



Bureau of Land Management

Classroom

Investigation

SERIES



# SOLAR-GENERATED ELECTRICITY



Middle School Teaching Guide

# Dear Teacher,

Welcome to this Classroom Investigation Series unit about solar-generated electricity on public lands. From its three activities, students will learn how solar facilities generate electricity, the tradeoffs involved in large-scale solar facilities, and the interest groups that inform Bureau of Land Management (BLM) decisions about whether to approve new solar facilities.

This unit is designed for middle school students, but it can be adapted for the high school and upper elementary levels. The activities offer students speaking, data interpretation, and teaching roles as they progress through the unit. The activities engage students in using diverse cognitive skills, such as interpreting charts and tables, sorting through conflicting arguments, and weighing tradeoffs.

The unit supports innovative strategies in education, such as:

**Inquiry-based instruction:** Students develop and address questions about solar energy based on charts and tables, and they take part in a simulated public hearing in which a variety of opinions are expressed about whether the BLM should approve solar facilities.

**Social and emotional learning:** Students participate in small groups in which they need to work together, listen and speak to one another, and collaborate. They also encounter diverse views on a policy question for which there is no clear right answer.

**Interdisciplinary instruction:** While the unit focuses on facts about solar energy, it also addresses key concepts in social studies and English language arts. For social

studies, students examine how a federal agency considers diverse perspectives and collects public input as it makes decisions; for English language arts, students translate data and information into a persuasive speech.

Each activity in the unit takes either one or two 45-minute class periods, for a total of four periods. The activities work best as a collective unit that progresses from exploring how solar facilities work to grappling with tradeoffs to making decisions about where to site facilities.

## Curriculum Connections

In its entirety, the unit aligns with Next Generation Science Standards:

- MS-ESS3-3: “Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.”
- MS-ESS3-5: “Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.”

The activities address the following essential questions:

- What is solar energy, and how is it generated on public lands?
- What are the benefits and tradeoffs of solar electricity generation on public lands?
- How do public land managers balance tradeoffs as they make decisions about solar energy projects?

## About the Bureau of Land Management

The BLM cares for about 245 million acres of federally owned public lands, mainly in the Western United States and Alaska. These lands, representing about one-eighth of our nation's land area, belong to all Americans. In addition, the BLM administers 700 million acres of mineral estate across the entire country.

Public lands are used for many purposes. They support local economies, providing Americans with coal, oil and gas, forest products, livestock forage, and other commodities. As a haven for plants and wildlife, they play a critical role in habitat and resource conservation efforts. They embrace some of our country's most important historical, archaeological, and paleontological sites. Open spaces on public lands offer places for people to play, learn, and explore. In recent years, some BLM lands have been designated as part of the National Conservation Lands, a network of lands afforded special status and managed almost exclusively to conserve their scientific, cultural, educational, ecological, and other values.

The BLM is responsible for managing public lands under the principles of multiple use and sustained yield in a manner that best meets the current and future needs of the public. With so many resources and uses, the BLM's job is challenging. Thankfully, countless partners, volunteers, and communities provide invaluable support, helping the agency carry out its stewardship mission. To learn more about your public lands and how you can get involved, visit <http://www.blm.gov>.

## The Importance of Solar Electricity Generation

One key goal of the President's Climate Action Plan is, by 2020, to reduce U.S. greenhouse gas emissions by 17% of 2005 levels. To help reach this goal, the President is requiring the Department of the Interior to grant permits on public lands for renewable energy projects that could power 6 million homes using wind, solar, geothermal, and hydroelectric power.

State renewable energy goals, concern about global warming, investment tax credits for solar energy projects, and volatile oil prices have all driven public and industry interest in utility-scale solar energy development. Solar energy projects can provide significant amounts of electricity while emitting virtually no greenhouse gases, but they require large areas of relatively flat land. And like all land use decisions, choosing where to build solar facilities involves balancing diverse values, such as habitat protection and cultural preservation.

The BLM manages more than 19 million acres of public lands with excellent solar energy potential in six states: Arizona, California, Colorado, Nevada, New Mexico, and Utah. The BLM Western Solar Plan, approved in 2012, provides a blueprint for deciding where utility-scale solar energy facilities should be built. The plan establishes solar energy zones with access to existing or planned transmission lines, incentives for development within those zones, and a process for considering additional zones and solar projects. Projects in the designated zones could produce as much as 27,000 megawatts of solar energy, enough to power approximately 8 million homes.

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# Activity 1: Introduction to Solar Energy on Public Lands



## For the Teacher

This activity addresses the following essential question:

- What is solar energy, and how is it generated on public lands?



## Overview

This is the first of three activities that address solar energy on public lands. This activity examines two methods of large-scale solar electricity generation on public lands, why such facilities are being built, and where solar generation fits into the mix of electricity sources in the U.S.

## Time Estimate

45 minutes



## Learning Objectives

Students will be able to (1) describe two methods for generating electricity from the sun's radiance; (2) explain how photovoltaic and concentrating solar power facilities on BLM-managed lands generate and distribute electricity; (3) identify current percentages of U.S. electricity generated by nonrenewables, renewables in general, and solar energy; (4) compare carbon dioxide (CO<sub>2</sub>) emission effects among sources of energy such as coal, natural gas, and solar; and (5) describe renewable energy elements of the President's Climate Action Plan and the role of solar energy in the plan.



