# Climate Change and Forests

## "Nature-Based Solutions to Mitigate Climate Change"

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Diné Institute for Navajo Nation Educators (DINÉ)

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## Introduction

This is my first unit for the Diné Institute for Navajo Nation Educators (DINÉ), an initiative model of curriculum development for students in a diverse classroom. I am one of the DINÉ Fellows in the program, Climate Change and Forests. This is the first time I have attended a challenging program based on the current issues we are now facing. This topic is often hard to teach to students especially if they have no background information and a lack of awareness regarding the basic concepts needed to understand climate change and its effects on the Earth.

The changing climate has already impacted humankind. Many of the extreme climate changes that we are experiencing with increasing frequency have had devastating consequences. We now have more major weather events like super typhoons and drought, and the consequence of changing precipitation and temperature is believed to lead to decreased crop harvests and to the death of terrestrial and aquatic flora and fauna, coral bleaching, and many other things. Climate change has a great impact on Navajo people and culture. Drought has caused a decrease in the harvest of crops like corn, squash, and beans. We even catch less trout now in Ganado lakes. The short term lack of snowfall has led to a decrease in the growth rate of forests (such as pine trees, juniper, and ponderosa) which are a source of timber products.

This curriculum is on nature-based solutions centered on the use of alternative sources of energy to mitigate climate change related issues aligned with the Navajo Nation (Diné).

## Context and Rationale

Classroom Demographics

Ganado, a small city located in Apache County, Arizona, is one of the chapters in Navajo Nation. According to the 2010 U.S. Census, there are 1,505 residents, 321 families and 422 households that reside in Ganado. The population density is 168.2 people per square mile (64.9/km$^2$). The racial make-up of this chapter is 87.3% Native American (Navajo), 10.8% Caucasian, 2.4% Hispanic/Latino, 0.1% Black or African American, 0.1% Asian, 1.1% from other races, and 0.5% from two or more races. Ganado is considered a progressive chapter of Navajo Nation.

Ganado shares one delegate seat on the Navajo Nation Council with the following cities: Jeddito, Cornfields, Ganado, Kinlichee and Steamboat. The Ganado Irrigation Project is managed by the local farm board including the surrounding cattle and sheep ranches. Ganado is 30 miles away

from Window Rock and 37 miles away from Chinle. The common languages used in Ganado are the Navajo (55%) and English (45%).

The Ganado Unified School District (G.U.S.D.) is located in Ganado. The district is composed of the Primary School and the Intermediate/Middle School which are both located at the Main Campus and the High School which is six miles away. Our district serves students from Pre-K to High School. I am assigned to Ganado Middle School as a Grade 7 Science and Research Teacher. I am also part of the Leadership Team in our School. G.U.S.D. provides the latest technology, resources and instructional aides to ensure students are ready for post-secondary education and beyond.

At G.U.S.D., we adhere to Navajo Culture and values. All staff are dedicated to ensuring that students learn about their culture and ancestry. Staff and administrators are truly life-long learners, leading the way as examples to our students and community. We provide the best possible instructional services to our students, including cutting-edge technology in every classroom. Both middle school and high school athletic programs teach students personal responsibility and the benefits of a healthy lifestyle. The community is renowned because of the high school men and women basketball teams' gamesmanship. We partner with our stakeholders and communities to make sure that these values are met at home as well as in the classroom. We include the community in planning events. Our community also benefits from our school district's resources as it enables nearby residents to be able to take advantage of our schools' facilities.

The Ganado community is considered one of the most advanced communities in Navajo Nation. Within Ganado, there are some agricultural parcels that are managed by a local board of farming advocates. The ranches that surround the town are sources of organic beef and mutton. There is also sheep, cattle and horse herding.

In Ganado Middle School (GMS), we have 332 students who are predominantly of Navajo descent. (Ninety-eight percent of our students are Navajo while the remaining two percent are Asian-Pacific, Hispanic and Caucasian.) As of 2021, approximately twenty students are considered Exceptional Student Service and Life Skills learners, and twelve are English Language Learners. I have been teaching in Ganado Middle School for four years. During this time, I have taught Integrated Science and Research classes. I am also an adviser of Grade 7 research and we compete in Investigatory Projects every year. We won several awards and recognitions for three consecutive years from 2017-2019 at the Navajo Nation Science Fair which is usually held at Red Rock in Gallup, New Mexico. At the 2019 competition, we won the 1$^{st}$ through 4$^{th}$ awards. We joined the State Science Fair in 2017.

