# HYDROPOWER LESSON PLAN

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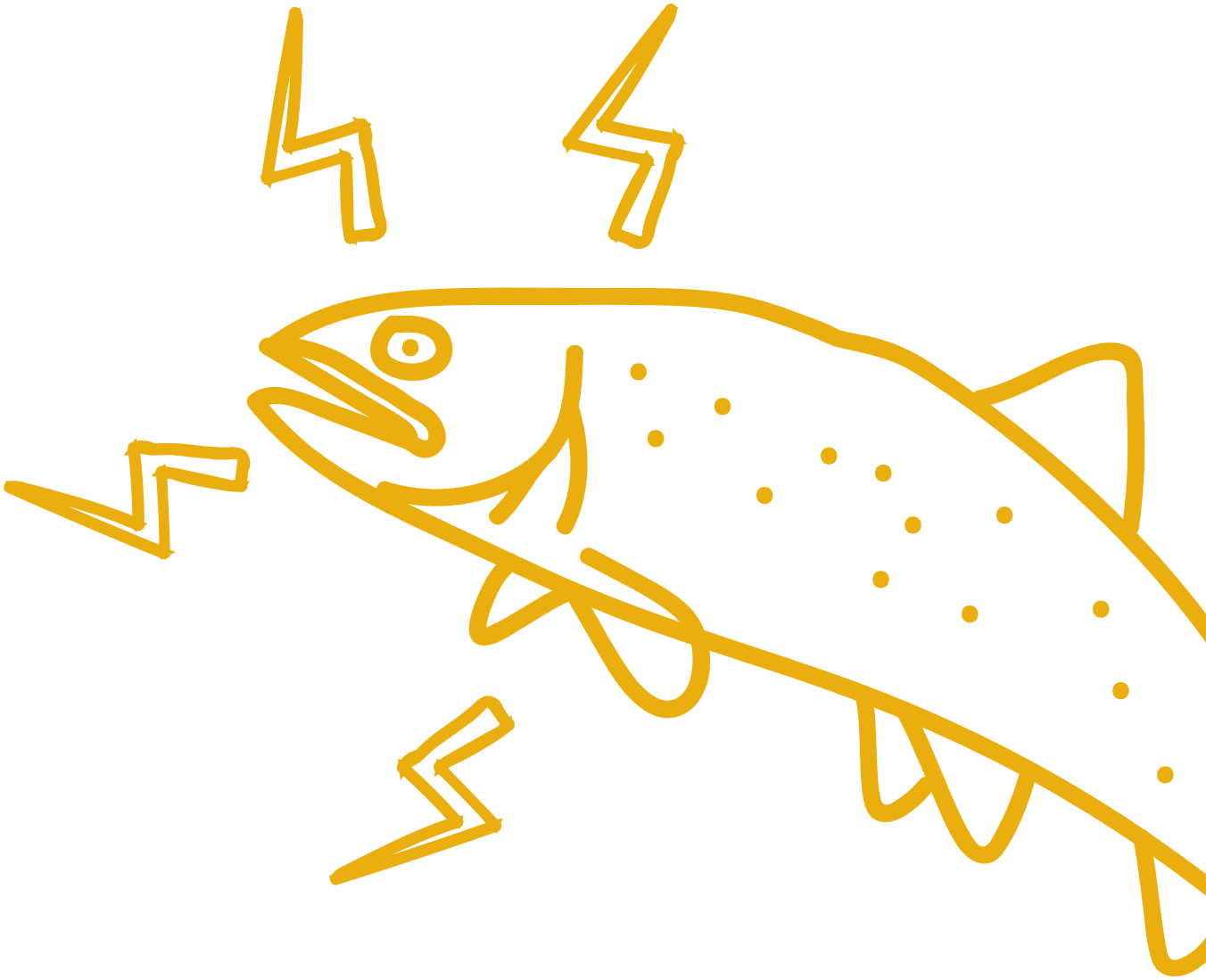

PRICKLY PEAR LAND TRUST

# Hydropower

**Location:** In classroom, Mt. Helena or Hauser Dam

**Aim:** How do we use hydropower without causing further damage to natural ecosystems?

**Time:** 1.5-2 hours

**Next Generation Science Standards:**

HS-LS2-6, HS-LS2-7, HS-LS4-6, HS-ESS2-2, HS-ESS2-5, HS-ESS3-1

**Guiding Questions:**

What is hydropower and how does it work?
How do dams impact fish populations?
What concerns need to be taken into account when building new dams?

