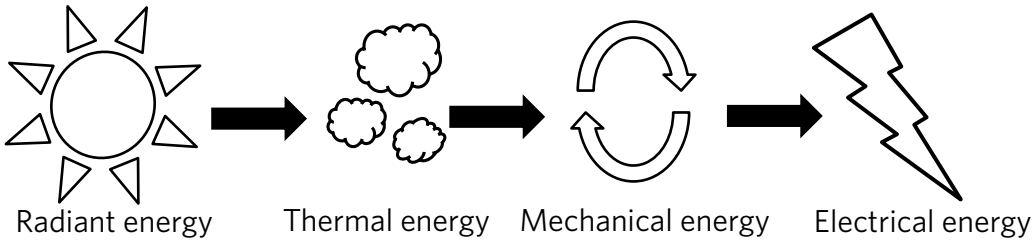
Solar Energy

Solar energy is a way to harness sunlight for heating or electricity. There are different ways to convert sunlight into usable energy. Concentrated solar power uses mirrors to focus the energy from the sun onto a smaller area. This concentrated thermal energy heats water into steam, which turns a turbine connected to a generator. The generator converts the mechanical energy of the spinning turbine into electrical energy. Concentrated solar power plants need between 500 to over 1,000 acres of land—more than 400 football fields!—to have enough mirrors to generate electricity efficiently. Often they are found in unpopulated desert regions—like the Ivanpah Solar Electric Generating System in the Mojave desert—which means the electricity generated has to be transmitted a long distance to where it will be used. It also means that large regions of desert ecosystems can be impacted[1].



Another technology that can convert the energy of sunlight into electricity is solar photovoltaics (PV). When sunlight strikes a solar photovoltaic cell, it is absorbed by a semiconductor—a material like silicon that can conduct electricity under the right conditions. This excites electrons in the semiconductor, which then flow, generating an electrical current. A bunch of solar photovoltaic cells can be grouped together to create a solar panel. Solar panels can be installed on the roofs of homes and buildings in solar arrays, so they are better options for cities. Solar panels are relatively easy to take care of and aren't noisy.

Solar photovoltaic technology produces no direct carbon dioxide or other greenhouse gases that can warm the climate. Sunlight is free, abundant, and renewable, since it won't run out for billions of years. The Earth's surface continuously receives 10,000 times more energy from the sun than the world currently uses[2]!

Unfortunately, solar energy isn't a great option everywhere or all of the time. Regions that don't get a lot of constant or direct sunlight aren't ideal places to use solar energy. Solar panels don't work at night and don't work as well when it is cloudy. Solar technology is becoming cheaper, but there is a cost to build a large concentrated solar power plant or install solar panels.

1 The New York Times: BrightSource Alters Solar Plant Plan to Address Concerns Over Desert Tortoise (Feb. 2010)

2 U.S. Department of Energy

Weighing the Benefits and Drawbacks of Solar Energy

For a complex problem, we need to evaluate how a solution fares across multiple dimensions:	Benefits	Drawbacks
Environmental Factors		
Social & Cultural Factors		
Economic Factors		

Exploring Energy

Weighing the Benefits and Drawbacks of Solar Energy

For a complex problem, we need to evaluate how a solution fares across multiple dimensions:	Benefits	Drawbacks
Environmental Factors	• Solar PV does not directly produce greenhouse gases like carbon dioxide that contribute to global warming and climate change.	• Large concentrated solar power plants can impact ecosystems because of their large land footprint.
Social & Cultural Factors	•There is more than enough solar energy to go around.	
Economic Factors	• Sunlight is free!	• There is a cost to installing solar panels. • Building large concentrated solar power plants can be expensive. • Solar power isn't a feasible option for energy generation everywhere, since not every region has a lot of direct or constant sunlight.

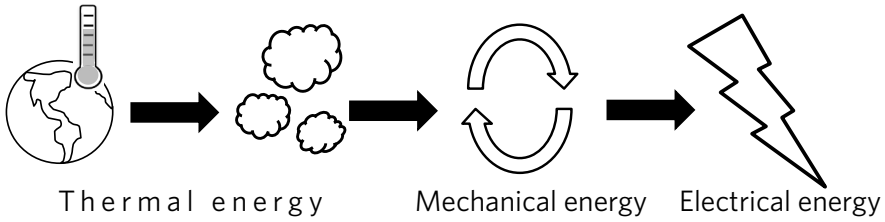
Additional resources

GRID Alternatives: Making solar technology accessible to underserved communities
Solar Energy Basics from the National Renewable Energy Laboratory

Geothermal Energy

How is electricity generated at a geothermal power plant? Well, it is often a lot like how electricity is generated at a coal-fired power plant, but with one key difference. In both cases, water is heated into steam, which turns a turbine connected to a generator. The generator converts the mechanical energy of the spinning turbine into electrical energy that can be transmitted to homes and buildings through transmission lines.

