provide less than 20% of California's electricity, they are experiencing rapid growth. **Figure 1** shows growth in California's renewable energy generation since 2002. Energy from small hydro, geothermal, and bioenergy resources has remained relatively constant during this period, while electricity from solar increased by over 520% and electricity from wind approximately 620%.

Figure 1: California Electricity from Renewable Sources, 2002–2013



Source: CEC 2014b

Energy Generation and Consumption in San Bernardino County

In 2013, San Bernardino County used approximately 14,124 GWh of electricity, or approximately 5% of total statewide usage. Residential activities within the unincorporated county used approximately 4,227 GWh (30% of county usage), while nonresidential activities used approximately 9,897 GWh (70% of county usage) (CEC 2008a). In 2013, the county used approximately 503,533,225 therms of natural gas. San Bernardino County's residential activities used approximately 262,938,708 therms (52%), while nonresidential facilities used approximately 240,416,517 therms (48%) (CEC 2008b). Specific information on the amount of energy used in the unincorporated areas of the county is not known at this time. Energy in San Bernardino County is predominantly supplied by Southern California Edison (for electricity) and Southern California Gas Company (for natural gas), with a smaller portion of the supply provided by other private companies and publicly owned utilities. Additional discussion of the electricity providers in San Bernardino County is included in the Access chapter (Barriers: Affordability section) of this Appendix. **Figure 2** shows changes in countywide electricity and natural gas use over time.

Residential energy usage is highest in the Valley region of San Bernardino County, which is where most of the county's residents live. Per-household energy use data is shown in **Table 5** for 2008, which is the most recent year with currently known figures for individual communities at this time.

Per-household electricity use is extremely low in the Mountain region relative to the rest of San Bernardino County. Households in the Valley and Desert regions have fairly similar electricity needs, although Desert households use approximately 2% more electricity on average. Similarly, communities in the Mountain region have much higher per-household natural gas usage, while the natural gas usage of houses in the Valley and Desert regions is fairly consistent (the typical desert household uses approximately 3% more natural gas). Climate is likely the primary driver of these differences, as most cooling equipment is powered by electricity, while natural gas is commonly used for heating.

Figure 2: Electricity and Natural Gas Use in San Bernardino County, 2006–2013

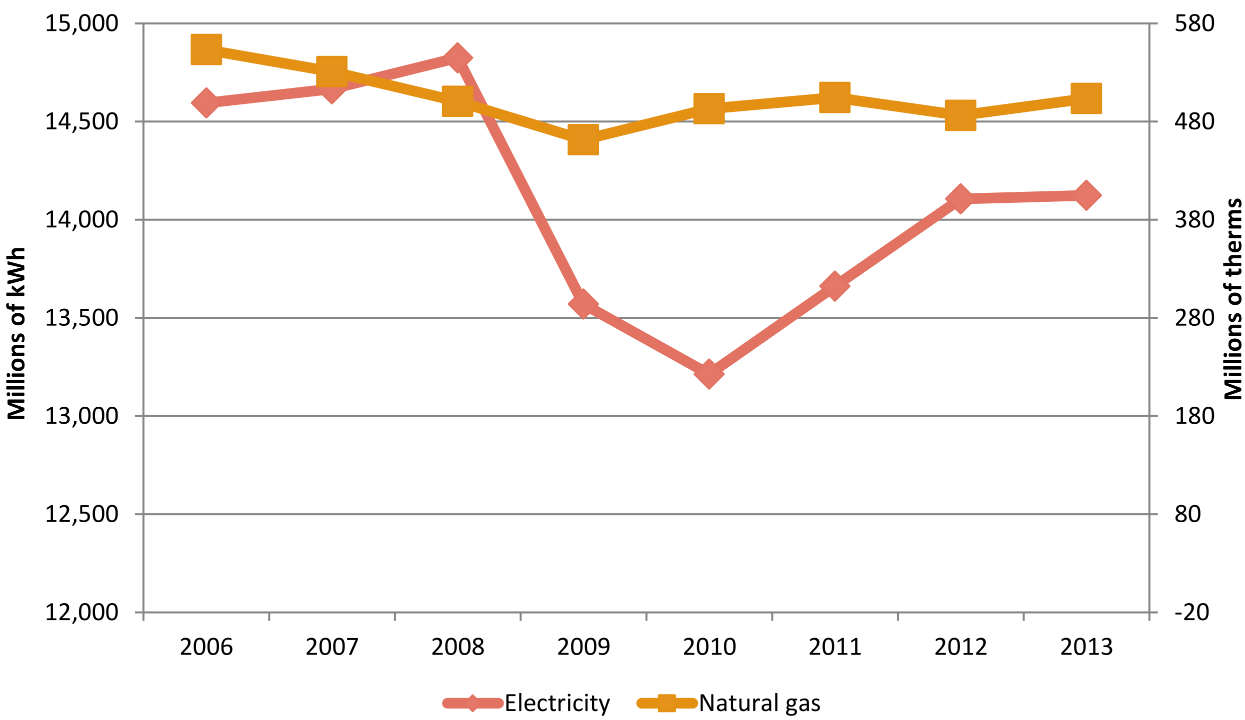


Table 5: Residential Total and Per-Household Energy Use by Region, 2008

Community	Residential kWh	Residential Therms	Number of Households	Per-Household kWh	Per-Household Therms
Valley communities	2,893,376,110	148,617,460	369,820	7,820	400
Mountain communities*	2,421,000	4,998,180	2,200	1,100	2,280
Desert communities	665,614,910	33,886,930	83,580	7,960	410

Source: SANBAG 2013

* The only Mountain region community for which data is available is Big Bear Lake, which has a very high tourism population in the winter (when heating demand is highest) and a relatively small population of permanent residents. The Mountain region very likely does have lower per-household electricity use and higher per-household natural gas use than the rest of San Bernardino County, but it is probable that the factors listed above exaggerate the difference.

Note: The numbers shown here are an aggregation of most (though not all) incorporated communities in San Bernardino County. It is likely that the per-household energy use shown in this table is a reasonable reflection of unincorporated per-household energy use in the different regions of the county.

The CEC has developed 16 distinct climate zones for California, which are used to define necessary standards for building energy efficiency. Four climate zones are present in San Bernardino County: zones 10, 14, 15, and 16 (CEC 2015c).

Zone 10, which constitutes the interior valleys of Southern California, includes the Valley region of San Bernardino County. This region is mostly warm and sunny, although frost occurs occasionally in the winter. Temperatures can exceed 100°F in the summer, although rarely. Zone 14, the medium and high desert, includes most of the Desert region of the county. Temperatures in this region are similar to Zone 10, although slightly higher and lower. Zone 15, the low desert, covers the southeastern portion of San Bernardino County's Desert region. This region is hotter than Zone 14, with summer temperatures exceeding 110°F at times, and short and mild winters. The high mountains, Zone 16, include the county's Mountain region. Temperatures are cooler in this zone, with a high degree of precipitation and persistent snow throughout much of the winter (PG&E 2006).

Although much of the Desert region (the portion in Zone 14) has a different climate than the Valley region, the demand for heating and cooling is relatively similar (heating demand is somewhat higher in the Desert region). The low desert parts of San Bernardino County, Zone 15, have higher temperatures and therefore more cooling demand and less heating demand than the desert parts in Zone 14, but this area constitutes a minority of San Bernardino County's Desert region, and data on energy use for the communities in this region is not available at this time. The high altitude climate of the Mountain region creates very little cooling demand (and therefore reduced electricity use) with significant heating use (hence the high natural gas use). Information on heating and cooling demand for the different regions is provided in **Table 6**.[6]

Table 6: Heating and Cooling Demand in San Bernardino County Climates

Region	Heating Demand	Cooling Demand
Zone 10: Southern Interior Valleys (Valley region, Ontario)	1,360	1,900
Zone 14: High Desert (Desert region, Barstow)	2,290	2,570
Zone 15: Low Desert (Desert region, Needles)	4,545	1,227
Zone 16: High Mountains (Mountain region, Big Bear Lake)	6,600	90

Source: NOAA n.d.

Nonresidential energy use varies across the different regions in the county due to varying concentrations and types of business activities.

Although natural gas is the primary heating fuel in San Bernardino County, it is not the only option. This is especially true in the unincorporated areas of the county, which may lack the pipeline infrastructure to supply natural gas service. Without natural gas, the primary home heating fuel alternatives are electricity, propane, or wood (US Census Bureau 2013). **Table 7** compares home heating fuels in the entire county and in the incorporated and unincorporated communities.

San Bernardino County has abundant energy resources and is home to a number of electricity generating facilities, both renewable and nonrenewable. There are currently 93 known power plants of various types in the county, as shown in **Table 8**.[7]

[6] Heating and cooling demand are measured in Heating Degree Days (HDD) and Cooling Degree Days (CDD), a weather-based metric that calculates heating and cooling demand based on deviations in temperature.

[7] This list only includes power plants with a capacity greater than 0.1 MW (100 kW). For facilities comprising multiple units, each unit may be treated as an independent power plant.

Table 7: Home Heating Fuels in San Bernardino County

Fuel Type	San Bernardino County	Incorporated Communities	Unincorporated Areas
Natural gas	74.07%	76.48%	61.33%
Propane	3.20%	1.33%	13.08%
Electricity	18.89%	19.78%	14.19%
Fuel oil	0.08%	0.05%	0.20%
Coal or coke	0.02%	0.02%	0.01%
Wood	2.14%	0.91%	8.67%
Solar energy	0.06%	0.06%	0.06%
Other fuel	0.27%	0.09%	1.24%
None	1.27%	1.28%	1.21%

Source: US Census Bureau 2013

Table 8: Power Plants in San Bernardino County

Technology	Number of Facilities	Total Capacity (MW)	Average Capacity per Facility (MW)
Coal	3	187	62.3
Hydroelectric (large)*	3	429	143.1
Hydroelectric (small)	14	40	2.8
Natural gas	22	3,109	141.3
Oil	1	149	149
Solar thermal	12	792	66.0
Solar photovoltaic	29	173	6.0
Wind	5	9	1.9
Bioenergy	4	6	1.4
Total	**93**	**4,895**	**52.6**

Source: CEC 2014c

* Per CEC guidelines, large hydroelectric facilities are those with a capacity of at least 30 MW.

At the end of 2014, San Bernardino County had 1,332 MW of wholesale renewable energy capacity, referring to the capacity of facilities that sell power directly to a utility company for off-site use. These wholesale facilities may include both utility-scale and larger-scale distributed generation facilities. This places San Bernardino County fifth among California counties with the most wholesale renewable energy capacity, behind Kern (4,888 MW), Imperial (1,961 MW), Riverside (1,705 MW), and Solano (1,460 MW). San Bernardino County's wholesale renewable energy facilities are listed in **Table 9**. Note that due to differences in data analysis methods and data collection dates, the information here may not match that in **Table 8**.