Why I choose Nature-Based Solutions for my Topic

Climate change is one of the topics that I really want to focus on in my research and my class discussions. The drought, the decrease in the amount of snowfall, and the existence of stronger typhoons, has boosted my curiosity and has caused me to consider including the topic of climate change in my curriculum unit for my 7$^{th}$ Grade class. However, despite my interest in this topic, I

have a hard time developing instructional materials and strategies to discuss and attain maximum participation and retention amongst my students.

When I started working in Ganado, the culture, educational system and weather was a huge adjustment for me. I am from the Philippines and I moved to Arizona in 2017. In my home country, we experience two kinds of seasons, the summer (where it is dry) and the rainy season. It took me years to adapt to the cold winters here in Northern Arizona.

I have found it interesting that my students are fond of winter. Some of my students are absent on days during winter because they help their parents collect timber for firewood. Almost 95% of my students and their families are dependent on firewood during the winter. They use this to produce heat, cook their food and in many other ways. Electric based heaters are very expensive and most of my student's families can't afford to use them. They don't have the ability to pay for high electricity bills so they prefer to use cheaper methods. I have suggested that perhaps there are some alternatives or nature-based solutions that the community could use to produce heat during the winter. These solutions are cheaper, more readily available in the community, have a low cost of maintenance, are easily managed and can be used for a long period of time.

Most families in Ganado are not aware of the effects of burning firewood for warmth. Wood burning fires release an enormous amount of greenhouse gases such as carbon monoxide (CO), carbon dioxide ($CO_2$), sulfur oxide ($SO_2$), and nitrogen oxide (NO). These gases trigger global warming and so one of the consequences of burning firewood is climate change.

When I travel in Arizona, whether I go to Window Rock, Flagstaff or Phoenix, I see the beauty of the forest ecosystems. I see different trees such as ponderosa, pine, oak and juniper. I am amazed by their beauty, diversity, size and structure. I wonder how these trees help us mitigate climate change by sequestering greenhouse gases. With all the benefits that we can get from forests, such as timber, I wonder if Navajo people are aware of the consequences and effects of emissions like carbon when they cut down these trees just to sustain their need for heat. Are they aware that there are nature-based solutions for things like heat that lessen the effects of climate change? Can they do something that does not contribute to the emission of greenhouse gases into the atmosphere? Are they willing to make changes to help our environment by preventing greenhouse gas emissions? Can they think of alternative ways, or ways to maximize the use of nature-based solutions to sustain the energy needs in their home?

Having taught 7$^{th}$ Grade for almost four years, I have learned teaching strategies such as the Problem-based/Research-based Approach, the Science Technology and Society Approach, and the Cooperative Approach. These approaches help students develop the grit to study hard, learn how to participate in class, and increase their retention rate in my subject area. Duch et al., (2001) describes Problem-Based Learning (PBL) as a teaching method where real world problems are used to promote the learning of different concepts. It promotes 20$^{th}$ Century skills such as critical thinking, problem solving, and communication. PBL is more functional and promotes lifelong learning, and helps teachers find and evaluate research materials.

PLB can be adapted creatively by different subject areas. However, core problems will vary among disciplines (Duch et al., 2001). In their book, Duch, Groh, and Allen, suggest that good

PBL should have the following characteristics: it should motivate students to seek deeper understanding of the concepts, require students to make reasoned decisions and defend them, incorporate content objectives from previous courses, and requires a level of complexity to ensure that students are working together. There are three related techniques on how to distribute PBL in classroom instructions: case studies, role plays, and simulations.

On the other hand, the Science Technology and Society (STS) approach develops skills that respond to issues that impact students' lives and helps them become active and responsible citizens (Yager, 1996). Yager adds that the experience of science education through STS strategies will create a scientifically literate citizenry for the twenty-first century. Harms includes STS as one of the five areas of concern in school science programs in the United States. The Harms Project Synthesis Study was organized around four goal clusters (Yager, 1996). First, science for meeting personal needs. Second science to resolve current societal issues. Third, science to assist with career choices. And fourth, studying science to prepare for further study. This approach helps students deal with their own environment and their own frame of reference. It advocates for the use of real-world applications and technology. Students will make connections to their lives and to their traditional disciplines. If students deal with the real world and real problems, they can improve their attitudes and it will sharpen their creativity.

Finally, the Cooperative Approach is a teaching strategy that improves social and critical thinking skills. In *Teaching Cooperative Learning: The Challenge for Teacher Education*, Cohen argues that American schools have a growing diversity, including qualities such as cultural diversity, learning styles, intelligence and attitudes (Cohen et al., 2012). To achieve the goal of providing a good education for all, teachers must structure the educational and social environment so students develop the knowledge, skills and attitudes required to interact with others who have perceived and actual differences and disabilities. The practice of a variety of strategies and techniques should be used by educators. In my opinion, Cooperative Learning is the best strategy to achieve this goal and I have used it extensively during regular education classrooms.