**Learning Objectives:**

Discuss the pros and cons of dams and hydropower
Discuss how dams impact fish populations
Describe structures that can be built into dams to aid fish passage

# Lesson Timeline

Note: The introduction to the topic should take no more than 45min. The students will then play the salmon game, which will demonstrate the barriers to fish passage. The class will end with a discussion on the challenges fish face moving through a river, as well as measures that can be taken that aid fish passage around dams. If the lesson takes place at hauser dam, we will work with the dam operator to give a tour, education volunteers would just be responsible to administer the Salmon game as time permits.

**Students arrive, greet them and introduce yourself**

**10 MIN** Try to be as engaging as possible. The introduction with the students is what sets the tone for the rest of the lesson. This does not require you to have any special skills, just be friendly and be yourself. It would be great if you included some information about what you do, or did, for work. It is a good opportunity to introduce the students to different careers and does not need to be related to the lesson you are leading.

Ask the students to introduce themselves. Up to you how you want to do this.

**15 MIN** **Ask the students if they know of any dams in the Helena area**. Do they form any lakes? If they don't know, tell them that Hauser Dam created both Lake Helena and Hauser Lake. Have the students brainstorm why dams are useful, why we build them. Introduce hydropower.

**15 MIN** **Ask the students if they can name the main other ways we create electricity.** Discuss how coal, natural gas, wind, and nuclear power sources all produce electricity through the use of turbines. Breifly talk about how solar panels use non-turbine methods to create electricity. Ask students to think about the benefits of hydoelectric power compared to other energy sources? Discuss the electircal outputs of the Hoover Dam, Niagra Falls and Bonneville Dam.

**10 MIN** **Ask the students if they can think of any negative consequences** of building a dam. If the students come up with fish, ask them how dams disrupt fish populations Discuss with students that dams, along with other human factors like fishing, are putting many fish populations at risk.

**5-10 MIN** **Introduce the students to the concept of migratory fish species** and ask them if they can think of any. Tell them a little about salmon and pallid sturgeon

# Lesson Timeline Cont.

**5 MIN** **Play the salmon game with the students** first without human disruptions, and then with human disruptions

**5-10 MIN** **Bring the students back and discuss** with them what they discovered playing the game. Discuss why so many fish die, and how human structures and practices make it even harder for fish to survive

**5-10 MIN** **Ask students if they can think of ways to conserve fish populations** See what they come up with. It is ok if they want to talk about overfishing, even though it is not the main topic of this lesson

**5 MIN** **Ask the students how they would help fish get around dams** Discuss fish ladders, creating turbines that do not kill fish, and passage for juvenile fish

**If you have time,** you could look up the fish cannon that some people have been proposing. They are very entertaining but not necessarily the best solution. Ask the students what the pros and cons of these might be

# Background Info

## Introduction

**We are at a point in time** when it has become necessary to switch to renewable energy. However, as we make this switch, we need to ensure that the renewable energy we are switching to is not causing further harm to ecosystems. In this lesson we will discuss the pros and cons of dams and hydropower, as well as the impacts dams have on natural ecosystems.

**Historically,** dams were built as a means to conserve or divert water flow. Many ranches or farms would dig new channels for a stream to irrigate their crops. They would then use a dam to cut off flow to the original channel and divert it into the new channel. In drier areas or around towns people would build dams as a way to conserve water and create a reliable water source. In this scenario, a dam would be built across a river and then closed so that the area upstream of the dam would flood and form a new lake.

**Today we still build dams** for basically the same reasons. We now understand that diverting a stream can have serious consequences for the riparian and river ecosystems and, when moving a stream, people attempt to do it in a way that will not impact the overall ecosystem. And we still build dams as a means to control water flow. In areas prone to drought, we build dams to ensure access to water, while in areas prone to flash flooding, we build dams as a means to protect infrastructure and prevent flooding. Another reason we build dams is to create electricity.