Table 9: Wholesale Renewable Energy Facilities in San Bernardino County

Technology	Number of Facilities	Total Capacity (MW)	Average Capacity per Facility (MW)
Bioenergy	3	7	2.3
Small hydro	11	38	3.4
Solar PV	37	462	12.5
Solar thermal	12	825	68.9
Total	**63**	**1,332**	**21.1**

Source: CEC 2014d

In addition to wholesale facilities, there are a number of small-scale solar PV arrays throughout San Bernardino County due to the area's abundant solar resources. These facilities are mostly installed on residential rooftops, although some are ground-mounted and/or installed on nonresidential properties. Most of these facilities are installed in incorporated communities, although unincorporated communities such as Helendale, Joshua Tree, and Phelan also have large numbers of solar arrays. Note that the location of these facilities is self-reported; property owners may indicate that they are located in an incorporated city even if they are technically outside of the city limits. As a result, it is possible that the number of small-scale solar PV arrays in the incorporated communities is slightly exaggerated. **Table 10** includes information on these facilities.[8]

The county may be home to additional distributed generation facilities, using solar PV or other technologies, not accounted for here.

[8] Due to data limitations, the table shown here may not account for all small-scale solar PV facilities in San Bernardino County.

Table 10: Small-Scale Solar PV Arrays in San Bernardino County

Location	Number of Arrays	Total Capacity (kW)	Average Capacity per Array (kW)
Incorporated Communities			
Adelanto	50	217.74	4.35
Apple Valley	1,039	5,427.27	5.22
Barstow	236	1,837.01	7.78
Big Bear Lake	0	0.00	—
Chino	430	2,928.55	6.81
Chino Hills	539	3,239.84	6.01
Colton	40	278.47	6.96
Fontana	792	6,263.33	7.91
Grand Terrace	83	500.33	6.03
Hesperia	547	3,474.64	6.35
Highland	469	2,692.25	5.74
Loma Linda	153	965.73	6.31
Montclair	54	347.34	6.43
Needles	15	112.14	7.48
Ontario	336	2,594.88	7.72
Rancho Cucamonga	1,378	9,877.71	7.17
Redlands	752	4,720.68	6.28
Rialto	240	1,584.47	6.60
San Bernardino	581	4,028.93	6.93
Twentynine Palms	175	1,067.34	6.10
Upland	470	3,637.03	7.74
Victorville	543	4,043.98	7.45
Yucaipa	654	4,345.31	6.64
Yucca Valley	222	2,478.33	11.16
Total Incorporated Communities	9,798	66,663.29	6.80

Location	Number of Arrays	Total Capacity (kW)	Average Capacity per Array (kW)
Unincorporated Communities			
Angelus Oaks	2	14.93	7.47
Baker	2	11.30	5.65
Big Bear City	1	7.40	7.40
Bloomington	52	373.95	7.19
Blue Jay	1	6.86	6.86
Crestline	2	14.98	7.49
Daggett	3	17.66	5.89
Essex	1	3.06	3.06
Fort Irwin	3	16.01	5.34
Green Valley Lake	2	10.81	5.41
Havasu Lake	62	342.79	5.53
Helendale	110	654.46	5.95
Hinkley	4	21.68	5.42
Johnson Valley	7	40.97	5.85
Joshua Tree	114	603.00	5.29
Lake Arrowhead	17	101.51	5.97
Landers	5	28.76	5.75
Lucerne Valley	33	506.04	15.33
Lytle Creek	1	7.80	7.80
Mentone	39	495.55	12.71
Morongo Valley	27	280.88	10.40
Mt Baldy	2	7.64	3.82
Newberry Springs	28	155.98	5.57
Oak Glen	1	4.90	4.90
Oak Hills	88	530.54	6.03
Oro Grande	1	6.24	6.24

Location	Number of Arrays	Total Capacity (kW)	Average Capacity per Array (kW)
Patton	1	6.62	6.62
Phelan	118	837.76	7.10
Piñon Hills	43	334.07	7.77
Pioneertown	7	46.24	6.61
Running Springs	5	22.77	4.55
Trona	7	39.51	5.64
Twin Peaks	2	15.01	7.50
Wrightwood	15	662.39	44.16
Yermo	6	30.63	5.11
Total Unincorporated Communities	803	6,176.06	7.69
Total San Bernardino County – Unincorporated and Incorporated Communities	**10,601**	**72,839.36**	**6.87**

Source: California Solar Statistics 2014

Note: Unincorporated communities without any known solar panels are not included. Due to rounding and data analysis methods, totals may not match the sum of their component parts.

REGULATORY FRAMEWORK

FEDERAL

Agencies

The US Department of Energy (DOE) was established in 1977 as a response to the 1973 energy crisis. It is responsible for promoting energy efficiency and renewable energy at a federal level, ensuring the safety and effectiveness of nuclear material, improving the federal electricity grid, and other matters related to the use and production of energy. The DOE is responsible for conducting federal authorization and environmental review for the siting of interstate transmission lines (DOE 2015b) and implements a variety of laws related to energy (DOE 2015c). The DOE is also part of the West-wide Energy Corridor planning effort to designate corridors for energy transmission lines on federally owned land in 11 western states, including California (West-wide Energy Corridor 2015a). In San Bernardino

County, all transmission corridors under this effort have already been designated as transmission corridors through local actions (West-wide Energy Corridor 2015b).

The US Department of the Interior (DOI), which includes the Bureau of Land Management (BLM), the US Fish and Wildlife Services (USFWS), the National Park Service (NPS), and a number of other divisions, oversees much of the federally owed land in the United States. As a result, the DOI and its divisions are responsible for granting permits for renewable energy projects on federal land. The DOI also issues permits for any activities that impact federally listed species or their habitat (CEC 2011). The BLM oversees approximately 6 million acres in San Bernardino County, while the NPS oversees another 1.7 million acres (DRECP 2014b).

A number of other federal agencies also have a role to play in permitting renewable energy development, although in a more limited capacity than the DOE and the DOI. The US Army Corps of Engineers is responsible for issuing permits for projects that impact navigable waters, which may include renewable energy facilities in some instances. The US Environmental Protection Agency (EPA) is responsible for determining the adequacy of the environmental review process for federal projects under the National Environmental Policy Act (NEPA). The US Department of Defense (DOD) determines whether projects near defense facilities are compatible with the military operations at the facility (CEC 2011) and also manages approximately 1.9 million acres of land in San Bernardino County (DRECP 2014b).

Laws and Statutes

The Energy Policy Act of 2005 provides grants, subsidies, and loan guarantees for renewable energy projects and requires the DOE to conduct studies on renewable energy resources. It establishes targets for renewable energy on federal land and for the amount of biofuels that must be mixed into gasoline. The act also requires all public utilities to offer net metering, which helps facilitate small-scale renewable energy components (GPO 2005). The act has since been modified and expanded by other laws, particularly the Energy Independence and Security Act of 2007 and the American Recovery and Reinvestment Act of 2009.

The Production Tax Credit (PTC) was first established by the Energy Policy Act of 1992 and is one of the most prominent and influential examples of congressional action on renewable energy in recent history. It provides a tax rebate for companies that generate electricity from some types of renewable resources (solar is not eligible) for the first ten years of the generating facility's operational life. The PTC is either 1.1 cents or 2.3 cents per kWh, depending on the technology used. It has been renewed multiple times since it was adopted and expired at the end of 2014, although it may be extended at a later date (DOE 2014c).

The Investment Tax Credit (ITC) is a tax rebate for the installation of certain types of renewable energy technologies, including wind and most solar energy systems. Unlike the PTC, which is an annual credit based on the amount of energy produced by a renewable energy system, the ITC is a one-time credit based on the cost of the renewable energy system (10%–30% of the system cost, depending on the technology). The credit is currently set to expire at the end of 2016 (DOE 2014d).

Several other federal laws and actions also help provide a regulatory and incentive framework for renewable energy systems. The Clean Air Act, first passed in 1970, is being used by the EPA to reduce pollution from power plants. Increased production of renewable energy is a key strategy to meet the pollution reduction targets being established by the EPA (EPA 2015). The National Energy Act, originally passed in 1978, gives tax credits to individuals who install renewable energy equipment and provides loans for families to purchase solar energy systems (CEC 2011). The Clean Water Act and Endangered Species Act both require projects, including renewable energy systems, to seek permits for certain activities with environmental impacts (CEC 2011). Additionally, the President's Climate Action Plan, while not a legal mandate and not binding, establishes goals for increased production of renewable energy, including doubling the amount of solar and wind energy production from 2012 to 2020 (USEOP 2013).

STATE

The California Energy Commission was first established in 1974 and is California's primary agency for energy planning and policy (CEC 2005c). The CEC certifies thermal power plants at least 50 MW in size and is the lead agency for projects of this sort for review under the California Environmental Quality Act (CEQA).[9] It advances the development of renewable energy resources, conducts a number of energy efficiency and renewable energy educational programs, and regulates publicly owned utilities. The CEC also implements a number of energy efficiency, energy conservation, and renewable energy programs, often in conjunction with other agencies (CEC 2015d).

The California Public Utilities Commission (CPUC) is the state's regulatory agency for privately owned utilities, including energy utilities such as Southern California Edison and the Southern California Gas Company. The CPUC approves power purchase agreements for private utilities, permits large transmission lines, and administers energy efficiency and renewable energy programs for private utilities in conjunction with the CEC. It also regulates the safety of California's energy transmission and distribution systems (CPUC 2007).

The California Independent Systems Operator, established in 1998, is a nonprofit state company that oversees the operation of California's electrical market and electrical transmission/distribution systems; it is known as a balancing authority. It approves connections to the electrical grid and ensures that the grid operates reliably by matching electrical demand with supply. The area overseen by CAISO covers approximately 80% of California, including almost all of San Bernardino County; nine other public and private agencies manage the electrical grid in the remaining portion of the state (CAISO 2014a). The

[9] A thermal power plant is one that produces heat to create steam, which spins a turbine to generate electricity. This includes solar thermal, biomass, geothermal, and fossil fuel power plants. The CEC does not directly approve wind or solar photovoltaic projects, although it may have some authority over these facilities in other ways.

Western Area Power Authority's Western Area Lower Colorado, a division of the DOE, acts as the balancing authority in the easternmost parts of the county near the Colorado River (CEC 2013b).

California's Renewables Portfolio Standard (RPS) was established in 2002 and modified to its current form by Senate Bill (SB) X1-2 in 2011. It requires the state's electrical utilities, both public and private, to procure 33% of their electricity from eligible renewable sources by the end of 2020 (CEC 2013a), the highest 2020 RPS target of any state (DOE 2014e); eligible renewable sources includes solar, wind, and most forms of biomass (CEC 2013a). The RPS is administered jointly by the CEC and the CPUC. The state's major utilities supplied 22.7% of their electricity from eligible renewable sources in 2013 and are on progress to achieve the RPS goal by 2020 (CPUC 2015c). In January 2015, Governor Jerry Brown announced a goal for the state to procure 50% of its electricity from renewable sources by 2030 (OGCA 2015).

California is working to achieve its RPS through a mixture of efforts intended to spur renewable energy development at all scales. Most electricity is generated by large-scale facilities owned by independent power providers (IPPs), who enter into power purchase agreements (PPAs) with the utility companies. However, the State also has programs intended to increase procurement of renewable energy from distributed generation facilities.