In 2018 and 2019, Ganado Middle School students ranked low in academic and achievement assessments in English Language Arts and Math based on the Galileo Benchmark Test and State Testing. This has given our school a "F" rating for three consecutive years. However, our students have routinely ranked high in Science State Testing which suggests that when they have a higher level of interest in a subject, they are more likely to succeed. The Galileo Benchmark Test results showed that science classes from Grade 6 to 8 have high mean percentage scores and a high level of proficiency. Climate change and discussing ways to mitigate it are some of the topics that students will enjoy because it will challenge Navajo students who are especially fond of their environment and nature. Some of my students have lots of resources such as crops, livestocks and trees from forests near their homes. Because my students often live close to the land, I can use these resources to explain some means by which to mitigate climate change. These are the best tools to help them understand the lessons so they are able to apply what they learn in their daily life.

Why we Need to Teach Dinè Students about Forests

Forests are a sink for carbon dioxide. Trees are very helpful to humans and the ecosystem because they consume $CO_2$. Some human activities emit greenhouse gases (GHG). These activities include the burning of fossil fuels (coal, gas and oil), the conversion of forests to agricultural land and forest fires. We do these things to sustain our needs and desires as human beings, such as the desire to have the energy required to be comfortable in our everyday lives. For example, in Ganado, people gather firewood from the forest and burn it to heat their houses. In spite of the obvious benefits of having energy, people are not aware that the burning of wood also produces carbon dioxide, an emission that worsens climate change.

In my curriculum, I will present common nature-based solutions that Navajos can use to lessen emissions of carbon and can help mitigate climate change. Suggestions and information on this topic can be obtained from residents, students, GMS staff, and teachers. This curriculum will cover three lessons. Each lesson will have one strategy and one activity.

My lesson plan falls under the new science standard in Science 7 under the Earth and Space program which analyzes and interprets data to construct an explanation for how advances in technology have improved weather prediction. This standard covers basic concepts about weather, climate, and seasons. The factors affecting the change in seasons and weather are also discussed. I will apply crosscutting concepts such as patterns, cause and effect, scale, proportion and quantity. I will also use systems and systems models, energy and matter, stability and change, structure and function.

These Concepts fall under the $7^{th}$-$8^{th}$ Diné culture standards
Each performance objective (PO) is different.
$7^{th}$-$8^{th}$ Culture Standard
PO 3 I will choose a topic of nature and present it.

**Content Objectives**

What is Climate Change?

Climate change is one of the biggest challenges of our time. The concentration of greenhouse gases in the atmosphere has skyrocketed, particularly carbon dioxide, methane and nitrous oxide. We know that these gases accelerate climate change because they trap heat in the atmosphere, thus producing an increase in the earth's average temperature (Rubin, 2011).

Brusca et al. pointed out that endemic species that thrive in the Southwestern Sky Islands are vulnerable to climate change because climate change projections show that the temperatures will be too hot and that the precipitation will be too low for native species to survive (Brusca et al., 2013) . If the temperature increases, it affects the weather and causes a decrease in the rain and snowfall. These changes affect the ecosystems. Some of the effects of an increase in temperature are the increased life cycle of insects (Waring et al., 2009), the mega drought like we have seen in 2002 in the Southwestern U.S., and increased tree mortality (Anderegg et al., 2012). One of the consequences of climate change is the reduction of water availability (Seager et al., 2013)

which can result in an increase in the accumulation of dry fuels (Westerling et al., 2006) and thus increase the potential of stand replacing wildfires (Singleton et al., 2019). According to Bonan, one of the outcomes of severe wildfires is the release of stored carbon from the forest into the atmosphere, creating a positive climate feedback (Bonan, 2008).

Human activities such as the conversion of land and the use of fossil fuels are major sources of greenhouse gases. Studies have revealed that countries in Latin America, Africa, and Southeast Asia have tremendous emissions of $CO_2$ from land use changes.

What is the role of Forests, Trees, and Plants in Climate Change?

Forests have many uses to mitigate climate change. They help stabilize the climate by regulating ecosystems, protecting biodiversity, playing an integral part in the carbon cycle, supporting livelihoods, and can help drive sustainable growth.

The role of forest is two-fold. They act as both a cause and a solution for greenhouse gas emissions. Twenty-five percent of global emissions come from the land sector and is the second largest source of greenhouse gas emissions after the energy sector.

Forests absorb one third of $CO_2$ released from burning fossil fuels in their process for making and storing food.