## Teacher Preparation

1. Read the Background Information.
2. Make enough copies of Handout 1.1 for each student.
3. Arrange for the ability to show YouTube videos to the class.



## Background Information

According to the Environmental Protection Agency:

“Greenhouse gases trap heat and make the planet warmer. Human activities are responsible for almost all of the increase in greenhouse gases in the atmosphere over the last 150 years. The largest source of greenhouse gas emissions from human activities in the United States is from burning fossil fuels for electricity, heat, and transportation” (EPA 2015b).

“Carbon dioxide (CO<sub>2</sub>) is the primary greenhouse gas emitted through human activities. In 2013, CO<sub>2</sub> accounted for about 82% of all U.S. greenhouse gas emissions from human activities. Carbon dioxide is naturally present in the atmosphere as part of the Earth’s carbon cycle (the natural circulation of carbon among the atmosphere, oceans, soil, plants, and animals). Human activities are altering the carbon cycle—both by adding more CO<sub>2</sub> to the atmosphere and by influencing the ability of natural sinks, like forests, to remove CO<sub>2</sub> from the atmosphere” (EPA 2015a).

Electricity generation in the U.S. produced 2,043 million tons of CO<sub>2</sub> emissions in 2014. CO<sub>2</sub> emissions from electricity generation are measured in number of pounds of CO<sub>2</sub> per megawatt hour (MWh) of electricity generated. Coal produces 2,249 pounds per MWh; natural gas generates 1,135 pounds per MWh; and renewables such as solar energy produce essentially no CO<sub>2</sub> when generating electricity.

Solar energy is converted to electricity in two ways:

- **Photovoltaic** (PV or solar cells) change sunlight directly into electricity. Individual PV cells are grouped into panels and arrays of panels that can be used to charge calculators and watch batteries, power individual homes, or generate electricity for the transmission grid.



- **Concentrating solar power** (CSP) plants use mirrors or lenses to concentrate a large amount of sunlight onto a small area to heat a fluid, often molten nitrate salt. The heated fluid produces steam to power a turbine generator. Using molten salt instead of water as the heat-transfer fluid makes it possible to store the energy so that electricity can be generated at night or on a cloudy day. Power from the generator then reaches homes and businesses through the transmission grid.



BLM-managed lands in the California desert host a large solar electric generating system named Ivanpah for the desert valley where it is located. It is a CSP “power tower” system on more than 3,400 acres. Power tower systems use flat mirrors (“heliostats”) to focus and concentrate sunlight onto a receiver on the top of a tower. Ivanpah has about 170,000 heliostats surrounding its three towers. Ivanpah generates 370 megawatts of electric power. A

megawatt provides enough electricity for about 300 homes, so Ivanpah can power 111,000 homes.

BLM lands also host a California desert PV facility called Desert Sunlight. It is located on

about 4,100 acres managed by the BLM. The facility uses more than 8 million photovoltaic modules to generate power. It provides 550 megawatts of electricity to the grid—enough energy to power about 165,000 homes.



## Procedure

1. **Introduce the topic:** Capture students' current knowledge of solar electricity generation along with what they want to

learn, using a KWL chart (see the Model KWL Chart; leave the "L" column blank until the end of the unit).

### Model KWL Chart

K	W	L
<p>What <b>KNOWLEDGE</b> Do You Bring?</p>	<p>What Do You <b>WANT</b> to or Think You Will Learn?</p>	<p>What Did You <b>LEARN?</b></p>

2. **Present background information:** Provide a 15-minute description of greenhouse gases and CO<sub>2</sub> emissions, the President's Climate Action Plan, and the two types of solar facilities that generate electricity. The YouTube video found at <https://www.youtube.com/watch?v=QTNU1JMhzxA> introduces CSP systems, and the YouTube video found at <https://www.youtube.com/watch?v=0elhIcPVtKE> introduces PV systems.
3. **Individual student work:** Students use Handout 1.1 to examine CO<sub>2</sub> emissions and

- learn, using a KWL chart (see the Model KWL Chart; leave the "L" column blank until the end of the unit).
- historic and recent data on the percentage of electricity generated from various renewable and nonrenewable sources; they also complete the questions on the handout individually.
4. **Form groups:** Students form groups of four or five to review their answers to the questions (see the Teacher Answer Key).
5. **Class discussion:** Lead a discussion with the question: What are the benefits of CSP and PV solar projects?



## Assessment

Circulate among the groups as students discuss their answers to the math questions. As an alternative, omit the group

peer review of the problems, and grade them individually (see the Teacher Answer Key).



## Adaptations to Consider

Direct students to <http://www.eia.gov/beta/MER/index.cfm?tbl=T07.01#/?f=M&start=200001>, and ask them to identify the latest trends in

solar electricity generation versus other sources of electricity.