In a coal power plant, burning coal supplies the energy to heat the water. This process releases carbon dioxide—a powerful greenhouse gas that contributes to global warming and climate change—and other pollutants that can be harmful to the environment and human health into the atmosphere. But in a geothermal power plant, this energy comes from heat that is already present below the Earth's surface. Geothermal energy is a good energy option in places where there is hot magma close to the Earth's surface that naturally heats water in the ground into steam. In such places, geothermal energy is a constant and reliable source of energy.



Compared to coal and other fossil fuels, geothermal energy releases much less carbon dioxide into the atmosphere[1] and produces much less pollution. But geothermal energy isn't a good option everywhere. The best places for geothermal energy production are where there is a heat source, like magma, close to the Earth's surface, as well as a constant supply of water in the ground that can be heated into steam. Some water can be pumped back into the ground after it is used, but some of it evaporates into the atmosphere, so over time the water in the ground often needs to be replenished. During a drought, this can be an issue. Also, there is evidence that the pumping of water into and out of the ground associated with geothermal power can generate small earthquakes[2].

With geothermal energy, there is no fuel cost, since the fuel is naturally-occurring magma. However, upfront costs associated with building a new geothermal power plant and drilling wells to access the steam underground can be high[3].

1 National Renewable Energy Laboratory: Energy Analysis

2 University of California, Santa Cruz Newscenter: Geothermal power facility induces earthquakes, study finds

3 Geothermal Energy Association

Weighing the Benefits and Drawbacks of Geothermal Energy

For a complex problem, we need to evaluate how a solution fares across multiple dimensions:	Benefits	Drawbacks
Environmental Factors		
Social & Cultural Factors		
Economic Factors		

Exploring Energy

Weighing the Benefits and Drawbacks of Geothermal Energy

For a complex problem, we need to evaluate how a solution fares across multiple dimensions:	Benefits	Drawbacks
Environmental Factors	• Geothermal power plants produce less pollution and greenhouse gas emissions than coal-fired power plants.	• Pumping water into and out of the ground might induce small earthquakes around a geothermal power plant.
Social & Cultural Factors		
Economic Factors	• The 'fuel' for geothermal energy is free since it is naturally-occurring magma. • In places where geothermal energy is a viable option, it is a constant and reliable source of energy.	• Geothermal energy is location-specific and isn't an option where there isn't enough heat below the ground. • The initial costs associated with building a geothermal power plant and drilling steam wells can be high.

Additional resources

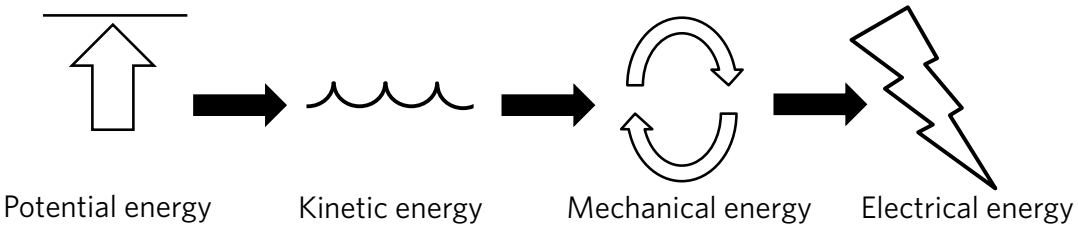
Learn about [The Geysers geothermal power plant in California]

Exploring Energy

Science Texts for Close Reading

Hydroelectric Power

Hydroelectric power (or 'hydropower') uses the energy of moving water to generate electricity. But how exactly can we capture and transform this energy into usable electricity? One of the main ways to do this is by building a dam on a river. By trapping water behind a dam, we can increase the level of the water behind the dam, building up its potential energy. When special gates in the dam are opened, the water—pulled by gravity—flows down through the dam and through turbines connected to a generator. The potential energy of the water is turned into kinetic energy as it flows, and then mechanical energy that turns the turbines. The generator converts the mechanical energy of the spinning turbines into electrical energy that can be transmitted to homes and buildings through transmission lines.



The water reservoirs (lakes and ponds) created behind dams can serve as recreational spaces for people who enjoy fishing, swimming, or boating. The water in these reservoirs can also be used for irrigation in agricultural areas.

Hydropower does not pollute the water nor the air. It also produces no direct carbon dioxide or other greenhouse gases that can cause damage to the climate. However, building a dam on a river can have significant impacts on ecosystems. Some fish species like salmon that migrate seasonally up rivers and streams to spawn are blocked from reaching their spawning destinations by dams[1]. The reservoir created behind a dam often floods land that wasn't originally underwater. In addition to impacting the plants and animals living on this land, this can displace people too.

Hydropower is reliable as long as there is enough available water. During a drought, this can be a problem. And while flowing water is free, building a dam can be expensive. Dams also don't just trap water, but anything being moved by the river. Sand and rocks can build up behind a dam over time, not only decreasing the amount of water the dam can store and release, but reducing the amount of sand that is carried into the coastal ocean to supply beaches[2].