How Important are the Trees for Navajos?

The Navajo People or, Diné as they refer to themselves, is the largest group of Native Peoples residing in North America. The early Diné people lived in hogans (simple-wood framed homes covered in tree bark and mud). These dwellings were always built facing east to receive the early morning sunlight. Some traditional Navajos still live in these light-framed structures. Neighboring Pueblo Natives taught the Navajos an agricultural form of subsistence with the cultivation of corn, beans, and squash--known as the three sisters.

Yazzie (1987) cites the value Navajo people have for the forest. The forest provided many of the necessities of their life. The forest provided food, wood products for homes and other dwellings, corrals, fence posts, ceremonial needs, firewood, and habitat for deer and other wildlife. Forests have a great potential for recreational uses during the entire year. One of the most important uses is the ability to let domestic livestock graze alongside wildlife. Additionally, the timber taken from forests generates substantial revenue for the Tribal Government and provides employment for Navajos.

Multiple Uses of the Navajo Forest

An unrestricted amount of dead and downed firewood is available to all Navajos for personal use and for resale to the public. Commercial poles are cut for hogans, cabins, fences, and posts. Non-commercial trees are used for firewood, posts, and fences. Under regulation, seasonal Christmas tree cutting is also permitted. The forest is inhabited by wildlife species, including deer, bear, beaver, coyote, bobcat, fox, porcupine, rabbits, squirrel, chipmunk, turkey, birds, and waterfowl.

The forest provides a diverse habitat for thermal cover, hiding cover, roost sites, riparian zones, feeding, nesting, and fawning (Yazzie, 1987).

## The Role of Forests in Climate Change Mitigation

Climate change has a lot of negative effects on our Earth both on the living and nonliving components of our ecosystem. Forest trees contribute significantly to climate change mitigation through carbon sinks and carbon storage functions (Unasylva, 2019). Unasylva adds that forest trees play essential roles in reducing vulnerabilities and enhancing the adaptation of people and ecosystems to climate change and climate variability, the negative impacts of which are becoming increasingly evident in many parts of the world.

On the other hand, Njana et al. cite the importance of forests by providing services which are essential for the wellbeing of human development (Njana et al., 2021). There are benefits that people can obtain from the ecosystem. This includes the mitigation of climate change which is achieved through carbon sequestration, avoiding deforestation and forest degradation, and working on conservation and improving the management of forests. Njana and his colleagues suggest that to mitigate climate change, mapping and monitoring the changes made to forests is fundamental and should be accurate for estimating quantities of CO2 sequestered by forests, as well as CO2 emitted due to the loss of forests. It was further observed that the use of unbiased estimators to account for errors in classification of forests and deforestation improved the forest extent and deforestation estimates significantly.

Moomaw emphasizes that reducing greenhouse gas emissions alone is insufficient to avoid large global temperature increases. He suggests that to avoid atmospheric concentrations of greenhouse gases that may lead to alterations of climate, the following things should be done: large reductions in carbon dioxide emissions from fossil fuel combustion and land use changes, and to sequester atmospheric carbon dioxide (Moomaw et al., 2020).

## Nature-based Solutions to Mitigate Climate Change

Frantzeskaki states that nature-based solutions can be a great help to develop resilience and responses to climate change and to lessen the vulnerability to the impacts and risks of climate change (Frantzeskaki et al., 2019). Therefore, for cities to be responsible we need them to find ways to mitigate climate change. Cities are good grounds for smart design, innovation and experimentation.

On the other hand, Van Ham and Klimmeck emphasizes that we need to forge networks and develop trans-disciplinary and inclusive partnerships and governance approaches in order to successfully take up nature-based solutions (NBS) in response to challenges resulting from climate change (van Ham & Klimmek, 2017). Collaborative arrangements are important to implement sustainable agendas due to the following defining characteristics: create and catalyze synergies between different parts of society by pooling together resources and skills and to be flexible and versatile in the roles they adopt, as partners match and complement their competencies and capacities to undertake a task or to achieve a common interest. Von Ham and Klimmerck add that partnerships are an important key for successful conservation action. Some

of the diverse stakeholders that are involved are governments, NGO's, scientists, businesses, local communities and Indigenous peoples.

Pauleit et al. describes nature-based solutions (NbS) that aim to use nature itself to deal with challenges such as climate change, food security, water resources and disaster risk management. The concept of nature-based solutions was introduced by the World Bank and IUCN at the end of 2000. It highlights the importance of biodiversity conservation for climate change mitigation and adaptation. Some of the core principles of this concept suggested by the IUCN include cost efficiency, harnessing both public and private funding, ease of communication, and replicability of solutions (Pauleit et al., 2017). Nature-based solutions can be cost effective and the benefits range from environmental protection to creating jobs and stimulating innovation for a green economy.