## Teacher Answer Key

1. Which source saw the greatest decrease from 1990 to 2014? **Coal**
2. How much growth was there from 1990 to 2014 in the percentage of power generated by solar facilities? **From 0 to 0.4%**
3. What do you think are some of the reasons for the growth in solar electricity generation? **Desire to reduce CO<sub>2</sub> emissions, falling costs of solar technologies**
4. Which change from 1990 to 2014 most surprises you, and why? **Responses will vary**
5. Burning coal generates about 2.1 million pounds of carbon dioxide (CO<sub>2</sub>) per gigawatt. With about 300 gigawatts of electricity from coal in 2014, roughly how much CO<sub>2</sub> is emitted by coal-powered electricity each year? **630 million pounds**
6. With coal generating 39% of the electricity used in the U.S. in 2014, accounting for 300 gigawatts, calculate how many gigawatts were generated by solar facilities that year, given that 0.4% of electricity was generated by solar facilities. **Approximately 3.1 gigawatts**
7. If solar facilities generate 50 gigawatts of electricity in a year, roughly how much CO<sub>2</sub> will be emitted? **0**





## Handout 1.1: Comparison of U.S. Sources of Electrical Power

According to the Environmental Protection Agency's "Overview of Greenhouse Gases" website, "The main human activity that emits carbon dioxide (CO<sub>2</sub>) is the combustion of fossil fuels (such as coal, oil, and natural gas) for energy and transportation. The combustion of fossil fuels to generate electricity is the largest single source of CO<sub>2</sub> emissions in the nation, accounting for about 37% of total U.S. CO<sub>2</sub> emissions in 2013. Different fossil fuels used to generate electricity will emit different amounts of CO<sub>2</sub>. For example, to produce a given amount of electricity, burning coal will produce more CO<sub>2</sub> than burning natural gas."

Study Figures 1 and 2, which present the percentages of the main sources of electrical power in 1990 and 2014. Compare the differences between time periods, and then answer the questions.

**United States Sources of Electrical Power, 1990**

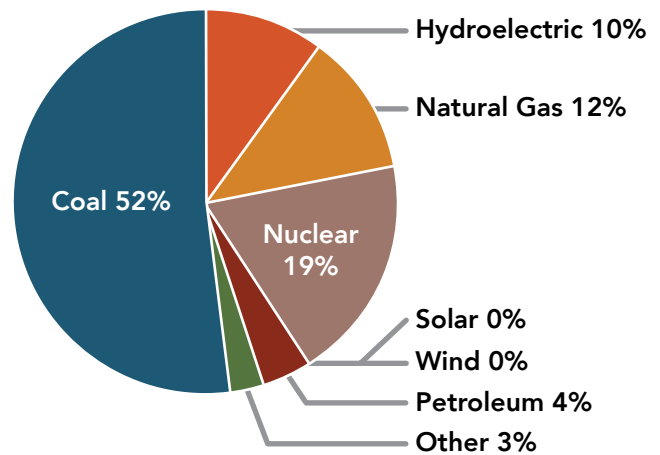


Figure 1. Major energy sources and percent share of total U.S. electricity generation in 1990. Source: Energy Information Administration

**United States Sources of Electrical Power, 2014**

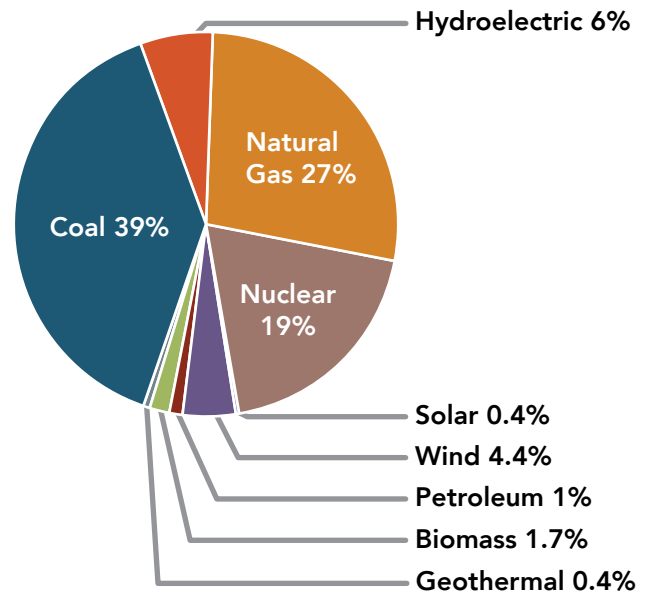


Figure 2. Major energy sources and percent share of total U.S. electricity generation in 2014. Source: Energy Information Administration

## Questions

1. Which source saw the greatest decrease from 1990 to 2014?
2. How much growth was there from 1990 to 2014 in the percentage of power generated by solar facilities?
3. What do you think are some of the reasons for the growth in solar electricity generation?
4. Which change from 1990 to 2014 most surprises you, and why?
5. Burning coal generates about 2.1 million pounds of carbon dioxide (CO<sub>2</sub>) per gigawatt. With about 300 gigawatts of electricity from coal in 2014, roughly how much CO<sub>2</sub> is emitted by coal-powered electricity each year?
6. With coal generating 39% of the electricity used in the U.S. in 2014, accounting for 300 gigawatts, calculate how many gigawatts were generated by solar facilities that year, given that 0.4% of electricity was generated by solar facilities.
7. If solar facilities generate 50 gigawatts of electricity in a year, roughly how much CO<sub>2</sub> will be emitted?