The Solar Photovoltaic Program is a program administered by the CPUC allowing utilities to buy electricity from smaller-scale solar PV installations to count toward their individual RPS goals. Each of California's three major electrical utilities has its own targets and implementation plans, but in total the program allows utilities to enroll up to 1,100 MW of power. Certain amounts of power can come from facilities owned directly by the utilities, while the remainder must come from facilities owned by other entities procured through a process called the Renewable Auctions Mechanism (RAM) (CPUC 2010, 2014d). Although any size of solar array can participate in the program, it is generally not cost effective for utilities to buy power from an array smaller than 1 MW.

California's Energy Storage Procurement Framework and Design Program, established by Assembly Bill (AB) 2514 in 2010, requires the state's electrical utilities to procure set amounts of their electricity from storage facilities by 2020 and to finalize installation of the necessary storage facilities by 2024. This target is 1,325 MW for California's three major electrical utilities; smaller electrical suppliers have individual requirements equal to 1% of their annual 2020 peak load. There are separate targets for transmission-connected, distribution-level, and customer-side storage (CPUC 2014a).

In addition to the RPS, the State is also actively incentivizing small-scale distributed generation on the customer side of the meter. The Homebuyer Solar Program, which went into effect at the beginning of

2011 and is administered by the CEC, is one such example. Owners of developments with at least 50 single-family homes for sale (approved after 2011) must participate in one of two efforts to increase renewable energy availability. Owners may offer the Homebuyer Solar Option, which involves informing prospective buyers about the cost of a solar energy system, estimated cost savings from the system, and information about incentives and resources. Alternatively, owners may participate in the Solar Offset Program, which states that they must build a solar energy system equal in capacity to the combined size of typical solar PV arrays on 20% of the homes in the development. The program also includes reporting and verification requirements (CEC 2010).

To ensure that properties have access to solar resources, the California Solar Rights Act establishes the right of property owners to access sunlight for renewable energy production. It protects building owners from unreasonable restrictions on solar energy systems from local governments and homeowners associations, and requires local jurisdictions (such as the County) to provide a ministerial approval process for solar energy systems that serve on-

Building Standards and Renewable Energy

The current version of Title 24 (the California Building Standards Code) does not require renewable energy systems, but does require many types of buildings to be "solar ready," making it easier to install solar energy systems later as desired.

Single-family homes in subdivisions of at least 10 units must have a designated "solar zone" on the roof or other structure suitable for solar energy systems, a pathway for running wiring (or pipes for solar water heaters), space for any support equipment, and a dedicated spot for a solar electric system on the electric service panel. Construction documents must clearly show these spaces and include calculations for the design load of the solar zone (CEC 2014e).

Multi-family homes ten stories or less must have the solar zone, the pathway and space for support equipment, and construction documents with the appropriate calculations and labels (CEC 2013c, 2014e).

site uses.[10] AB 2188, which passed in 2014, expands on these rights by requiring local jurisdictions to create a streamlined approval process for small-scale solar energy systems with a number of specific components. AB 2188 also limits the circumstances under which a local jurisdiction may deny a residential solar energy system and prevents homeowners associations from imposing standards on residential solar energy systems that substantially increase the system's cost (Anders et al. 2014).

Community choice aggregation (CCA) is a program that enables local governments to procure electricity for customers in their jurisdiction and distribute it using existing transmission and distribution lines owned by other organizations, including private utilities. As a result, CCA effectively allows local governments to act as municipal utilities without needing to build additional infrastructure. CCA was established by AB 117 in 2002 as a response to the statewide electrical crisis of 2000–2001. Although originally intended to give local governments increased flexibility in procuring electricity to avoid electrical shortages, CCA has thus far been used to supply communities with more renewable energy than the utilities at comparable (sometimes lower) rates (CPUC 2014b). Two CCAs are currently active in California: Marin Clean Energy (active in unincorporated Marin County and its incorporated communities, unincorporated Napa County, and the cities of Richmond, Benicia, and San Pablo) and Sonoma Clean Power (active in unincorporated Sonoma County and some of its incorporated communities) (MCE 2014; SCP 2014a, 2014b). The City of Lancaster is in the process of establishing its own CCA, which is expected to begin operations in 2015 (City of Lancaster 2014a). Other communities throughout California are also exploring establishing CCAs. More information on CCA is included in the Access chapter (Benefits: Energy Independence section) and the Community Choice Aggregation Case Studies chapter of this Appendix.

A number of other state laws and programs help facilitate renewable energy development. Title 24 of the California Building Standards Code, administered by the CEC, requires certain types of new buildings to be built in such a way so as to facilitate rooftop solar energy installation at a later date (CEC 2013c, 2014e). The Renewable Energy Transmission Initiative (RETI) is a comprehensive statewide approach to designate, site, and permit transmission corridors to support increased production of renewable energy. The CEC, CPUC, and CAISO are all involved, along with other state and regional entities (CEC 2015e). The Desert Renewable Energy Conservation Program (DRECP) is a joint venture between the CEC, the California Department of Fish and Wildlife (CDFW), the BLM, and the USFWS to streamline renewable energy development in desert areas on state and federally owned land in the California desert and to establish consistent mitigation and conservation measures for desert species and habitats. Portions of seven California counties are part of the DRECP, including most of San Bernardino County (DRECP 2014a). Although not a binding document, the Governor's Clean Energy Jobs Plan sets a number of renewable energy–related goals by 2020, including 12,000 MW of rooftop and other small-scale renewable energy potential, 8,000 MW of large-scale renewable energy potential, and the necessary transmission lines (OGCA 2010).

[10] A ministerial permit is one that a jurisdiction is required to grant if the application complies with all applicable codes and standards. It is different from a discretionary permit, which jurisdictions may approve or deny at their preference.

II. Environmental Compatibility

Introduction

Renewable energy facilities, as with any other form of development, can have an effect on the natural environment. These effects could include result in negative consequences for the plant and animal species in San Bernardino County and their habitats, paleontological resources that provide evidence of ancient earth, artifacts and relics with cultural or historic significance, or critical natural resources such as groundwater. Renewable energy facilities may also affect the human inhabitants of San Bernardino County by affecting air quality and the risk of flooding. This chapter discusses the existing natural environment in San Bernardino County that may be affected by renewable energy development. Additional considerations for interaction of renewable energy facilities on human communities are included in the **Community Compatibility** chapter of this **Appendix**. The County also describes biological resources and other elements of the natural environment, and goals and policies to protect these resources, in the Conservation Element of the San Bernardino County General Plan.

This chapter discusses the following features of the natural environment:

- **Biological resources**. San Bernardino County is home to a wide array of plants and animals, including many that are sensitive to increased pressures such as loss of habitat, and a diverse number of environments that support these species. This chapter presents the existing biological resources as well as the connectivity of the natural environment, which allows species to move with relative ease to different locations.

- **Soil resources**. Soils help to store and filter water, support important biological communities, and produce crops that support large numbers of people, and are therefore key to the environment in San Bernardino County. Soils may be damaged or lost by inappropriate vegetation removal, poor agricultural practices, and development activities that do not use effective soil conservation methods, as well as natural erosion. Soil resources may also pose a risk to human health if they become airborne, which may lead to respiratory ailments.

Avian Mortality at Solar Energy Facilities

San Bernardino County's high solar energy potential has made bird deaths at solar energy facilities an issue of concern for many residents, although the precise impacts of these facilities remain unknown. For example, quantitative estimates of avian mortality at the Ivanpah power plant (ISEGS) range from 600 to 28,000 each year (Richardson 2014).

One recent study found that solar power tower facilities such as ISEGS have the greatest impact, with 141 recorded bird deaths during the study period. Solar PV facilities had a moderate impact (61 recorded bird deaths), and parabolic trough facilities such as SEGS and the Mojave Solar facility had the least number of bird deaths with 31 recorded (Kagan et al. 2014).

- **Cultural, archaeological, and paleontological resources**. These resources include Native American resources, archaeological and sacred sites, streetscapes and landscapes, paleontological sites, and historic sites, which together are a highly valuable resource that reflects the diversity of San Bernardino County and are therefore important to preserve. Maintaining these unique resources contributes to county's quality of life, allows the county to retain its sense of place, and helps support the vitality of the region.

- **Flood hazards**. Even in the semi-arid and arid conditions that make up much of San Bernardino County, flooding is a concern. Any development in flood-prone areas is at an elevated risk of damage from these events, which can occur with little warning. Development in areas with a higher flood risk may also impede the natural flow of floodwaters, which may create flooding or cause it to be more severe in adjacent areas where the risk is lower.

- **Water resources**. Much of San Bernardino County relies on groundwater, which can be depleted without careful management. With limited surface water supplies and imported water sources facing increased pressure from climate change, groundwater may continue to meet much of the county's water needs for the foreseeable future. Renewable energy facilities rely on water for cooling and/or cleaning needs.

EXISTING CONDITIONS

BIOLOGICAL RESOURCES

Each of the three distinct regions in San Bernardino County (Valley, Mountain, and Desert) has its own biological conditions, including unique habitats and species. There are a number of sensitive species throughout the county, including some species that live nowhere else. Sensitive species are those that meet at least one of the following conditions:

- Species listed as endangered, threatened, or proposed for listing under the federal Endangered Species Act, as listed at http://www.fws.gov/endangered/.

- Species listed as endangered, threatened, or rare under the California Endangered Species Act, as listed at https://www.wildlife.ca.gov/Conservation/CESA.

- Plants listed as rare, endangered, and/or of limited distribution by the California Native Plant Society, as listed at http://www.rareplants.cnps.org/.

- Species considered endangered, threatened, or sensitive by the US Forest Service, as listed at http://www.fs.fed.us/biology/tes/.

- Species considered a federal species of concern and/or a California species of special concern, as listed at https://www.dfg.ca.gov/wildlife/nongame/ssc/ (County of San Bernardino 2007a).

Valley Region Biological Resources

The loggerhead shrike (*Lanius ludovicianus*), a California Species of Special Concern and listed as sensitive by the US Forest Service (NPS 2010)

The native biological communities in the Valley region are predominantly a mixture of chaparral, coastal sage scrub, deciduous woodlands, grasslands, and wetlands (County of San Bernardino 2007a). Wetland habitats are particularly sensitive, as these diverse habitats have been widely destroyed throughout California, and the few that remain are high priorities for conservation (USFWS 2011a). The Valley region is also home to alluvial sage scrub, a habitat that has adapted to the frequent flooding of the rivers and dry washes in the region, and as a result hosts a number of unique species. The Valley region is home to 121 sensitive species, including the Stephen's and San Bernardino kangaroo rats (both considered endangered under the federal Endangered Species Act), the golden eagle, and the Santa Ana River woolly star (a perennial herb endangered under both the federal and California Endangered Species Acts). Details on species and biological communities in the Valley region are included in the Environmental Impact Report (EIR) for the County General Plan (County of San Bernardino 2007a).