The European Commission's Expert Groups listed examples of nature-based solutions like the protection and expansion of forest areas to capture gaseous pollutants, planting windbreaks for soil conservation, protecting urban green spaces and planting green roofs for various benefits such as the promotion of biodiversity, carbon storage and storm water retention.

Cabral et al. suggests ways to mitigate climate change and through the use of urban gardens. This can be done through a range of provisioning, regulating and cultural ecosystem services such as multi-functional nature-based solutions in a city. Urban gardens provide benefits like food, they contribute to water regulations through unsealed soils, improve air circulation and cooling through plant transpiration and shading, and offer micro-climate oases to many users such as gardeners, visitors, and immediate neighbors (Cabral et al., 2017).

Floating solar photovoltaics, or floatovoltaics (FPV) is a new form of renewable energy. It decarbonizes the energy supply while reducing land-use pressures. It offers higher electricity generating efficiencies compared to ground–based systems. However, there are some unresolved issues related to this equipment. For example, the effects on lake temperature and stratification of FPV on sheltering the surface water from the wind and limiting the solar radiation reaching the water column (Exley et al., 2021).

Exley et al. also states that FPV has the potential to mitigate some of the impacts of climate change on bodies of water and is a useful tool for water body managers dealing with water quality inducing deleterious impacts on standing water ecosystems. The simulations they develop can serve as a starting point to inform the possible design of systems that can use ecosystem services and environmental benefits from the development of new water body use.

According to Endenhofer et al. there is an increasing demand for energy and other services to meet social and economic development and to improve human health and welfare. Every society requires energy services to meet basic needs such as electricity for cooking, heat, mobility and communication. To sustain these needs, most of the world uses fossil fuels (coal, oil, and natural gas). Consequently, there is a rapid growth in carbon dioxide emissions (Edenhofer et al., 2011).

There are possible options to lower GHG's emissions while satisfying the global demand for energy. Possible options are energy conservation, switching from fossil fuels to renewable

energy, and nuclear and carbon capture and storage. Renewable energy can provide wider benefits as it can contribute to social and economic development, an expanded energy access, a secure energy supply and reduces negative impacts on the environment and health.

Renewable Energy

Renewable energy is a heterogeneous class of technologies. Various aspects of it can supply electricity and thermal and mechanical energy, producing fuels that are able to satisfy multiple energy service needs. Renewable energy includes bioenergy, direct solar energy, geothermal energy, hydropower, ocean and wind energy.

Bioenergy can be produced from biomass feed stocks such as agricultural and livestock residues, short rotation forest plantations, energy crops, the organic component of municipal waste, and other organic waste streams. While produced through different processes, these feedstocks can be used directly to produce electricity and heat, or can be used to create gaseous, liquid or solid fuels.

Direct solar energy technologies harness the energy from solar radiation to produce electricity using photovoltaics (PV) and concentrating solar power (CSP). This produces thermal energy (heating or cooling, through passive or active means) meets direct lighting needs and potentially, to produce fuels that might be used for transport and other purposes. The maturity of this technology ranges from R&D (fuels produced from solar energy) to relatively mature (CSP), to mature (passive and active solar heating and water-based silicon PV).

Another source of renewable energy is geothermal energy which uses thermal energy from the earth's interior. Heat is usually extracted from geothermal reservoirs using wells or other means. Hydrothermal reservoirs are reservoirs that are naturally hot and permeable, on the other hand Enhanced Geothermal Systems (EGS) are reservoirs that have sufficiently improved hydraulic stimulation. Once at the surface, fluids of various temperatures can be used to generate electricity or can be used more directly for applications that require thermal energy. The applications of geothermal energy include district heating or the use of low-temperature heat from shallow wells for geothermal heat pumps. When this source is used to generate electricity, geothermal power plants can offer constant output.

Hydropower harnesses the energy of water moving from higher to lower elevations to generate electricity. Hydropower projects include dams with reservoirs, run-of-river and in-stream projects and cover a continuum in project scales. Hydropower meets large centralized urban needs as well as decentralized rural needs. It has a controllable output provided by hydropower facilities with reservoirs that can be used to meet the demands of electricity and to balance the electrical system that has large amounts of variable renewable energy generation.

Ocean energy is a renewable energy that comes from the potential kinetic, thermal and chemical energy of saltwater and can be used to provide electricity to the community, to create thermal energy, and even potable water. Possible technologies are available such as barges for tidal range, submarine turbines for tidal and ocean currents, heat exchangers for ocean thermal energy conversion, and a variety of devices that harness the energy of waves and salinity gradients.