1 NOAA Fisheries: About Dams & Fish

2 CoastalCare.org: Dams–Cutting Off Our Beach Sand

Weighing the Benefits and Drawbacks of Hydroelectric Power

For a complex problem, we need to evaluate how a solution fares across multiple dimensions:	Benefits	Drawbacks
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Social & Cultural Factors		
Economic Factors		

Exploring Energy

Weighing the Benefits and Drawbacks of Hydroelectric Power

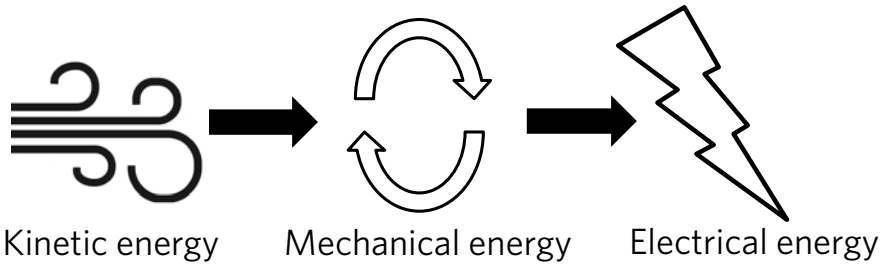
For a complex problem, we need to evaluate how a solution fares across multiple dimensions:	Benefits	Drawbacks
Environmental Factors	• Hydroelectric dams do not pollute the water nor air and do not directly produce carbon dioxide.	• Hydroelectric dams can block fish migrations up and downstream. • The reservoirs created by dams can flood sensitive and important habitats and ecosystems. • Dams can prevent sand from being carried down rivers and out to beaches along the coast.
Social & Cultural Factors	• The reservoirs created by dams can often be used for recreational purposes, like fishing, boating, or swimming. • The reservoirs created by dams can often be used for agricultural irrigation.	• Dams can flood land where people are living, forcing them to move elsewhere.
Economic Factors	• Flowing water is a free and renewable source of energy.	• Building a dam can be very expensive. • Dams might not be a reliable source of energy when there is a drought. • Dams can become less useful over time as the reservoirs fill up with sand and rocks.

Additional resources

KQED News: California Plumbing: A Mind-Boggling Web

Wind Energy

Have you ever tried to make a toy pinwheel spin by blowing on it? We can harness the power of moving air on a much larger scale and use it to produce electricity with wind turbines. When the wind is strong enough (has enough kinetic energy), the blades of a wind turbine turn, which spins a shaft connected to a generator. The generator converts the mechanical energy of the spinning shaft into electrical energy that can be transmitted to homes and buildings through power lines.



There are many different kinds of wind turbines, from small turbines that can be put on the roof of a house to really large turbines that can be built together in wind farms to power entire communities. Wind energy—a renewable resource—can be produced anywhere where there is wind, but the stronger and more consistently the wind blows, the better. Unfortunately, in most places the wind isn't blowing all of the time, and in places that aren't very windy, wind turbines probably aren't a good way to generate reliable electricity.

Wind energy doesn't directly produce carbon dioxide or other greenhouse gases that can cause damage to the climate. Wind power is also relatively inexpensive. The wind itself is a free resource, and although it costs money to build and operate wind turbines, advancements in technology have significantly reduced these costs over time. Wind energy doesn't pollute like coal burning, and pollution can cause health problems for people[1]. However, like with any infrastructure, some people express concern about wind turbines being too noisy or ruining the look of a landscape, and therefore don't necessarily want wind turbines near their homes.

Some kinds of wind turbines, particularly larger ones, can cause harm to birds and bats[2]; however, people are working on ways to reduce the impact of wind turbines on birds and bats, such as changing the height or location of the turbines.

1 World Health Organization: What are the effects on health of transport-related air pollution?

2 Smallwood, 2013

Weighing the Benefits and Drawbacks of Wind Energy

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Environmental Factors		
Social & Cultural Factors		
Economic Factors		

Exploring Energy

Weighing the Benefits and Drawbacks of Wind Energy

For a complex problem, we need to evaluate how a solution fares across multiple dimensions:	Benefits	Drawbacks
Environmental Factors	• Wind energy does not produce greenhouse gases like carbon dioxide that contribute to global warming and climate change. • Wind power does not produce air and water pollution.	• Wind turbines can harm bats and birds.
Social & Cultural Factors		• Some people are concerned about the way wind turbines might look or the noise they might generate.
Economic Factors	• The 'fuel' for wind power—the wind!—is free. • Wind power technology is relatively inexpensive	• Wind power isn't a feasible option for energy generation everywhere, since not every region has a lot of wind. Even in places that have a lot of wind, it still isn't blowing all of the time.

Additional resources

California Academy of Sciences: **Our Clean Energy Future**
California Academy of Sciences: **Birds vs. Energy**