# Activity 2: Solar Electricity Tradeoffs

## Time Estimate

45 minutes



## For the Teacher

This activity addresses the following essential question:

- What are the benefits and tradeoffs of solar electricity generation on public lands?



## Overview

This is the second of three activities that address solar energy on public lands. This activity introduces students to the benefits and tradeoffs associated with developing facilities for solar electricity generation. Students examine how solar facilities may affect bird populations and wildlife habitat and require new transmission lines.

## Learning Objectives

Students will be able to (1) explain the role of solar energy in the President's Climate Action Plan; (2) identify how solar facilities may negatively affect wildlife habitat, recreation areas, and other land uses; and (3) identify the criteria used by decisionmakers when choosing among energy sources for electricity generation.



## Teacher Preparation

1. Read the Background Information.
2. Make enough copies of Handout 2.1 for each student.



## Background Information

Though solar-generated electricity has significant advantages over other sources when it comes to CO<sub>2</sub> emissions, it is not entirely without environmental consequences. Solar facilities can use large areas of land, threaten wildlife habitats, harm birds, and affect the landscape's scenic character and

recreational and cultural sites. Some impacts can be mitigated but usually at an increased cost. Handout 2.1 provides facts that can help students make judgments about which consequences may be worth risking to get the benefits of clean electricity.



## Procedure

1. **Review the benefits of solar energy:** Remind students that the Climate Action Plan calls for a 17% reduction of U.S. greenhouse gas emissions from 2005 levels by 2020 and that solar facilities on public lands are a key strategy to achieve the goal.
2. **Form groups:** Divide the class into groups of five or six students each, distribute Handout 2.1, and give students 25 minutes to read the handout and discuss the questions at the end of each section.

Ask groups to select one or more group members to explain their responses to the questions to the rest of the class.

3. **Class discussion:** Ask the spokesperson from each group to describe his or her group's views on the tradeoffs related to birds, recreation, desert tortoise habitat, transmission, and costs. Conclude by asking which source of electricity each group would like to see expand and how the criteria exercise helped them decide.



## Assessment

- Let students know that the group presentations will be graded on (1) whether spokespeople address all the tradeoffs and (2) whether spokespeople describe the complexity surrounding the tradeoffs.



## Adaptations to Consider

- Ask students to research the current cost of solar electricity generation, which has dropped dramatically over the past 5 years; further declines may affect whether cost is an important tradeoff.
- Ask the groups to describe how they would find answers to one of their outstanding questions (e.g., the methods used to count bird deaths at a CSP facility).



## Handout 2.1: The Tradeoffs of Solar-Generated Electricity

**Directions:** Read each section to yourself, and discuss the questions at the end of each section with the others in your group.

### Introduction

One goal of the President’s Climate Action Plan is, by 2020, to reduce U.S. greenhouse gas emissions from electricity generation by 17% of 2005 levels. The plan notes that climate change caused by CO<sub>2</sub> emissions is likely to raise sea levels, threaten low-lying island nations and coastal areas, and negatively affect plant and wildlife habitats.

Solar facilities such as Desert Sunlight and Ivanpah will help the U.S. reach the goals of

the Climate Action Plan, but they come with tradeoffs. Solar facilities cover large areas of land that could be used in other ways (such as for recreation or conservation), can fragment habitat of wildlife such as the desert tortoise, may harm birds, may alter the landscape’s scenic character, and are a relatively expensive way to generate electricity when compared to facilities that use other sources. Here is a closer look at some of these tradeoffs.

### Recreation, Tourism, and Scenery

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To the north of the Ivanpah facility is Primm, Nevada, which is a tourism-based border town with hotels, casinos, restaurants, a shopping mall, and an outdoor amusement park. The Primm Valley Golf Club is located in California, directly east of and adjacent to the Ivanpah plant. The course advertises itself as a place for golfers to get out of the city and “enjoy the amazing desert landscape to its full extent.”

Directly west and south of the Ivanpah solar energy plant is the 1.6 million-acre Mojave National Preserve, which overlooks the Ivanpah Valley. The preserve is a land of mountain ranges, sand dunes, great mesas, extinct volcanoes, and other desert landforms. At the foot of the Mojave National Preserve is the Ivanpah Dry Lake, a large open space and an international travel destination for land sailing, kite bugging, archery, and disc throwing.

The remote, vast spaces and vistas provide an opportunity for visitors to discover and experience a wide variety of historical and natural features that exist nowhere else in the U.S. in such proximity to one another.

1. Do you think the solar energy benefit of nearly zero CO<sub>2</sub> emissions is worth the tradeoff of threats to recreation, tourism, and scenery? Explain.
2. What more would you like to learn to be more confident in your decision?

## Birds

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It is difficult to measure the number of bird deaths each year at the Ivanpah Solar Electric Generating System. The current estimate is 3,500 bird deaths per year, with a wide range of estimates between 1,400 and 28,000. Many of these birds die flying through a “solar flux” field where temperatures reach about 800 degrees Fahrenheit. The birds chase insects that are attracted to the light reflected by Ivanpah’s mirrors. The U.S. Fish and Wildlife Service is conducting a study to determine the facility’s impact on birds and what kind of steps might keep the birds away from the solar flux.