Ocean technologies are in the demonstration and pilot project phases and many require additional R&D.

Finally, wind energy harnesses the kinetic energy of moving air. The primary application of that is relevant to climate change mitigation is the ability to produce electricity from large wind turbines located on land or in salt or freshwater. Onshore wind energy technologies are already being manufactured and deployed on a large scale. Offshore wind energy technologies have greater potential for continued technical advancement. Wind electricity is both variable and unpredictable.

**Classroom Activities**

Activity 1: Prediction/Anticipation Guide

In this activity, students will answer part one before the class discussion. Part two will be answered after the discussion. Students will draw a happy face if the statement is correct and a sad face if the statement is incorrect. In the first part, students will predict the possible answer to the question. Discussion will then follow. After the concept is discussed by the teacher, the post-discussion activity will be answered by the students.

*Part One*

Choices: True 

False 

| Item No. | Concept | Answer |
|---|---|---|
| 1 | Climate change results in an increase in temperature on Earth's surface. | |
| 2 | Global warming is the same as climate change. | |
| 3 | Forest trees mitigate climate change. They absorb carbon dioxide from the atmosphere. | |
| 4 | Forest thinning for restoration/to reduce fire risk can produce fire woods, e.g. Wood for Life Program. | |
| 5 | Solar, wind and geothermal energy are alternative sources of energy that mitigate climate change. They use renewable sources of energy that do not produce greenhouse gases. | |