## Hydroelectricity

**Hydropower is not a new method of creating electricity.** The first hydropower plant opened in 1882 in Wisconsin, and today all but two states use hydropower in some form.

**In hydropower dams,** the pressure built up at the bottom of the lake forces water through channels with turbines. The water turns the turbines, which in turn rotate generators, creating power. Hydropower is a clean renewable energy source but, if a drought hits an area that relies on hydropower, they often have to turn to coal or other fossil fuel sources for power. In addition to not being reliable 100% of the time, dams can have seriously damaging effects on the ecosystems surrounding them.

# Impacts on Fish Species

**When dams are built,** they change the river system. A new lake is artificially formed, flooding existing habitat and creating a lake that was not there before. Downstream of the dam, the river will often be smaller and shallower than it was before. The water that is released from dams is usually released from the bottom of the dam, which makes the water colder and clearer. Dams also prevent sediment transportation along the river. On the upstream side, dams accumulate sediment that often has to be removed, while the downstream side receives little to no new sediment. This increases erosion downstream because the river is only moving sediment without getting any new sediment from upstream.

**These changes to the structure of a river** have serious consequences for the fish species that rely on these rivers. Dams create a barrier for both migratory and non-migratory fish species. For non-migratory species like trout, dams create a barrier that separates the fish into separate populations. This can lead to decreases in genetic diversity because the fish cannot travel as far. Additionally, it can cut off some of the population from their historic spawning grounds, which can lead to a decrease in reproduction. For migratory fish species, dams can wipe out populations. Migratory species, like salmon, that move from freshwater to saltwater and back again, are reliant on the ability to navigate rivers and streams to make it to their feeding and spawning grounds. Even migratory populations that remain in freshwater their entire lives, like the pallid sturgeon, can be significantly harmed by dams.

**In addition to being a physical barrier**, dams create other obstacles for migratory fish species. Salmon, for example, rely on currents to navigate a river. If a salmon is able to make its way past a dam they are faced with a lake, a slow moving body of water with little to no current. Salmon slow down and wander in lakes, making them more vulnerable to predators and increases the amount of stored energy they use, decreasing their chance of making it to their spawning site. Pallid sturgeon are native to the Missouri and Mississippi Rivers and are descendants of sturgeon that were alive 80 million years ago. Today they are endangered and their populations are on the brink of collapse. In the 1900s, they were almost wiped out because they were fished for their roe. Today they face barriers from dams. Pallid sturgeons inhabit murky warmer waters. The water that comes out of dams is often clear and cold. This could be a contributing factor to the pallid sturgeon population decline, in addition to the physical barrier dams create that block the fish from reaching their spawning sites.

**Hydropower dams create an additional problem for fish**. Juvenile fish not strong enough to swim out of the current can be swept into the turbines and killed.

## The Benefits of Hydropower

**Dams create problems for the ecosystems they are built in, but** they are necessary for the lives we lead today. Therefore, it is our responsibility to limit the damage caused by dams. Across the world, people are beginning to remove dams that are not needed anymore and restore habitat. PPLT is in the process of restoring the creek on their Sevenmile property, and about a year after removing the dam we are already seeing an improvement in the fish populations. Scientists are working to create solutions to fish passage around dams. These include designing turbines that prevent juvenile fish from being killed, fish ladders that allow adult fish to swim up the dam, as well as passages for juvenile fish to swim downstream in. We have not come up with solutions that entirely solve the problems with dams but it is necessary that we keep working towards that goal.