Mountain Region Biological Resources

The Mountain region consists of elevations between 2,000 and approximately 11,500 feet above sea level. Many of the species present here also live elsewhere in the county during part or all of the year. The biological communities in the Mountain region are mainly shrubs, woodlands (both deciduous and coniferous), and wetlands. This area also includes pavement and pebble plains, unique flat areas of quartz-based rock surfaces or pebbles. This region is home to the San Gorgonio Wilderness Area, a prime conservation site and the largest wilderness area in Southern California. Despite the small size of the Mountain region, it is home to 330 sensitive species, more than either of the county's other two regions. Sensitive species in the Mountain region include several species of endangered plants called milk-vetches, burrowing owls, and the endangered California dandelion. A more detailed description of the natural environment in the Mountain region is included in the EIR of the County General Plan (County of San Bernardino 2007a).

Desert Region Biological Resources

The desert tortoise (*Gopherus agassizii*), a federally and state-listed threatened species, and a focus of extensive preservation efforts (NPS 2008)

The Desert region of San Bernardino County, although sometimes thought of as a desolate area, is in fact a highly fragile and diverse environment. The region can itself be split into three subdivisions: the high desert (the Mojave), the low desert (the Colorado), and the complex topography of the Great Basin in the northern parts of the county. Scrublands are the predominant biological community in the Desert region, but other biological communities include sand dunes, woodlands, and even wetlands. The Desert region includes the 1.4-million-acre Mojave National Preserve and parts of Joshua Tree National Park. The Desert region is home to 256 sensitive species, including the endemic Barstow woolly sunflower, the Mojave ground squirrel, and the desert tortoise (County of San Bernardino 2007a). The County General Plan EIR describes the biological resources of the Desert region in greater detail.

Renewable energy projects, as with most other types of developments, can potentially have unwanted effects on the biological resources in San Bernardino County. Past renewable energy projects in the county have included a number of conditions and measures designed to reduce these effects, including ongoing monitoring for the presence of such species at the site and the cessation of work if the species are found, limiting work during important times of the year (e.g., when mating and breeding activities are occurring), and requirements to permanently set aside land as protected habitat (County of San Bernardino 2012a, 2012b).

Desert Tortoise

The Mojave desert tortoise (*Gopherus agassizii*) is one of two desert tortoise species in the southwestern United States and the only one found in California. A symbol of desert wildlife, the species has been designated a threatened species under the federal Endangered Species Act since 1980 and under the California Endangered Species Act since 1989. The primary threat to the desert tortoise is habitat destruction from housing, mining, agriculture, and off-road vehicle activities, although illegal collection, disease, and predation also have impacted the species. The Desert Tortoise Recovery Plan (released in 1994 and revised in 2011) established 6 million acres of protected land for desert tortoises in California, Arizona, Nevada, and Utah (USFWS 2011b, 2012, 2014).

Wildlife Corridors

Wildlife corridors, also known as connectivity areas, are a critical component of maintaining healthy biological communities. These corridors, which consist of natural lands, riparian areas, or other types of protected open space, connect larger open space areas to each other. Such pathways allow species to move around as they migrate, disperse to new regions, or forage or hunt for food. The corridors themselves may or may not provide suitable habitat for species (DRECP 2012b).

California does not identify any critical wildlife corridors in the Valley region, due at least in part to the region's high urbanization. Open space in the Valley region is connected directly to the Mountain region or to open space in another county, or has been fragmented by development (CDFG & Caltrans 2010). Although not present in the list of critical wildlife corridors as mapped by the state, the Santa Ana River and other riparian and dry wash habitats can serve as wildlife corridors.

Most land in the Mountain region is considered to be an essential wildlife connectivity area, with the exception of the area to the north and northwest of Big Bear Lake, the area south of Big Bear Lake to the Santa Ana River, and areas immediately to the east of the lake near the communities of Big Bear City and Sugarloaf. Large portions of land in the Mountain region, including most of the essential connectivity areas, remain largely undeveloped although not necessarily protected (CDFW 2015; CDFG & Caltrans 2010).

The sparsely populated and largely rural Desert region has a number of wildlife connectivity areas, including along canyons and dry washes. Many of these wildlife corridors are adjacent to federally or state-protected areas (discussed in the Habitat Conservation section below), or provide connectivity between these protected locations. These connectivity areas include four essential corridors recognized by state agencies as determined by the California Essential Habitat Connectivity Project: (1) Colorado Desert corridor, (2) Joshua Tree-Rodman Mountains corridor, (3) Rodman Mountains-Death Valley corridor, and (4) Rodman Mountains-Mojave corridor. These essential corridors, which are summarized in **Table 17**, mostly provide paths between large protected areas. These are not necessarily the only areas of important habitat connectivity, and other planning projects may identify other key wildlife corridors. Note that the names of the essential corridors are given for the sake of convenience; these are not necessarily official names.

Table 11: San Bernardino County Desert Region State-Recognized Essential Wildlife Corridors

Corridor	Description
Colorado Desert corridor	Extends northeast from the northeast corner of Joshua Tree National Park throughout the southeastern part of the county; does not connect to any large protected area.
Joshua Tree-Rodman Mountains corridor	Extends north from the northwest corner of Joshua Tree National Park, to the west of the Twentynine Palms Marine Corp Base, to the Rodman Mountains Wilderness Area and surrounding terrain. Provides connections to the Mountain region.
Rodman Mountains- Death Valley corridor	Extends north from the Rodman Mountains Wilderness Area, through the western portion of Fort Irwin and the Grass Valley Wilderness Area, to the southern portion of Death Valley National Park.
Rodman Mountains-Mojave corridor	Two parallel corridors running west from the Mojave National Preserve. One connects to the Rodman Mountains, and the other connects to the Rodman Mountains-Death Valley corridor north of Barstow.

Sources: CDFW 2015; CDFG & Caltrans 2010; DRECP 2012b

In addition to these critical corridors identified by the state, San Bernardino County also notes 62 open space areas throughout all three regions of the county, some of which serve as wildlife corridors and may overlap with the state-recognized areas (County of San Bernardino n.d.a).

Habitat Conservation

As previously noted, San Bernardino County has a large number of federally protected areas, including Chino Hills State Park and Prado Basin in the Valley region, the Cucamonga and San Gorgonio Wilderness Areas in the Mountain region, and Joshua Tree National Park and the Mojave National Preserve in the Desert region (County of San Bernardino 2007a). There are four habitat conservation plans in San Bernardino County: (1) the Desert Renewable Energy Conservation Plan (DRECP, currently a draft document), (2) the Town of Apple Valley Multi-Species Habitat Conservation Plan, (3) the West Mojave Plan, and (4) the West Valley Habitat Conservation Plan. These four plans are listed in **Table 18**. Not all protected land in the county is included in an existing habitat conservation plan.

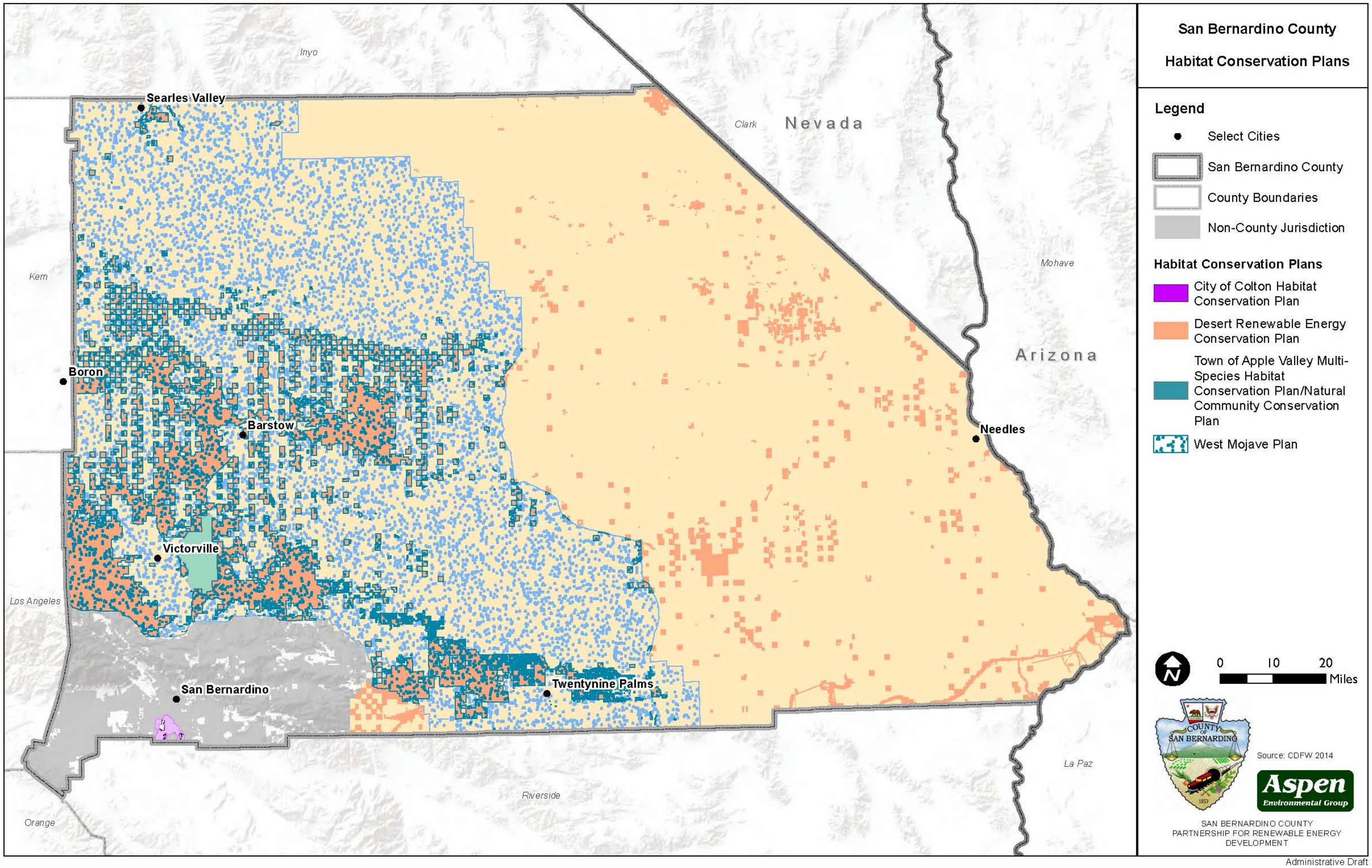
Table 12: San Bernardino County Habitat Conservation Plans

Conservation Plan	Region	Description
West Valley Habitat Conservation Plan (1996)	Valley	Borders of the plan are contiguous with the city limits and sphere of influence of Colton (approximately 9,930 acres). Developed to streamline development review due to concerns about the presence of the endangered Delhi sands flower-loving fly.
West Mojave Plan (2003)	Desert	Habitat conservation plan for 9.3 million acres across four counties, including the western half of the Desert region. Consistent with the Desert Tortoise Recovery Plan and resource management plans for military facilities.
Town of Apple Valley Multi-Species Habitat Conservation Plan (2015)	Desert	Applies to areas within the city limits and sphere of influence of Apple Valley (approximately 50,900 acres). Intended to streamline development while ensuring conservation of sensitive species.
Desert Renewable Energy Conservation Plan (draft released 2014)	Desert	Designates suitable land for renewable energy and habitat conservation across seven counties, including 11.98 million acres in San Bernardino County. Implemented in part through amendments to the West Mojave Plan. Currently in draft form.