*Part Two*

Choices: True 

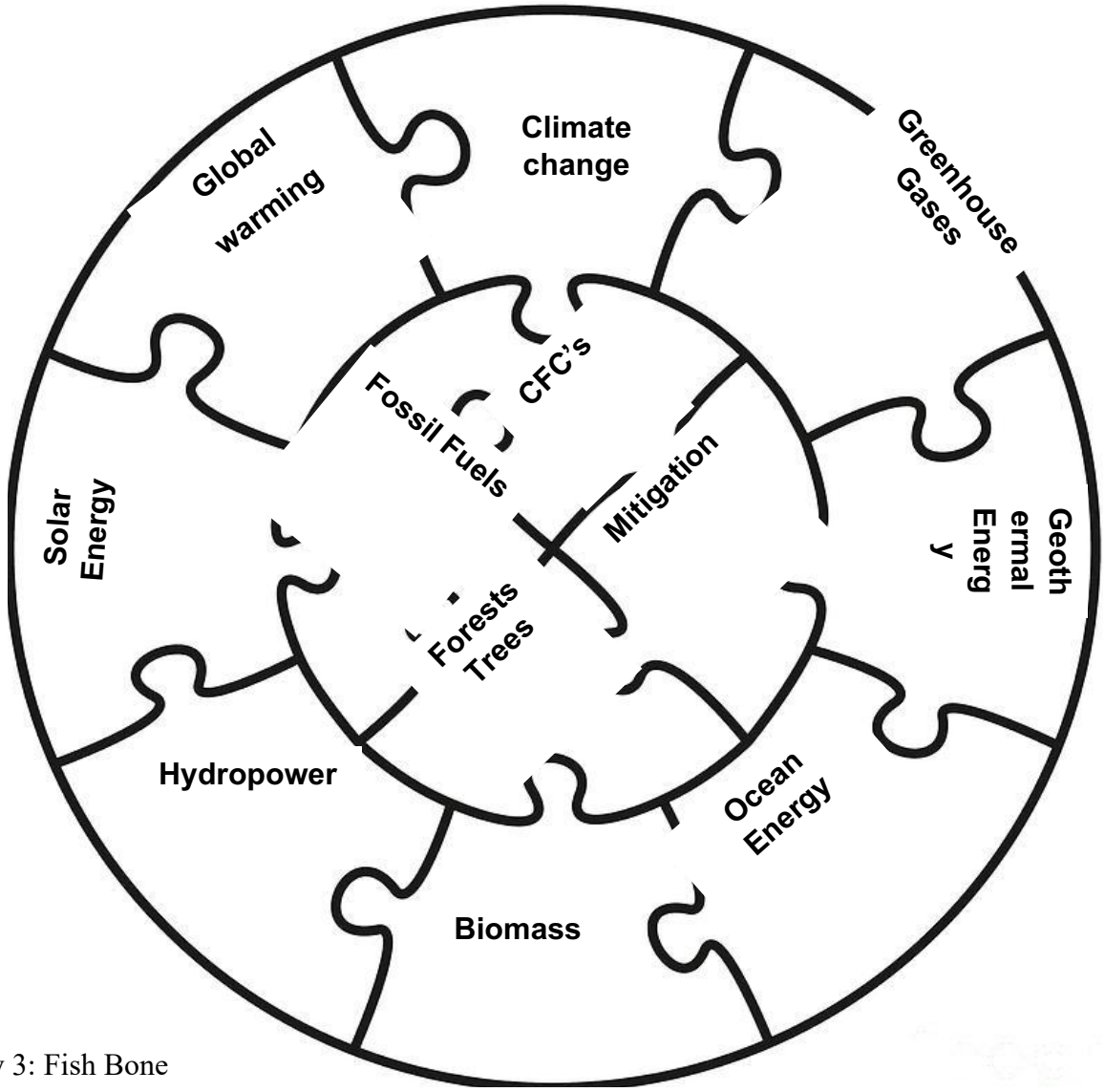
False 

| Item No. | Concept | Answer |
|---|---|---|
| 1 | Climate change results in an increase in temperature on the earth's surface. | |
| 2 | Global Warming is the same as climate change. | |
| 3 | Trees are important in mitigating climate change. They absorb carbon dioxide from the atmosphere. | |
| 4 | Burning firewood is helpful to Navajos and does not produce greenhouse gases. | |
| 5 | Solar, wind, and geothermal energy are alternative sources of energy that mitigate climate change. They use renewable sources of energy that do not produce greenhouse gases. | |

Activity 2: Left-Thumb Rule

*Strategy/Approach: Cooperative Learning Approach*

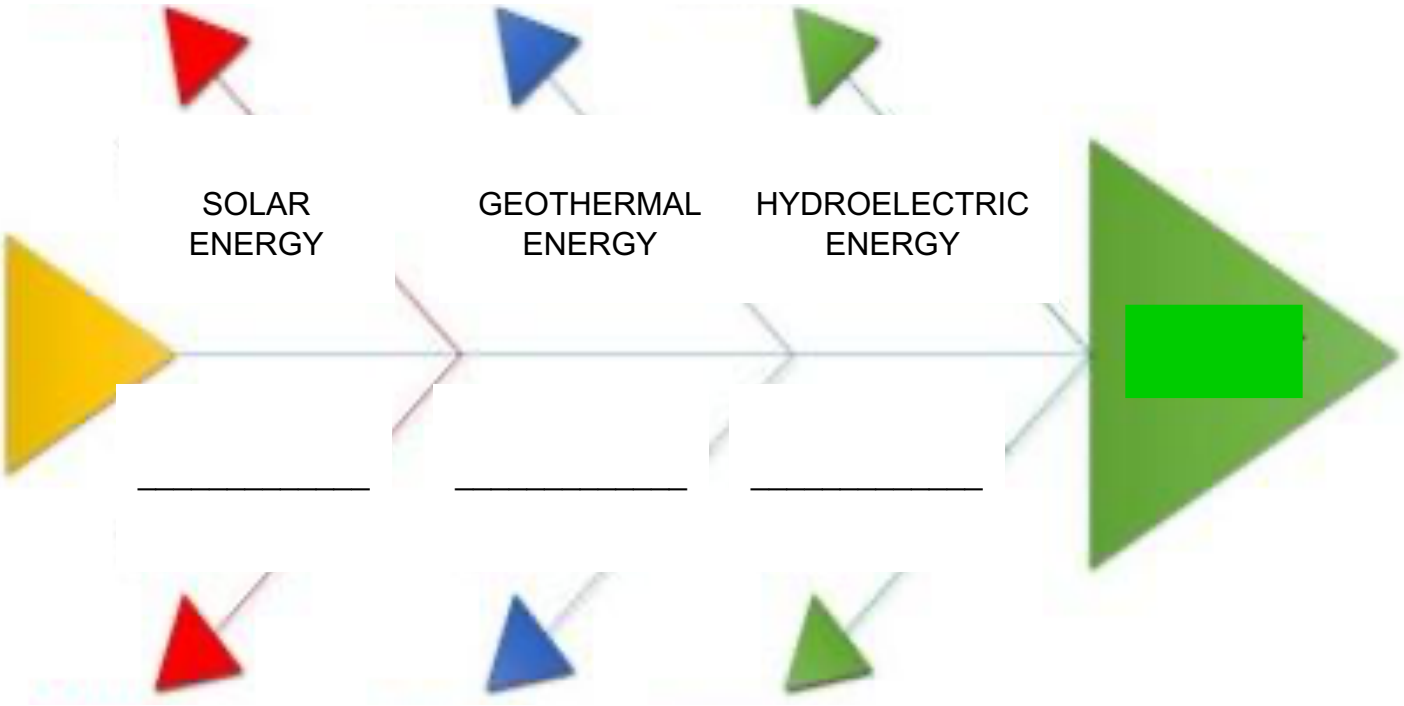
This activity is intended to develop vocabulary skills. The lesson will be more productive if students understand the vocabulary before the discussion starts. We will go over the definitions of words such as climate change, global warming, greenhouse gases, forest trees, mitigate, solar energy, geothermal energy, and wind energy. As the activity starts, students will no longer read from the text. The teacher will pass a ball that has vocabulary words printed on its surface. The teacher will play music and the students will pass the ball to each other. As the music stops, the student that has the ball will define the word closest to their left thumb. The activity will be played for five minutes.