Ivanpah’s managers are now testing methods to discourage birds from flying close to the facility, such as special lights that repel insects, recordings of raptor calls to frighten the birds, and “bird buffer” machines that spray a liquid that birds find unappealing. Actions like these are sometimes called “mitigation measures.”

Even if the highest estimate of bird deaths at Ivanpah is true (28,000), it can be compared to

other causes of bird deaths. Here are the minimum estimates of birds killed in the U.S. each year by other means:

- Collisions with buildings: 365 million
- Stray and outdoor cats: 1.4 billion
- Electricity generating facilities that use fossil fuels: 8 million
- Communication towers: 7 million
- Power lines: 12 million

1. Do you think the solar energy benefit of nearly zero CO<sub>2</sub> emissions is worth the tradeoff of lost bird lives? Explain.
2. What more would you like to learn to be more confident in your decision?

## Desert Tortoises

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Before the Ivanpah Solar Electric Generating System was built, Ivanpah’s managers expected to find 30 desert tortoises, a species listed as threatened under the Endangered Species Act of 1973, on the facility’s 3,500 acres. Instead, they found more than 170 tortoises, so the managers moved them first to pens and then to more remote locations. The two main threats to the desert tortoise are fragmented habitats and climate change caused by greenhouse gas emissions. BLM biologist Larry LaPre says

of the tradeoff: “If there were no push toward renewable energy, animals like the desert tortoise and plants like the Joshua tree could be impacted quite a bit” by climate change. So solar and other renewable energy projects may help save the desert tortoise but may threaten its habitat at the same time. Ivanpah’s managers have worked to reduce or mitigate the impact of the project on the tortoise by investing \$22 million in moving tortoises to desert sites outside of the facility.

1. Do you think the solar energy benefit of nearly zero CO<sub>2</sub> emissions is worth the tradeoff of impact on the desert tortoise? Explain.

2. What more would you like to learn to be more confident in your decision?

## Transmission

Large concentrating solar power (CSP) facilities such as Ivanpah need transmission lines to deliver their power to cities and towns. People usually do not want to live near a solar generating facility that sits on thousands of acres, so the power often has to travel hundreds of miles or more to reach consumers. There is currently not enough transmission capacity to handle electricity generated by new renewable energy facilities, so new lines will have to be built. New transmission lines can cost \$1 million per mile or more. Recently built lines from California's Imperial Valley to San Diego cost a total of nearly \$2 billion. Transmission lines can divide wildlife habitat, diminish the quality of views on the landscape, and cut through recreation areas used for

hiking, all-terrain vehicle and horse riding, and mountain climbing.

1. Do you think the solar energy benefit of nearly zero CO<sub>2</sub> emissions is worth the tradeoff of the costs and effects of new transmission lines? Explain.

2. What more would you like to learn to be more confident in your decision?

## Cost

The table shows estimated costs per megawatt hour for facilities starting operation in 2020 and

pounds of CO<sub>2</sub> per megawatt hour of electricity in 2013.

Type	Estimated Cost (\$/MWh)	Pounds of CO <sub>2</sub> /MWh
Coal, conventional technology	95	2,249
Natural gas, conventional technology	75	1,135
Concentrating solar power facility	220	0
Photovoltaic solar panel	125	0

Source: Energy Information Administration

1. Do you think the solar energy benefit of nearly zero CO<sub>2</sub> emissions is worth the tradeoff in financial costs? Explain.

2. What more would you like to learn to be more confident in your decision?

## Conclusion

Fill every square with a rating of -2, -1, 0, 1, or 2 to indicate whether you think the source is negative, somewhat negative, neutral,

somewhat positive, or positive. Talk with others in your group about how you rated each source against each criterion.

Criterion	CSP Solar	PV Solar	Natural Gas	Coal
Low cost per MWh				
Low CO <sub>2</sub> emissions				
High reliability in all weather				
Low impact on tortoise habitat				
Low impact on birds				
Low impact on tourism and recreation				
Low impact on scenic character of landscape				
Low need for new transmission lines				
Low acres of land per MWh				
<b>Total Rating</b>				

1. Which energy sources would your group like to see used more for electricity generation?
2. Are any criteria more or less important to you or others in your group?
3. What more would you like to learn to be more confident in your decision?



# Activity 3: Should the BLM Approve One or More Solar Facilities?

## Time Estimate

90 minutes



## For the Teacher

This activity addresses the following essential question:

- How do public land managers balance tradeoffs as they make decisions about solar energy projects?

## Learning Objectives

Students will be able to (1) identify interest groups involved in disputes over permitting new solar facilities; (2) synthesize and defend positions based on the views of an interest group; and (3) explain how the BLM balances diverse perspectives about land use decisions concerning new solar facilities.



## Overview

This is the third of three activities that address solar energy on public lands. This activity encourages students to grapple with the decisions that public land managers face as they balance renewable energy requirements with preserving cultural resources, wildlife habitat, and scenic quality. The choice in the activity is whether to approve zero, one, or two solar electricity-generating facilities on public lands. Small groups of students represent different interest groups and explain to BLM decisionmakers how the options may affect heritage areas, scenic backdrops, tourism, desert tortoise habitat, and bird safety.