Sources: BLM 2012; CDFW 2015; City of Colton 2014; DRECP 2014c; Town of Apple Valley 2015

A map showing the location of these four conservation areas is provided as **Figure 13**.

Figure 3: Habitat Conservation Plan Areas in San Bernardino County



There are six nationally protected areas partially or entirely located in San Bernardino County:

1. Angeles National Forest
2. Death Valley National Park
3. Havasu National Wildlife Refuge
4. Joshua Tree National Park
5. Mojave National Preserve
6. San Bernardino National Forest

The county is also home to a large number of national wilderness areas, which may lie inside other protected areas.

SOIL RESOURCES

The flat bed of Soda Dry Lake in the Mojave National Preserve. The Desert Studies Center at Zzyzx is in the foreground (Wilson 2013).

As with many other conditions in San Bernardino County, the types of soil resources vary from place to place. In the Valley region, soils usually comprise materials laid down by repeated flooding from rivers, a soil type known as alluvial deposits, although there are some areas of dune sand. Soils in the Mountain region tend to be fairly shallow and are made up largely of granite and sandy loam (a type of soil composed mostly of clay, with smaller amounts of silt and sand). Desert region soils are predominantly sand based, although there are patches of desert pavement (layers of small, closely packed rock) and alluvial deposits from dry washes. The Desert region is also home to a number of dry lake beds, which are usually surfaced with a mixture of sediments and alkaline salts. Additional detail about soils in San Bernardino County is included in the Conservation Element and the EIR for the County General Plan (County of San Bernardino 2007a).

A prime concern with soil resources, particularly in the Desert region, is dust created by construction activity. The sandy soils of the Desert region are easily airborne, where they can obscure visibility and create or exacerbate respiratory conditions. These soils may also contain certain fungal organisms that can be inhaled when the soil is airborne. The organisms settle in the lungs, causing a disease called coccidioidomycosis (valley fever) in approximately 60% of people who inhale the fungal spores (the other 40% show no symptoms). The disease can cause fever, muscle and joint pain, and widespread exhaustion. In severe forms of valley fever, patients may develop chronic lung infections, skin conditions, and meningitis (CDC 2014). Valley fever is most common in the southern San Joaquin Valley, although cases are sometimes reported in San Bernardino County (CDC 2009a). Less dangerously, sandy soils may also be deposited on buildings, plants, and cars, requiring washing. In the past, some renewable energy projects in the county have been required to submit dust control plans to the applicable air district, stop work on unpaved areas during high wind events, and wash equipment regularly (County of San Bernardino 2012c, 2013b).

Cultural, Archaeological, and Paleontological Resources

Cultural and archaeological resources are physical objects, buildings and structures, locations, living biological resources, or landscapes with unique cultural or historical significance. In San Bernardino County, these resources may include Native American tools, artwork, other possessions or artifacts, structures, and sacred locations. These resources also include items left by settlers from Europe and elsewhere, dated between 1770 and 1950. The San Bernardino County Archaeological Information Center recognizes over 12,000 historic sites from Native American periods (pre-1770), the Mission period of Spanish occupation (1770 to 1820), the Mexican period (1820 to 1848), and the American period (1848 to 1950).[11] In addition to the cultural resources associated with historic sites, a number of traditional cultural properties (TCPs) in and around San Bernardino County have cultural significance to Native American communities. The precise number of TCPs in the county is unknown due to privacy concerns, incomplete mapping, and changing professional standards, but it may reach into the thousands (County of San Bernardino 2007a). A large number of state and federally listed historic resources are located in the unincorporated parts of San Bernardino County, including Native American petroglyph sites, ghost towns, World War II military training facilities, and wagon roads across the Mojave (OHP 2015; DOI 2015).

Paleontological resources are evidence of ancient organisms, such as fossils. They occur primary in sedimentary rock (rock composed by the deposition of sand, silt, and other fine particles), although they may be found in other types of rock as well. Fossils are usually buried and can only be discovered through excavation, although some may be found on the surface due to erosion. There are approximately 3,000 known sites in San Bernardino County with paleontological resources (County of San Bernardino 2007a).

In order to avoid disturbing these important resources, renewable energy projects, like many other types of development, often take a number of protective steps. In the past, protective actions taken by renewable energy projects in San Bernardino County have included having paleontological and archaeological monitors on the project site during some ground-disturbing activities, stopping some activities around areas where any such resources are found, and working with the Native American Heritage Commission if any human remains of Native American origin are found (County of San Bernardino 2011b, 2014b, 2014c).

[11] While the American period is of course ongoing, resources after 1950 are generally not considered historical.

Flood Hazards

Floods are considered one of the most likely and high-intensity disasters in San Bernardino County, along with earthquakes and wildfires. The areas subject to flood inundation in the county are mostly those near rivers and dry washes, especially around the town of Baker and the western portions of the Mojave National Preserve. Areas in the Valley region are largely protected from flooding by levees. Most areas in the Desert and Mountain regions are considered to have potential but unknown flood risks. Of particular risk in the Desert and Mountain regions are flash floods in dry washes and lake beds resulting from sudden summer thunderstorms. These floods can cause widespread erosion and potential damage to buildings and infrastructure (County of San Bernardino 2011c). Structures built in previously undeveloped floodplains may redirect water in unexpected ways, potentially causing or exacerbating flood risks in other areas. In some renewable energy projects where this has been a potential issue, the project has been required to permanently set aside dry washes or other drainage areas, to ensure that sufficient drainage capacity remains after any capacity has been lost to development (County of San Bernardino 2013a). Additional discussion of flood hazards in the county is included in the Safety Element and the EIR for the San Bernardino County General Plan.

Water Resources

San Bernardino County has approximately 400 water providers, although four agencies supply most of the county's water (County of San Bernardino 2007a). The San Bernardino Valley Municipal Water District and the Inland Empire Utilities Agency, the two major water providers in the Valley region, obtain most of their water from local groundwater sources, supplemented by local water bodies and imported water from the State Water Project; the Inland Empire Utilities Agency also uses recycled and desalted water (SBVMWD 2011; IEUA 2011). Both the San Bernardino Valley Municipal Water District and the Inland Empire Utilities Agency are water wholesaler agencies; they do not supply water directly to customers but supply it to smaller government water agencies and private companies. The Crestline-Lake Arrowhead Water Agency, the primary water supplier in the Mountain region and a retail water provider (it distributes water directly to individual users), imports most of its water from the State Water Project, with only a small amount coming from local water bodies as needed (CLAWA 2011). The Mojave Water Agency, the primary water supplier in the Desert region, also uses groundwater as its primary source, although it relies more on water from local water bodies and the State Water Project than water suppliers in the Valley

Renewable Energy Facilities and Water Use

Large renewable energy facilities can use a great deal of water. Solar PV and solar thermal facilities often use water to wash panels, keeping them clear of dust to help maintain their maximum efficiency. Solar thermal facilities often use water for cooling as well, although air cooling technologies can reduce water use substantially, as much as 90% (NREL 2012b).

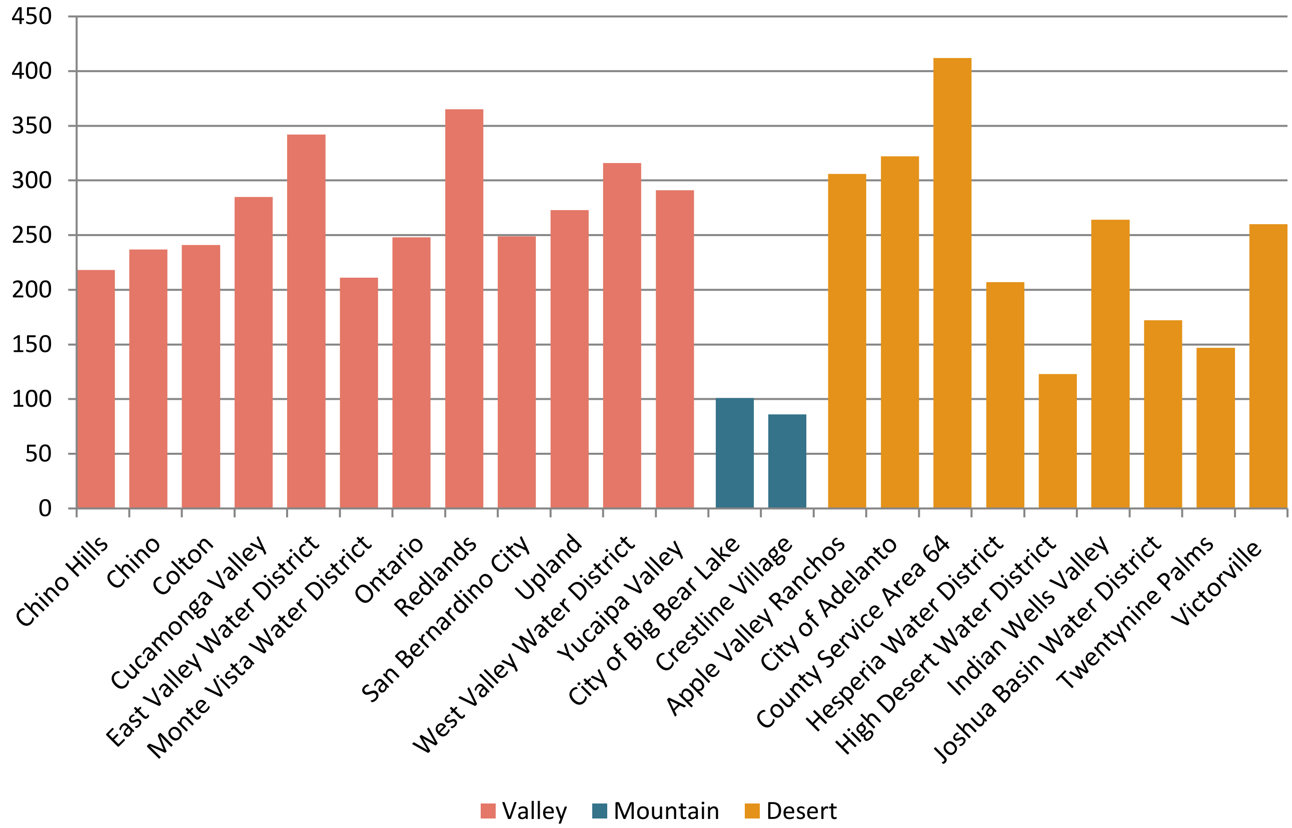
The Ivanpah power plant, also known as ISEGS, is one facility that uses this technology. It uses approximately 25 million gallons of water each year—about as much as a few hundred county residents (BLM 2010; Willis 2014).

region (Mojave Water Agency 2011). The Mojave Water Agency is also a water wholesaler. More information on water providers in San Bernardino County is included in the San Bernardino County General Plan EIR.