# OTHER ELECTRICITY PRODUCTION METHODS

## The U.S Electricity System

**The electricity grid includes** the wires and towers that connect our houses and businesses to the power plants that produce electricity. The grid distributes electricity based on demand by consumers. When you turn on your light switch, a production facility must coordinate the amount of electricity it sends to your home. A "baseload" electricity source refers to a source of energy that provides relatively stable levels of electricity production that can be easily increased or decreased based on current electricity demands. If there is an increase in demand for electricity, a power plant must match the demand by spinning more turbines quicker. This is easy for energy sources such as Coal, Natural Gas, Nuclear and some Hydroelectric. When the demand for electricity increases quickly, a power plant can burn more coal or gas, or a hydro plant can release more stored water, which provides the baseload power needed to meet the demand quickly. Sources of power such as wind or solar only work when energy from the wind or sun are in play. Solar energy produced while the sun is shining can only be used during the day, and energy produced from strong night winds can only be used during the nighttime. While some of the time sensitive issues with wind and solar energy may be mitigated through the use of better batteries, which store the energy to

# Baseload Power

"'TV pickup' Describes as an electricity nuance completely unique to Great Britain, it refers to the fact that massive swaths of the nation's population will all get up at the same time — at the end of a popular TV show — and cause a surge in electricity usage simply by boiling a kettle full of water to make a cup of tea.
So how big is this surge? Well, when the popular soap Eastenders comes to an end five times a week, the grid has to deal with around 1.75 million kettles requiring power at the same time. That's an additional 3 gigawatts of power for the roughly 3-5 minutes it takes each kettle to boil. So big is the surge that backup power stations have to go on standby across the country, and there's even additional power made available in France just in case the UK grid can't cope. The engineers manning the British National Grid have to keep an eye on what's playing on TV so they can brace themselves for the highly predictable surges and make sure the grid remains stable."

# Other Sources: Pros and Cons

In lieu of baseload power from renewable sources such as wind and solar, the grid requires a stable energy source from coal, natural gas, nuclear, or hydroelectric. When used in combination, baseload energies and time-sensitive renewable energies can make for a sustainable grid system. The challenge is balancing the positive and negative attributes of each baseload power source in determining the best way to meet the needs of the energy system. Below, different energy sources and their pros and cons are outlined.

**Natural Gas: (36%)** Over one third of the US electricity is produced by burning natural gas or methane. Natural Gas is a baseload power source that can be ramped up and down quickly to meet demand. Typical natural gas power plants boil water by combusting the methane, the steam from the water turns a turbine, producing electricity. The extraction of natural gas is commonly achieved by hydraulic fracturing, a process whereby a slurry of chemicals and water is injected underground to release the gas trapped in rock beds. The fracking process has been found to pollute groundwater and cause minor to severe earthquakes. The raw form of methane, when released into the atmosphere is a potent greenhouse gas, more damaging than CO2. While the combusted form of Methane releases less CO2 than other fossil fuels such as coal, the release of raw methane, a much more potent greenhouse gas, is not well monitored throughout the distribution and production process.

**Coal: (28%)** Coal had long been the king of baseload power, and more generally electricity production in the US, for a long time prior to the introduction of large scale methane use; methane's recent boom was in large part due to advancements in horizontal hydraulic fracturing technology which increased the previously unreachable supply of gas. Coal mining practices have long had negative impacts on environmental and human health. The combustion of coal, starting at a wide scale during the industrial revolution, has caused many of the issues related to climate change we see today. Like Methane, coal is burned to boil water that turns a turbine.

**Nuclear: (19%)** Nuclear energy is a baseload power produced by boiling water, or other liquids, that turns a turbine. Nuclear reactors use the process of nuclear fission to split radioactive atoms, which upon splitting release great amounts of heat energy. The heat energy is used to boil the water and turn the steam turbine. The steam commonly depicted coming out of a nuclear stack is just water vapor that has been flash boiled by the nuclear fission process. Nuclear energy has no clear emissions, and the modern uranium mining practices are incredibly low impact. The problem instead with Nuclear energy is the waste that accompanies the process. Nuclear waste is incredibly radioactive and takes thousands of years to degrade to a safe state. Currently, we bury most of our used uranium, which poses great environmental and security risks.

**Hydroelectric: (7%)** Under 10% of the US electricity is produced through the use of hydroelectric dams. When dams store water above the turbines, the reserved water serves as potential energy that can be released as a sort of baseload. While hydroelectric only provides 7% of electricity on a national scale, regional uses of hydro vary greatly. For example, hydropower provides 60% of the electricity to people in the northwest, thanks in large part to the Bonneville dam system.