## Teacher Preparation

1. Read the Background Information.
2. Make enough copies of Handout 3.1 for each student.
3. Make copies of Handout 3.2; there is a unique version of the handout for each interest group.



## Background Information

When deciding a land use question, such as whether and where to issue permits for solar electricity-generating facilities, public land managers must balance different values and uses of the public lands, such as recreation, conservation, federal and local goals, and economic growth. It is crucial for public land managers to listen to a variety of opinions representing a wide range of interests.

People who depend on the hospitality industry want high levels of tourism activity and often endorse decisions that promote recreation. Outdoor enthusiasts who enjoy hiking, rock climbing, fishing, and mountain biking in scenic areas also usually want to see decisions that accommodate recreation. Tribal leaders, historic preservationists, and conservationists often speak in favor of minimizing human impact on the land, even if that may mean limiting renewable energy and recreation.

Local business leaders and groups concerned about climate change may argue for constructing as many solar facilities as possible right away. Land use managers may be called on to decide the best way to promote renewable energy, preserve biodiversity, maintain balanced habitats, attract visitors to the public lands, promote economic activity, and ensure that future generations can enjoy cultural resources and recreational opportunities.

It is essential that students understand there is no right answer for the dilemma in this activity. Even the mitigation measures in the scenario can only reduce, but not eliminate, the impact of facilities. Students should appreciate the tradeoffs that land managers face when weighing the pros and cons of choices that may partially satisfy most interest groups but are unlikely to fully satisfy everyone.



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## Procedure

1. **Introduction:** Explain that public land managers make important decisions that can have long-lasting impacts, such as whether to approve solar facilities, and they hold public meetings to hear from everyone who could be affected before making such decisions. This activity will model the BLM's public meeting process and represent some of the opinions heard when the BLM makes decisions about solar energy facilities.
2. **Form interest groups:** Divide students into seven roughly equal-size groups, in which they will prepare and deliver a presentation

to BLM decisionmakers. Distribute Handout 3.1; ask students to read the scenario; and explain that their job is to develop arguments for the choice that best suits the interests of their group. Distribute the appropriate role sheet (from Handout 3.2) to each group. Ask each group to select a spokesperson. Provide about 20 minutes for the groups to develop their arguments. Provide any clarification for questions they may have, emphasize that there is no overall right answer, and discourage them from introducing factors that are outside the context of the activity.

3. **Form a BLM group:** Select one student from each interest group (someone other than the spokesperson) to form a new group: the BLM decisionmakers. Explain to the BLM decisionmaker group that their roles will change (they are no longer part of the “save the birds” or “preserve the desert tortoise habitat,” for example). From this point forward, as the BLM group, they will listen to each interest group’s presentation, take notes on each presentation, and ask each spokesperson any questions they may have.
4. **Interest group presentations:** Invite the spokesperson from each group to present his or her case to the BLM representatives. At the end of each presentation, have the BLM representatives ask the spokesperson any questions they may have.
5. **Discussion:** Once all groups have presented their positions, briefly lead students in a general discussion. Make sure students see that all groups have valid concerns and that tradeoffs will be necessary regardless of the final choice. [This will likely conclude the first class period.]
6. **Rearrange the groups:** While the BLM group is deciding which, if any, facilities to approve, rearrange the rest of the class into new groups made up of one person from each interest group. Ask students to argue for their own personal viewpoints rather than for the position of the interest groups they represented in Step 2. Have these groups decide what they think the BLM ought to do, and select a spokesperson.
7. **Reports from groups:** Once all groups have made a decision, ask the spokesperson from each to briefly share the group’s decision. Call on the BLM decisionmaking group last.
8. **Report from the BLM:** The BLM group’s spokesperson will then explain the BLM’s decision to the class, including the reasoning behind the decision and any mitigation measures that will be required.
9. **Discussion:** Ask students about the process: How hard was it to decide and to advocate? Did they personally agree with the position of their interest group? What are the tradeoffs for solar facilities, and are the benefits worth it?



## Assessment

Assign a persuasive essay in which students (1) state their personal views about siting a solar facility, (2) cite at least three pieces of evidence to support their positions, (3) describe the strongest argument by

those who disagree, and (4) conclude with a statement about why the issue is important. A rubric for persuasive essays can be found here: <http://www.readwritethink.org/files/resources/printouts/Persuasion%20Rubric.pdf>.



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## Adaptations to Consider

Display the KWL chart from activity 1, and ask students to suggest items for the “L” column reflecting what they learned.



## Handout 3.1: Decision Process for Developing Solar Facilities on Public Lands

### Instructions

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- Read the scenario, and compare the two possible solar facility sites.
- Consider the proposed solar facilities from the point of view of the interest group you represent. Read the group's description and interests, and discuss the factors that are of greatest interest to your group.
- Identify the mitigation measures (steps that may reduce the negative impacts), if any, that you want to see carried out in the event that the "BLM group" approves either or both projects.
- Select a spokesperson for the group who will present to the BLM group that is making the final decision. Present the following information:
  1. Your group's choice.
  2. The main reasons for that choice.
  3. Possible responses to arguments of those who oppose your group's position.
  4. What, if anything, you might be willing to give up or change about your position.
  5. How difficult it was to decide.
  6. The key tradeoffs your group discussed.