Water use varies widely throughout San Bernardino County. Residential customers of the Riverside Highland Water Company, which serves some customers in the Valley region, used an average of 490.5 gallons per person per day (gpcd) in December of 2014, the highest of any water supplier in California. At the other end of the scale, residential customers of the Crestline Village Water District in the Mountain region used only 61.6 gpcd (SWRCB 2015). Residential water use in the county is generally lowest in the Valley and Mountain regions and highest in the Colorado Desert in the southeastern corner of the county. Commercial water use varies throughout the county as well, depending on the types of nonresidential activities present in different locations.

Figure 14 shows the average overall (residential and nonresidential, minus agricultural) water use per capita for a selection of retail water providers in San Bernardino County. While overall per-capita water use is lowest in the Mountain region, the inclusion of nonresidential water use makes the results from the Valley and Desert regions similar. A Desert water provider (County Service District 64) has the highest per-capita water use, but another Desert region water provider (the High Desert Water District) has a lower per-capita water use than any Valley region water provider (Willis 2014).

Figure 4: Total Per-Capita Water Use by Retail Water Provider (gallons per capita per day)



Source: Willis 2014

MISSION FOR ENVIRONMENTAL COMPATIBILITY

Development of renewable energy facilities and production of renewable energy must occur in a manner that maintains a high level of environmental quality consistent with the County's vision, goals, and policies for protection and conservation of natural resources. As the number of renewable energy installations in San Bernardino County continues to increase, it is important that the County not substitute one type of environmental damage for another. Some of the potential environmental risks posed by renewable energy development are as follows:

- **Natural resources:** Among the largest potential environmental risks from renewable energy development is the threat to biological communities. To the extent possible, all renewable energy installations should be located on land that is already developed (e.g., on a rooftop or on structures above a parking lot) or is otherwise considered disturbed (such as an abandoned industrial or mining site). Because the site has already been substantially altered from its natural state, locating renewable energy facilities on these lands significantly reduces the odds that the installation will disturb sensitive species or critical habitat. This may also present the opportunity to productively use land that may have otherwise been abandoned for a lengthy period of time. Actions such as the use of wildlife-exclusion fencing and biological monitoring during construction can further help to reduce or avoid conflicts and potential degradation of resources.

- **Cultural, archaeological, and paleontological resources:** These resources are highly vulnerable to construction activities, including the construction of renewable energy facilities. Because many of these resources are buried in the ground or sit on the surface (petroglyphs, for example), they can easily be damaged by grading or other ground-disturbing activities. Best practices such as conducting preconstruction surveys and coordinating with the proper authorities can further help to reduce the risk of damage to cultural, archaeological, and paleontological resources.

- **Dust:** Renewable energy facilities should minimize dust creation. Construction activities, particularly grading, can create large clouds of dust that can affect nearby buildings and communities, potentially causing aesthetic and health concerns. Health considerations include valley fever, a condition caused by inhaling fungal spores that can be stirred up and made airborne by soil disturbance. There are a number of effective dust control methods which renewable energy installations should implement.

- **Water use:** Water is a critical and often scarce resource throughout California, especially in the arid climate that makes up much of San Bernardino County, and access to water may be more limited in the future as a result of climate change. While renewable energy facilities are not often thought of as needing water, these installations frequently require water for cleaning and sometimes for cooling needs. Renewable energy systems can and should implement a number of best practices to protect access to this vital resource.

In order to successfully encourage future development of renewable energy facilities in San Bernardino County, the County must address these potential environmental risks and provide a means for development of renewable energy in a manner that is environmentally compatible. San Bernardino County's natural environment is a major component of the county's identity. By promoting renewable energy development that is compatible with the existing environmental conditions, the county can continue to enjoy the cultural, economic, and quality of life benefits afforded by the natural environment.

III. Public Renewable Energy Exploration

The public participation program for the project invited a robust public dialogue. The purpose of the participation program was to assist the County in identifying community priorities for future renewable energy development and conservation. This effort included both digital and traditional in-person workshop events.

Performance Review

Prior to the first round of public workshops, the project team conducted performance review of the County's current policy framework, including the General Plan, policies, vision, and land use regulations. The team evaluated the General Plan, the Countywide Vision, the Development Code, and 2014 amendments to Section 84.29 of the Development Code for commercial solar energy facilities, looked at the following issues and questions:

Policy Development

1. Road map for future conditions
   - Does the framework create a vision for renewable energy and conservation, and if so, what is that vision?
   - How do codes and standards achieve the desired future conditions?
   - What other goals for resources or existing communities will interact with the renewable energy vision?
2. Identification and facilitation of renewable energy technologies
   - What types of renewable energy technologies are allowed, enabled, and permitted?
   - Where and under what conditions are renewable energy technologies permitted?
   - What are the review processes and typical findings for renewable energy projects?
3. Implementation of the County's vision for renewable energy and conservation
   - What resources are available for staff and project applicants to conduct the renewable energy permitting process?
   - How does the County disseminate information on the renewable energy planning process?
   - What other resources would ensure the long-term success and local benefits of renewable energy technologies?

Results of these findings guided the next steps of policy development for the Element.

PUBLIC PARTICIPATION

SPARC Forum

As part of the project, the County launched the online SPARCForum (www.SPARCForum.org), the interactive project website. SPARCForum provided 24-hour access to project information and opportunities to explore, discover, evaluate, and engage in all phases of the project. SPARCForum served as the home for all project information and provided equal access for all. SPARCForum also included several online participation activities for those who could not attend a public workshop. Online activities mirrored feedback opportunities offered at in-person events. The County used SPARCForum to replicate the activities at in-person workshops. SPARCForum also served as a platform to share outreach results with dynamic summary options, allowing the sorting and analysis of feedback by participant type or topic.

Round 1 Public Engagement

The first round of community engagement for the San Bernardino County Renewable Energy and Conservation Element included five workshops conducted by PMC and County staff on April 15, 16, 17, 22, and 23, 2014, and online engagement via SPARCForum.org. Round 1 represented the launch of public participation for SPARC to inform the community and stakeholders about the project and to collect input from community members and industry on the development of renewable energy projects in the unincorporated county. Overall, participant comments during the first round of public workshops revealed four primary shared values across all public outreach opportunities (in person and online):

1. Renewable energy development sites should be limited to previously disturbed land.
2. Small-scale distributed generation wind and solar projects (20 MW or less) are preferred over utility-tier projects.
3. Protecting the environment and wildlife should be a paramount consideration.
4. Clear communication and transparency between residents and the County from the initial application through project implementation is critical to a successful renewable energy program.

During the community priorities activity (in-person and online), participants in Round 1 engagement identified their top five community priorities as:

1. Water supply
2. Habitat conservation
3. Protection for sensitive species
4. Rural lifestyle
5. Energy independence

These results indicate that participants would like to move toward a more energy-independent future, but would also like the County to carefully consider environmental and quality of life impacts at every step.

Meetings were held in five different locations to invite a broad range of input from community residents and stakeholders. Workshops occurred in San Bernardino, Big Bear, Yucca Valley, Hesperia, and Barstow. A total of 82 individuals participated in person at Round 1 workshops.

Round 2 Public Engagement

Round 2 of SPARC community workshops provided the SPARC project team with a deeper and more nuanced understanding of renewable energy development issues of concern to county residents. Across the five workshops, opinions were shared about how the County should move forward with renewable energy and conservation policy development. The SPARC project team designed the workshops to be consistent in all locations and intended to quantify respondent results using the public workshop workbook. Participant expectations varied at each meeting. Some participants completed the workbook and others opted for discussion only.

During Round 2 of community engagement, SPARC stakeholders submitted verbal comments in small groups, in writing on the public workshop workbook, through the web on SPARCForum.org, and as a large group of more than 200 participants at the workshop in Hesperia. The project team compiled responses and discovered a range of perspectives from opposition to support for large-scale renewable energy production.

> **Perspective 1:** Strongly opposed to large-scale production and opposed to renewable energy projects larger than on-site rooftop production.
>
> **Perspective 2:** Willing to consider community-scale renewable energy, but reluctant due to concerns about ways that projects have historically been approved or developed.
>
> **Perspective 3:** Willing to consider scales of production larger than the community scale, but would like the County to adopt specific criteria to abate their concerns.
>
> **Perspective 4:** Support renewable energy at all scales.

Overall, across the four common perspectives, feedback received during the second round of public input revealed four common themes:

1. The importance of using locally produced renewable energy within San Bernardino County.
2. Support for distributed generation, no larger than 20 MW and with a preference for smaller systems.
3. Focus renewable energy development on disturbed lands to minimize negative impacts of larger projects.

4. Support for the County Board of Supervisors to take strong positions on policies and projects beyond the County's jurisdiction, for example, the State's Renewables Portfolio Standard, the Cool-Water Lugo transmission project, and the Desert Renewable Energy Conservation Plan.

As a result of the input receiving during Round 2 of engagement, the project team recognized that the County must make critical decisions about the future of renewable energy for San Bernardino County. Based on each of the Round 2 themes, critical decisions identified for the Element to address were:

1. *Where energy is used*, taking into consideration use on-site, use in the vicinity, use in the county, or export for use in other locations
2. *Where energy is produced*, taking into consideration tenure, level of land disturbance, county region, proximity to distribution/transmission infrastructure, and zoning
3. *How energy is produced*, taking into consideration type of technology, environmental compatibility, community compatibility, and scale
4. *How sites are enforced and decommissioned*, taking into consideration activities during construction and operation, and upon discontinuation of renewable energy generation
5. *What role the County plays in renewable energy decision-making*, taking into consideration land tenure (federal, local public, and private lands), technology and scale (jurisdiction for solar thermal depends on size of output), and need for supporting resources such as roads and water

Similar to Round 1 engagement, workshops were hosted in five different locations across the county. A total of 221 individuals attended the five workshops during Round 2.

Round 3 Public Engagement

In the third round of engagement, the County hosted a listening session workshop on March 5, 2015, to share the preliminary project framework and invite public input on the key issues the County prioritized to address in the Element. Approximately 100 individuals attended to provide input and review the County framework.

The listening session allowed public comment and input on the County framework. About 30 stakeholders and representatives at the meeting shared a range of comments. Several participants vocalized that the County framework for the Element served as a good start to the project. Several participants emphasized strong preferences for the Element to prioritize and encourage distributed generation. Input also identified concern with definitions of disturbed lands as potential areas for renewable energy development, due to potential incompatibilities with existing communities.