**Solar PV: (~2%)** While Solar Photovoltaic (PV) energy is one of the quickest growing energy sources in the U.S, its growth is relative to its small share of the overall energy mix. Solar Photovoltaic is a renewable, non-baseload power source that creates electricity through chemical reactions with the sun, as opposed to a turbine. Electricity is created when light strikes a photovoltaic cell and is absorbed by the semiconducting silicon surface of the solar panel. This incoming light energy causes electrons in the silicon to be knocked loose, which will eventually become the solar electricity you can use in your home.

**Wind: (~6%)** Wind energy presents a low cost, renewable, non-baseload energy source. Energy is created through the use of a wind turbine. The wind turbine functions much like a steam turbine, but the energy moving the turbine is captured by wind blowing on large blades. One of the limiting factors of wind power is its lack of baseload capacity, as we cannot change wind speeds and directions on whim. A common misconception behind wind power is its negative impact on bird populations. While wind turbines do kill some birds, when compared to the bird deaths related to coal and natural gas production, the deaths are negligible.

When thinking about the impacts of power sources such as Hydroelectricity it is important to be mindful of the alternatives. A healthy mix of power sources is required to keep society functioning, and it is imperative we are all informed on the pros and cons of the entire system when analyzing a single source.

# Salmon Game

## Materials

Prepare students for the outdoors with warm layers and safety boundaries.

Rope (at least 15 feet long)
Hula Hoop
Buckets (2-3)
Noodle (5' insulation tube)
Predator puppets (optional)
Caution tape or orange jacket
Cones (optional)

## Game Play

Students split into two groups and play a game mimicking the salmon's story. One half of the students start out as baby salmon on a hillside (representing their natal mountain stream) who must run along the stream (trail or 10' wide path marked out by cones) to the ocean (large area with a toy boat) where they run around the boat four times to represent their four years out at sea. They then have to return to their home on the mountain, walking backward to represent the tough current. If they are tagged by the other half of students (playing the roles listed below), they have to trade roles with the person who tagged them. Along the way, they face many challenges (played by other students):

Predators (bear, eagle, lynx, fox, salmon, orca, sea lion)
Fisherman (noodle and student with foot in bucket holding hula hoop)
Dam (two responsible students or adults swinging long jump rope)
Sediment/turbidity (Caution tape or orange jacket with foot in bucket)

These students have to plant one foot on the outside of the stream, and may tag the young salmon as they go by. The recreational fisherman may tag with the noodle. The commercial fisherman in the ocean may "catch" salmon inside his hula hoop (net). The dam is created across the "stream" with a spinning jump rope, and explained to students as the spinning blades of the turbines that create hydroelectric power. Students soon figure out that there is an area between the edge of the "stream" and where the person is holding the rope that they may use to crawl through. This represents a fish ladder. If students can hop the rope or run through unscathed, then they're free to continue out to sea. Pollution starts below the hill and can only move downstream slowly, for their foot is in a bucket. They can tag salmon in the stream.

The game is played for 20 minutes, and then students reflect on their experience being salmon. The facilitator needs to check to make sure every student has had the chance to be a salmon before the game ends. Ask students, is it hard being a salmon? How many salmon made it to their spawning stream up on the mountain? Why do you think so few salmon get to be adults? How many salmon in real life get to be moms and dads for baby salmon? (1 in 1,000) Did people make their lives harder? How did we do that? What can we do now to help them out? (Fish ladders, limiting catch numbers, protecting habitat, reducing and eliminating sources of pollution) What is one thing you could do this year to help salmon survive?

*Note:*
*Play one 20-30 minute round of the game without human interactions (remove the dam, pollution, and fishermen), and then play another round after that for 20-30 minutes adding in the trials of human impact. Students may understand the added challenges humans have made to salmon habitat.*

# Non-Classroom Activities

**Make Your Own Water Turbine**

https://www.teachengineering.org/activities/view/cub_environ_lesson09_activity3

**Virtual Energy System Manager**

https://www.next-kraftwerke.com/virtual-power-plant-vpp-simulation/?lang=en

**Great Online Interactive Game to Teach Students About Salmon Migrations**

https://lltk.org/project/survive-the-sound/

# HAPPY.

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# TRAILS.

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