### Scenario

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The Bureau of Land Management (BLM) is the federal agency that manages the lands where two solar facilities are being proposed. The BLM is considering whether to approve neither, one, or both of the solar facilities. The sites are in the same state and are ideally suited to year-round solar electricity generation because they feature:

- A sunny desert climate (more than 325 days of sun per year).
- Thousands of acres of flat land (sloping at only 2-3%).

The state has goals for renewable and solar energy that are aligned with the goals in the President's Climate Action Plan. However, the two sites are different when it comes to:

- Desert tortoise habitat.
- The amount of electricity they would generate.
- The number of birds placed at risk.
- Easy access to transmission lines.
- The presence of Native American heritage sites.

The BLM land managers have four options:

- Do not approve either solar site.
- Approve only Site 1, the photovoltaic facility.
- Approve only Site 2, the concentrating solar power facility.
- Approve both sites.

## The Sites

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### *Site 1 Characteristics*

- A 300-megawatt photovoltaic facility that can power 108,000 homes at a cost of \$125/MWh.
- About 3 miles from an interstate highway.
- Not visible from the highway but visible from nearby hiking trails.
- Nearly 2,300 acres of land that has never before been developed, so the impact on the environment is likely to be greater than at Site 2.
- Estimated number of desert tortoises that will have to be relocated: 125.
- Expected to have almost no impact on birds.
- About 8 miles from the city where homes and businesses will use the electricity, so the facility will connect to an existing substation and use existing transmission lines.
- No known cultural or historical resources on the site.

### *Site 2 Characteristics*

- A 475-megawatt concentrating solar power facility that can power 171,000 homes at a cost of \$220/MWh.
- Less than 1 mile from an interstate highway.
- Visible from the highway and from nearby hiking trails.
- Nearly 4,600 acres of land that has been previously used for agriculture, so the impact on the environment is likely to be less than at Site 1.
- No desert tortoises expected to have to be relocated.
- Likely to be responsible for killing at least 2,000 birds each year, a number that should drop over time as managers try new mitigation methods to keep birds away.
- About 45 miles from the city where homes and businesses will use the electricity, so the facility will connect to new transmission lines that must be built for this project.
- In part, considered culturally important by the local tribal nation.

## Possible Mitigation Measures

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- No artifacts have been found in either project area, but the solar companies will order all work to stop if any are uncovered, which will increase the cost.
- If more desert tortoises than expected are found, the companies will pay extra to relocate the tortoises to a suitable new habitat, which will increase the cost.
- The operator of the concentrating solar power facility will play recordings of the birds' predators, which some studies say helps keep birds from flying close to the concentrated sunlight.



## Handout 3.2: Different Interest Groups and Their Thoughts on Two Proposed Solar Facilities

**Preserve the Desert Tortoise** – You strongly oppose Site 1 and are not sure whether to support Site 2 given that some tortoises might be found there once construction crews start digging and building. Come up with all the arguments and reasons to oppose Site 1, and decide whether to support Site 2. Once you have decided about Site 2, come up with arguments and reasons, and prepare your presentation to the BLM managers. Discuss how the projects might affect tortoise conservation goals, such as preserving habitat, working to slow or stop climate change, and not disturbing land that has never been developed.

Other things to keep in mind: The state has set a requirement that by the year 2020, 33% of the energy used in the state needs to come from renewable resources. The solar facilities would be a step toward reaching this goal, and reducing the effects of climate change should be good for tortoises. Constructing the facilities would bring in new revenue for the state government, some of which may be used for wildlife protection. The solar facilities should create new jobs in nearby communities. The people hired for these jobs would then buy items at stores in those communities, and many of the items purchased would have a state sales tax.

What other factors might be of interest to your group regarding the proposed solar facilities? Be prepared to respond to arguments opposing your group's position or reasoning. What might you be willing to give up or change about your position? What mitigation measures (steps that may reduce the negative impacts) do you want to see implemented in the event that the projects are approved?



**Coalition for Carbon-Free Energy** – You support both Site 1 and Site 2. Come up with arguments and reasons to show your support for both sites, and prepare your presentation to the BLM managers. Discuss how the projects might support clean energy goals, such as reducing carbon emissions from electricity generation; promoting "green" jobs; and promoting the health of residents, habitats, and ecosystems. The state has set a requirement that by the year 2020, 33% of the energy used in the state needs to come from renewable resources. The solar facilities would be a step toward reaching this goal. The number of birds that would die each year from flying into solar facilities would be much smaller than the number of birds that die in the country from flying into buildings or from being hunted by cats. Generating carbon-free electricity would help the desert tortoise by reducing the impact of climate change, which affects tortoise habitat. Constructing the facilities would bring in new revenue for the state government. The solar facilities would create new jobs in nearby communities, and these workers would then buy items at stores in the area.

What other factors might be of interest to your group regarding the proposed solar facilities? Be prepared to respond to arguments opposing your group's position or reasoning. What might you be willing to give up or change about your position? What mitigation measures (steps that may reduce the negative impacts) do you want to see implemented in the event that the projects are approved?

**Save the Birds** – You oppose Site 2 and are not sure whether to support Site 1. Come up with all the arguments and reasons to oppose Site 2, and decide whether to support Site 1. Once you have decided about Site 1, come up with arguments and reasons, and prepare your presentation to the BLM managers. Discuss how the projects might affect bird conservation goals, such as preserving habitat and working to slow or stop climate change.