GLOSSARY

abandoned mine land site: Lands, waters, and surrounding watersheds where the extraction or processing of ores and minerals has occurred (EPA 2014b).

accessory renewable energy facility: A renewable energy facility that is physically located on the primary end-user's property and serves the on-site needs of the primary use before supplying energy into the grid. On-site needs may include a separate legal parcel, if both properties are owned by the same individual or entity. These facilities are a type of distributed generation (separately defined). Also referred to as an on-site accessory energy facility. Accessory renewable energy facilities include rooftop and ground-mounted accessory facilities.

air compressor: A machine that uses energy to compress air to a pressure greater than standard atmospheric conditions. Compressed air can be used as a form of energy storage (IEA 2014).

anaerobic: A condition characterized by the absence of free oxygen (Merriam-Webster 2015).

anaerobic digester: A piece of equipment with an anaerobic chamber containing bacteria and other microbes. Biomass is placed in the anaerobic digester, where the microbes convert it to bioenergy or an intermediate product through biochemical conversion (CEC 2015).

biochemical conversion: A process that uses plants or microbes to produce usable energy (CEC 2015).

biodiesel: A type of biofuel that acts as a substitute for petroleum-based diesel fuel. Biodiesel is derived from vegetable oils, animal fats, and/or recycled grease (EIA 2015).

bioenergy: Energy derived from organic material (CEC 2015). In general, bioenergy is energy converted from biomass, from sources such as animal waste and plant residues produced on farms and in forests, crops grown specifically to produce energy (energy crops), and urban-derived food, yard, and other organic waste, as well as energy produced from landfill emissions and gas or waste from water treatment facilities. Bioenergy comes in many forms, including electricity, gaseous fuels (biogas or biomethane as well as synthetic natural gas), and liquid transportation fuels. The generation of electricity from biomass can occur at a variety of scales, powering both on- and off-site uses. Bioenergy facilities can either produce electricity only, or in a combined heat and power operation, a portion of the stream is extracted to provide process heat. Bioenergy power generation can be developed at the utility scale or distributed generation scale.

biofuel: A liquid fuel and form of bioenergy that can act as a substitute for petroleum-based fuels, often for transportation proposes (EIA 2015).

biogas: A mixture of methane and carbon dioxide produced by decomposition of organic material by microbes in an anaerobic environment; also a form of a bioenergy (EIA 2015).

biomass: Broadly, the physical matter from a living or recently deceased organism. In an energy context, organic material that can be used to produce energy (EIA 2015).

biomethane: Biogas that has been processed and refined to serve as a substitute for natural gas (CEC 2013).

board of supervisors: In California, the organization that oversees the operation of a county government (Merriam-Webster 2015).

British thermal unit: A unit of measurement for energy, often for heat energy, abbreviated as Btu. Equal to the amount of energy required to increase the temperature of one pound of liquid water by one degree Fahrenheit at the temperature at which water is most dense (EIA 2015).

brownfield site: Property where any expansion, redevelopment, or reuse of the property may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant (EPA 2011).

building efficiency: The energy use of a building relative to its size, type, and other factors that affect energy demand (CEC 2015).

building envelope: The structural elements (walls, roof, floor, and foundation) of an enclosed building, also known as the shell (DOE 2013).

building orientation: The relationship of a building to true south, as specified by the direction of its longest axis (DOE 2013).

built environment: Generally speaking, the part of the physical environment constructed by humans, as distinct from the natural environment (Saelens and Handy 2008).

carbon dioxide: A colorless and odorless gas molecule comprising one carbon atom attached to a single oxygen atom. It is produced as a byproduct of combustion and other processes. Carbon dioxide is a type of greenhouse gas. The chemical formula of carbon dioxide is CO2 (EIA 2015).

chemical conversion: A process that uses chemicals to convert a material into usable energy (DOE 2015a).

Clean Air Act: A federal law first passed in 1963, allowing the Environmental Protection Agency to establish controls on air pollution (EPA 2015).

cogeneration: Generating both heat and electricity from a single fuel type. The heat can be used for space heating purposes or to generate additional electricity (DOE 2013).

combustion: Technically, the chemical oxidation of a material, which releases heat and light. In a general sense, burning. A form of thermal conversion (EIA 2015).

commercial energy facility: A renewable energy facility with the primary purpose of selling energy to a utility company for off-site use. This may include neighborhood, community, and regional tiers of renewable energy facility.

community choice aggregation: A state-level policy enabling local governments to supply energy to end-users within their jurisdictions using the existing electrical grid (DOE 2015b).

community-scale energy facility: A renewable energy facility larger than 5 acres but no more than 56 acres producing energy primarily for off-site use.

community solar: A voluntary solar-electric system that provides energy or financial benefit to multiple community members or is owned by multiple community members (DOE 2011).

concentrated solar power: See solar thermal.

Conditional Use Permit: A permit that provides a process for reviewing uses and activities that may be appropriate in the applicable land use zoning district, but whose effects on a site and surroundings cannot be determined before being proposed for a specific site (County of San Bernardino 2014d).

contaminated site: A site containing a physical, chemical, biological, or radiological substance or matter that has an adverse effect on air, water, or soil (EPA 2015).

cooking: An end-use that involves preparing food for eating, usually by using heat (Merriam-Webster 2015).

cooling: Reducing the air temperature of an indoor space to improve comfort, e.g., air conditioning (EIA 2015).

data center: A type of nonresidential building or part of a building used to store, process, and/or distribute data on networked computer servers (Merriam-Webster 2015).

deferred maintenance: The act of postponing maintenance on buildings, structure and infrastructure, or equipment, in order to reduce short-term costs (Merriam-Webster 2015).

direct use: Any use of a renewable energy resource in which the resource is converted directly from its raw form into its final form.

discretionary income: Income after regular needs and bills are paid (IES 1998).

disposable income: Income after taxes, regular interhousehold transfers, and charitable contributions (US Census Bureau 2004).

distributed generation: Small, modular renewable energy generation technologies that provide electric capacity or energy located where it's needed, often at a customer's location or close to a load center. Distributed generation facilities are often owned by non-utility entities, such as generation developers or utility customers that offset all or part of the customer's on-site electrical load. Typically (although not always), distributed energy facilities produce less than 20 megawatts of power and are located near the point of use. Distributed generation facilities can include wind turbines, photovoltaics, fuel cells, microturbines, reciprocating engines, combustion turbines, cogeneration, and energy storage systems. Such facilities may be either connected to the local electric power grid or isolated from the grid in stand-alone applications.

distribution: The delivery of energy from centralized systems to individual customers (EIA 2015).

distribution facilities: Facilities and infrastructure that transport energy from a centralized system to individual customers or that assist in this process (EIA 2015).

disturbed land: Areas where the natural environment has been altered by human activity to a point of significant change (USGS 2014). This includes land with existing buildings and structures, including paved surfaces such as parking lots; lands with significant grading, excavation, or stockpiling that have not been restored to their natural state; sites with industrial operations such as mining or mineral extraction; lands developed for former industrial or commercial sites that were previously degraded or contaminated and then abandoned or underused; and areas that were developed and contaminated by hazardous or potentially hazardous materials.

electricity: A form of energy caused by the presence and motion of charged subatomic particles (EIA 2015).

Endangered Species Act: A 1973 law requiring government agencies to establish protections for listed species and their habitat to ensure the species' continued survival (EPA 2015).

end-use: The purpose for which energy is consumed (DOE 2013).

end-user: A person or entity who purchases energy for their own consumption and not for resale (EIA 2015).

energy: The capacity to do work. Energy comes in several forms, including electrical, heat, kinetic, chemical, and nuclear (CEC 2015).

energy conservation: Reducing energy use by achieving a different outcome (CEC 2015).

energy consumption: The amount of energy used by the end-user (CEC 2015).

energy efficiency: Using less energy to accomplish the same outcome (CEC 2015).

energy efficiency retrofit: Installing or upgrading features of a building so that the building uses less energy (CEC 2015).

energy intensity: The amount of energy used by a building, piece of equipment, or other process or activity relative to its size, the number of people involved, or other factor.

energy loading order: A framework for ensuring a reliable and sustainable supply of energy in a successful, cost-effective manner (CEC 2005).

energy production: The act of converting energy into a useful form (EIA 2015).

energy supply: Energy made available for use (EIA 2015).

energy use: See energy consumption.

environmental constraints: Resources in the natural environment that impose constraints or limitations on land use actions that may occur on a site or specified location. Constraint types may include topography, the presence of sensitive species or habitat types, and the risk of natural hazards.

equitable access: Refers to equal access to resources between individuals of all groups, such as individuals of all incomes, classes, geographies, ethnicities, or other socioeconomic factors.

ethanol: A clear, colorless, and flammable alcohol that is often produced from organic material and used as a source of bioenergy, especially as a biofuel. Ethanol is typically produced through a biochemical or chemical conversion process. The chemical formula of ethanol is CH3CH2OH, sometimes written C2H5OH or C2H6O (EIA 2015).

feedstock: A raw material to be converted into a product. Can refer to any material resource for any product, but in an energy context generally refers to a type of biomass to be converted to bioenergy (DOE 2013).

fermentation: A biochemical conversion process in which microbes convert organic material into another product. In an energy context, the product is frequently methane or an alcoholic biofuel such as ethanol (DOE 2013).

flywheel: A spinning wheel, often used to control the speed of a piece of machinery. A flywheel can also serve as an energy storage device (Merriam-Webster 2015).

fossil fuel: A source of energy formed from decayed organic material over millions of years, subjected to intense heat and pressure in the earth's crust. Coal, petroleum, and natural gas are all fossil fuels (EIA 2015).

gasification: A form of thermal conversion that relies on high pressure and specific quantities of oxygen to convert an energy source to a gaseous fuel (CEC 2015).

geothermal energy: Thermal energy in the earth's crust, a result of leftover heat from the earth's formation and radioactive decay (EIA 2015).

gigawatt: A measure of power, equal to one billion watts, one million kilowatts, or one thousand megawatts (EIA 2015).

gigawatt-hour: A measure of energy, equal to one billion watt-hours, one million kilowatt-hours, or one thousand megawatt-hours (EIA 2015).

goal: A broad statement identifying desired future conditions.

government facility: A type of nonresidential building owned by a government agency and/or used for government operations.

government operations: Activities, procedures, and operations carried out by a government agency as part of its responsibilities. Examples include maintenance activities, permit review activity, or the provision of public services.

green building: A building with features enabling it to have a lesser environmental impact than comparable buildings. Generally, green buildings are those that use processes that are environmentally responsible and resource-efficient for the life cycle of the building, from design and construction, to operation and deconstruction (EPA 2014a).

green energy economy: Economic activity created by the design, construction, and maintenance of renewable energy facilities or by operations necessary to support these actions.

greenhouse gas: A gas that, in the earth's atmosphere, allows sunlight through but reflects heat energy, thereby trapping heat in the atmosphere. An increase of greenhouse gases in the atmosphere is responsible for climate change (EIA 2015).

green trades: Jobs that produce goods or provide services that benefit the environment or conserve natural resources, also known as green jobs (BLS 2011).

grid: The infrastructure used to produce electrical energy and convey it to end-users (EIA 2015).

habitat conservation plan: A plan, authorized by the US Fish and Wildlife Service, to minimize impacts to a listed species. A habitat conservation plan is required for activities that may result in the accidental harming of a listed species (USFWS 2005).

heating: An end-use that involves adding thermal energy to a system (Merriam-Webster 2015).

housing stock: The total of all housing units in a jurisdiction or set area.

housing unit: Living quarters where the occupant or occupants live separately from other individuals and have direct access to their living quarters from outside the building or through a common hall (US Census Bureau 2012).

implementation strategy: A specific, prescribed action intended to implement or support implementation of a policy.

incorporated city: A community that has established itself as a distinct legal entity for the purpose of establishing its own government and providing its own services (US Census Bureau 2012).

independent power producer: An entity that generates electricity for sale to an electric utility (CEC 2015).

indirect use: Any use of a renewable energy resource in which the resource is converted to one or more intermediate states before being converted into its final form.

industrial facility: A nonresidential building type primarily used for industrial processes.

industrial processes: Processes that involve the production of a good or service, including supportive processes such as research and logistic activities (Merriam-Webster 2015).

infrastructure: The basic equipment and structures needed for a system to properly function (Merriam-Webster 2015).

intermittency: An issue wherein the output of an energy generating facility is controlled by the natural variability of the resource (e.g., sunlight or wind) rather than by the facility's operators (EIA 2015).

jurisdictional control: The ability of a government to exercise regulatory authority. Land within which a government may exercise this authority is under said government's jurisdictional control.

kilovolt: One thousand volts (EIA 2015).

kilowatt: One thousand watts (EIA 2015).

kilowatt-hour: One thousand watt-hours (EIA 2015).

kinetic energy: The energy of a moving body, determined by its mass and velocity (DOE 2013).

Landfill Methane Outreach Program: A voluntarily program to help reduce methane emissions from landfills by encouraging the recovery and use of landfill biogas as an energy resource (EPA 2014d).

land use authority: The ability to regulate the way land is used, including the form and function of buildings and structures, the impacts from activities on resources, and how construction and demolition activities are carried out.

land use planning: Planning for how land can or should be used in the future.

lighting: An end-use that converts energy into illumination (Merriam-Webster 2015).

listed species: A species protected under the provisions of the Endangered Species Act (EPA 2015).

local consumption: The use of energy generated from off-site sources within the local distribution network.

local energy resources: Energy resources present in the unincorporated area of San Bernardino County.

local production: The generation of energy for off-site use within the local distribution network.

local use: See local consumption.

megawatt: One million watts or one thousand kilowatts (EIA 2015).

megawatt-hour: One million watt-hours or one thousand kilowatt-hours (EIA 2015).

methane: A colorless, odorless, and flammable gas comprising a single carbon atom and four hydrogen atoms. Methane is the primary component of natural gas and acts as a greenhouse gas in the atmosphere. The chemical formula of methane is $CH4$ (EIA 2015).

microgrid: A localized energy distribution grid that can disconnect from the traditional grid to operate autonomously. Microgrids often include renewable energy and/or energy storage systems (DOE 2015c).

military facility: A type of nonresidential building or facility owned by the US Department of Defense, used for national defense purposes.

mineral extraction facility: A type of industrial facility for the purpose of extracting a mineral resource from the natural environment, e.g., a mine.

motor: A machine that converts energy into force and/or motion (DOE 2013).

nascelle: The component of a wind turbine that houses the generator and related components, including the gear box and drive train (DOE 2013).

natural environment: All living and inorganic natural things around us, including the earth, air, water, and plants and animals (DOE 2013).

natural gas: A mixture of gases comprising hydrogen and carbon, with methane being the primary component (EIA 2015).

navigable waters: Waters currently used, or used in the past, or which may be susceptible to use, in interstate or foreign commerce, including all waters subject to the ebb and flow of the tide (USACE 2007).

neighborhood-scale energy facility: A renewable energy facility up to 5 acres in total area producing energy primarily for off-site use.

net energy metering: The practice of using a single meter to measure both consumption and production of energy by a small generation facility, such as a rooftop solar photovoltaic system, and to sell excess energy to a utility (DOE 2013).

non-local consumption: For purposes of energy, refers to supplying energy to the transmission grid.

non-local production: The production of energy outside the unincorporated county that supplies energy demand in the unincorporated county.

non-local use: See non-local consumption.

nonrenewable energy: Energy sources that cannot be replenished within a reasonable period of time (e.g., fossil fuels) (EIA 2015).

nonresidential: Buildings used for a purpose other than as human dwellings, such as offices, retail stores, and industrial facilities (CEC 2015).

NOx: A generic term for mono-nitrogen oxides, which consist of nitric oxide (chemical formula: NO) and nitrogen dioxide (chemical formula: NO2), both of which are air pollutants. The gases are most commonly emitted through the combustion of certain fuel sources and can contribute to smog, acid rain, and ozone pollution (EPA 2014c).

nuclear energy: Energy derived from a self-sustaining and controlled nuclear reaction. All nuclear energy used by people is derived from nuclear fission reactions (EIA 2015).

off grid: A building or group of buildings not connected to an energy distribution network.

office: A nonresidential building type, usually where people work at desks on business-related or professional activities (Merriam-Webster 2015).

office equipment: An end-use that involves operating equipment necessary for business-related or professional activities, such as computers and copier machines (CEC 2015).

off-site use: The use of energy not generated on the property.

on-site accessory energy facility: See accessory renewable energy facility.

outcome: Something that happens as a result of an activity or process (Merriam-Webster 2015).

passive solar: The use of energy from the sun without any electrical or mechanical systems, usually for heating or cooling purposes (EIA 2015).

passive solar building: A building that incorporates passive solar features.

payback: The period of time before the savings resulting from an action equal the cost of the action; for example, when the utility bill savings from a rooftop solar array equal the cost of installing and maintaining the array (DOE 2013).

photovoltaic cell: A device formed of layers of semiconducting materials, capable of creating an electrical current when illuminated (EIA 2015).

policy: A statement derived from a goal to guide decision-making and implementation strategies toward a specific outcome.

power: The rate at which energy is produced, transferred, or used. Measured in watts (EIA 2015).

power purchase agreement: An agreement between two entities wherein one agrees to generate power and sell it to the other (NREL 2011).

private sector: Private entities, including individuals and companies owned by individual shareholders.

propane: A gas comprising three carbon atoms and eight hydrogen atoms, present in unprocessed natural gas, which can be used as a fuel. Primarily used for lighting, heating, and industrial applications. The chemical formula of propane is C3H8 (CEC 2015).

public health: The health of members of the general public.

public land: Land owned by a government agency, not necessarily open for public access.

public sector: Government entities.

pumped hydro storage: A method of energy storage that involves using excess power to pump water uphill into a reservoir. During times of high demand, the reservoir releases water to operate hydroelectric generators (CEC 2015).

pyrolysis: A thermal decomposition process at high temperatures in the absence of air (EIA 2015).

refrigeration: The process of removing heat from one location and transferring it to another. A home refrigerator removes the heat inside the device and transfers it to the air in the room (DOE 2013).

regional-scale renewable energy: A renewable energy facility covering more than 56 acres but no more than 140 acres, with a net maximum power capacity no greater than 20 megawatts, producing energy primarily for off-site use.

renewable energy: Energy derived from resources that naturally replenish themselves within a reasonable period of time (EIA 2015).

renewable energy facility: A facility that generates renewable energy (DOE 2013).

renewable energy technology: A technology type that allows for the generation of renewable energy (DOE 2013).

renewable portfolio standard: A government mandate to produce a set amount of energy from renewable energy resources (NREL 2014). California's standard is known as the Renewables Portfolio Standard and requires electric utilities to procure 33% of their electricity from qualified renewable sources by 2020 (CEC 2015).

residential: Buildings used as a human dwelling, e.g., a home or apartment (CEC 2015).

resiliency: The ability to remain functional following a negative event (Merriam-Webster 2015).

Resource Conservation and Recovery Act site: A site participating in cleanup actions of hazardous waste under the Resource Conservation and Recovery Act's Corrective Action program (EPA 2013Ab).

retail: A type of land use or energy user that includes stores and shops providing a variety of merchandise.

scales: Different categories of renewable energy facilities, as determined by size and purpose.

sensitive biological species and habitat: Listed species, other rare species, species of special consideration, other species deemed worthy of protection, and the habitat necessary to support them, as well as habitat deemed worthy of protection for other reasons.

social environment: The immediate physical surroundings, social relationships, and cultural milieus within which defined groups of people function and interact. Includes built infrastructure, industrial and occupational structure, labor markets, social and economic processes, wealth, social and health services, race relations, social inequality, cultural practices, the arts, religious institutions and practices, and beliefs about place and community (Barnett and Casper 2001).

solar energy: Energy derived from electromagnetic radiation emitted by the sun (EIA 2015).

solar energy system: A system that collects solar energy and converts it to one or more usable forms using electrical and/or mechanical processes. Solar energy systems include but are not limited to photovoltaic, solar thermal, and solar water heating technologies. Solar energy systems do not include passive solar technologies, including solar cooking or passive solar features in a building for space heating and cooling.

solar oven: A device that concentrates heat energy from the sun in an enclosed or partially enclosed space for the purpose of cooking food.

solar thermal: An energy technology that converts solar radiation to heat energy (EIA 2015).

space heating: Increasing the air temperature in an enclosed space to improve comfort, e.g., through the use of a furnace (EIA 2015).

substation: A type of grid facility that switches, converts, and/or regulates the flow of electricity (EIA 2015).

sulfur dioxide: A colorless, toxic gas formed of a single sulfur atom and two oxygen atoms released through the combustion of materials containing sulfur. Sulfur dioxide is classified as a major air pollutant (EIA 2015).

Superfund site: An abandoned hazardous waste site undergoing cleanup activities through an EPA-administered program established by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (EPA 2013Aa).

system: A group of related parts that move or work together (Merriam-Webster 2015).

therm: A unit of measurement for heat energy, equal to 100 Btus, or approximately the amount of heat energy released by the combustion of 100 cubic feet of natural gas (EIA 2015).

thermal conversion: A process that uses heat to convert a resource into usable energy (DOE 2015A).

tiers: The combination of scales and intended users for renewable energy systems, when discussed in the context of San Bernardino County.

toxin: A substance or mixture of substances that can cause harm to humans or animals (EPA 2015).

transformer: A device that converts an electric current to a different voltage (EIA 2015).

transmission: The movement of energy from a central generating station or supply source along centralized corridors (EIA 2015).

unincorporated county: In California, the areas of a county not included in any incorporated city.

utility-scale renewable energy: A renewable energy facility with a net maximum power capacity in excess of 20 megawatts.

ventilation: The process of moving air in and out of an enclosed space, either naturally or through mechanical systems (DOE 2013).

visitor-serving use: A facility that supports individuals who do not normally reside or work in the area, including lodging.

visual resources: The factors and elements of the natural and built environment that contribute to the look of a particular location.

volt: A standard unit of electric potential (EIA 2015).

vulnerability: The condition of being open to harm or damage (Merriam-Webster 2015).

warehouse: A type of nonresidential building used for storing goods (Merriam-Webster 2015).

water heating: An end use that involves raising the temperature of water (Merriam-Webster 2015).

waterwheel: A device that uses the weight and/or force of moving water to turn a wheel to power machinery (EIA 2015).

watt: The standard unit of power (EIA 2015).

watt-hour: A common unit of energy, equal to one watt of power supplied or delivered continuously for one hour (EIA 2015).

wind energy: Energy derived from the kinetic energy of moving air particles (EIA 2015).

windmill: A form of wind turbine that converts energy into mechanical energy, usually for grinding grain (DOE 2013).

wind turbine: A device to convert wind energy to a usable form. Usually used to refer to devices that generate electricity (EIA 2015).

zero net energy: Producing as much energy as is consumed on-site (CEC 2015).

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