Other things to keep in mind: The state has set a requirement that by the year 2020, 33% of the energy used in the state needs to come from renewable resources. The solar facilities would be a step toward reaching this goal, and reducing the effects of climate change should be good for birds. Constructing the facilities would bring in new revenue for the state government, some of which might be used for wildlife protection. The solar facilities would create new jobs in nearby communities. The people hired for these jobs would then buy items at stores in those communities, and many of the items purchased would have a state sales tax.

What other factors might be of interest to your group regarding the proposed solar facilities? Be prepared to respond to arguments opposing your group’s position or reasoning. What might you be willing to give up or change about your position? What mitigation measures (steps that may reduce the negative impacts) do you want to see implemented in the event that the projects are approved?



**Desert Beauty and Recreation Association** – You strongly oppose both Site 1 and Site 2. Come up with arguments and reasons to show your opposition to both sites, and prepare your presentation to the BLM managers. Discuss how the projects might threaten the interests of people you represent: hikers, all-terrain vehicle riders, land sailers, hunters, climbers, and campers who use the recreation resources of the desert. How might the roads, facilities, transmission lines, construction traffic, and noise affect the area’s scenic views and other recreational values? While constructing the facilities would bring in new revenue for the state government, the area would lose some money from a huge decline in tourism, causing a drop in state sales tax revenue.

What other factors might be of interest to your group regarding the proposed solar facilities? Be prepared to respond to arguments opposing your group’s position or reasoning. What might you be willing to give up or change about your position? What mitigation measures (steps that may reduce the negative impacts) do you want to see implemented in the event that the projects are approved?



**State Governor's Office** – You support both Site 1 and Site 2. Come up with arguments and reasons to show your support for both sites, and prepare your presentation to the BLM managers. Discuss how the projects might support state goals such as: promoting jobs, tourism, and businesses; funding public services; promoting the health of citizens; and promoting the health of the environment, habitats, and ecosystems. The state has set a requirement that by the year 2020, 33% of the energy used in the state needs to come from renewable resources. The solar facilities would be a step toward reaching this goal. The number of birds that would die each year from flying into solar facilities would be much smaller than the number of birds that die in the country from flying into buildings or from being hunted by cats. Generating carbon-free electricity would help the desert tortoise by reducing the impact of climate change, which affects tortoise habitat. Constructing the facilities would bring in new revenue for the state government. The solar facilities would create new jobs in nearby communities. The people hired for these jobs would then buy items at stores in those communities, and many of the items purchased would have a state sales tax.

What other factors might be of interest to your group regarding the proposed solar facilities? Be prepared to respond to arguments opposing your group's position or reasoning. What might you be willing to give up or change about your position? What mitigation measures (steps that may reduce the negative impacts) do you want to see implemented in the event that the projects are approved?



**Construction Workers Union** – You support both Site 1 and Site 2. Come up with arguments and reasons to show your support for both sites, and prepare your presentation to the BLM managers. Discuss how the projects might support union goals such as: promoting jobs, tourism, and businesses; funding public services; promoting the health of citizens; and promoting the health of the environment, habitats, and ecosystems. The state has set a requirement that by the year 2020, 33% of the energy used in the state needs to come from renewable resources. The solar facilities would be a step toward reaching this goal. The number of birds that would die each year from flying into solar facilities would be much smaller than the number of birds that die in the country from flying into buildings or from being hunted by cats. Generating carbon-free electricity would help the desert tortoise by reducing the impact of climate change, which affects tortoise habitat. Constructing the facilities would bring in new revenue for the state government. The solar facilities would create new jobs in nearby communities. The people hired for these jobs would then buy items at stores in those communities, and many of the items purchased would have a state sales tax.

What other factors might be of interest to your group regarding the proposed solar facilities? Be prepared to respond to arguments opposing your group's position or reasoning. What might you be willing to give up or change about your position? What mitigation measures (steps that may reduce the negative impacts) do you want to see implemented in the event that the projects are approved?

**Tribal Council** – You oppose Site 2 and are not sure whether to support Site 1. Come up with all the arguments and reasons to oppose Site 2, and decide whether to support Site 1. Once you have decided about Site 1, come up with arguments and reasons, and prepare your presentation to the BLM managers. Discuss how the projects might affect cultural preservation goals, such as preventing people from entering sacred areas.

Other things to keep in mind: The state has set a requirement that by the year 2020, 33% of the energy used in the state needs to come from renewable resources. The solar facilities would be a step toward reaching this goal, and reducing the effects of climate change should be good for birds and desert tortoises. Constructing the facilities would bring in new revenue for the state government, some of which might be used for wildlife protection and cultural preservation. The solar facilities would create new jobs in nearby communities. The people hired for these jobs would then buy items at stores in those communities, and many of the items purchased would have a state sales tax.

What other factors might be of interest to your group regarding the proposed solar facilities? Be prepared to respond to arguments opposing your group’s position or reasoning. What might you be willing to give up or change about your position? What mitigation measures (steps that may reduce the negative impacts) do you want to see implemented in the event that the projects are approved?



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