Activity 3: Fish Bone

*Strategy/Approach: Science, Technology and Society (STS) Approach*

This graphic organizer activity will be done after the students watch a five-minute video about alternative sources of energy and nature-based technology that is used to mitigate climate change. Students will match the description to the appropriate source of energy.




Choices:

| | | |
|---|---|---|
| Comes from the potential, kinetic, thermal and chemical energy of saltwater. | Harnesses the energy of water moving from higher to lower elevations to generate electricity. | Harnesses the energy from solar radiation to produce electricity using photovoltaics and concentrating solar power (CSP). |
| Uses thermal energy from the Earth's interior. | Produced from biomass feed stocks such as agricultural and livestock residues, short rotation forest plantations, energy crops, the organic component of municipal waste, and other organic waste streams. | |

Activity 4: Building Renewable Source of Energy

*Strategy/Approach: Problem-Based Approach*

In this activity, students will make models for renewable sources of energy using recyclable materials, like cardboard, papers, plastic cups and bottles. They will have two options for models, they can make either a wind turbine or a water turbine. The time allotment for this activity is two or three days.

Wind Turbine (Wind Power)
Source: https://www.bikersrights.com/wind-turbine-for-a-school-project/
Objectives: Build a model of a wind turbine
Materials: a DC motor, one large piece of cardboard, a plywood board, a low resistance LED light, scissors, positive & negative wires, a hot glue gun, tape, and an external source of wind.

Procedures:
Step #1: Building the rotor

- Grab the large piece of cardboard and cut out four circle pieces that are about three centimeters in diameter each. Stick all the circles together with the glue to make one thick circle.
- Next, take a thin paper and wrap it around the thick circle created in step one, ensuring that it properly fits the circle both lengthwise and widthwise.

Step #2: Building the blades

- Cut up to four rectangular pieces from the large cardboard, each measuring eight centimeters by two and a half centimeters.
- Cut out one edge of the pieces so that they form a round shape and glue them to the rotor from the step above.
- Slightly bend all four pieces along the middle so that they appear somewhat rounded, just like the blades on a typical home wind turbine kit.
- Glue all the four blades to your rotor and leave them to dry out.

Step #3: Building the tower

- As the blades take time to dry, focus on making the tower which will hold the rotor up.
- Take the large piece of cardboard and cut out a thin portion, measuring 30cm by 12cm.
- Wrap this cutout around a pen to make a perfect hollow pole. Glue the paper end and pull out the pen so that all that is left is the tower.

Step #4: Mounting the motor

- Grab the DC motor and wrap it with a piece of cardboard paper which properly fits its length. Ensure that the pointy part of the motor stays outside the wrap work.
- Take the rotor with four blades and make a small hole through its middle. This is where the motor's pointy part will connect with the rotor.
- Connect the positive and negative wires to the motor with the help of a hot gun, making sure to leave an adequate length of wire to connect with the LED bulb on the other ends.
- Glue the paper wrapping the motor to the pole and leave it to dry.

Step #5: Building the house

- Make a model house which will be lit using the power produced by the wind turbine.
- To do this, cut four pieces of equal size to make the four walls of the house. Cut a door opening one piece and cut out window openings on the three remaining pieces.
- Glue all the four pieces together to complete the house, make sure the piece with door cutout stays on the front.
- Remember that another piece will need to be cut to make the roofing for the house…but don't do this yet.

Step #6: Connecting the light

- At this point, take the LED light and connect it to the wires originating from the motor (as in step #4). Stick this light to any of the house windows and use a tape to hold it in place.
- Once the light is well wired, and inside the house, make the roof. Take two pieces of cardboard and glue them on the edges to make a triangular roof shape. Then glue the roofing to the four walls of the house.
- Glue the complete house to a thick cardboard layer (which is the floor of the house) to make it feel more stable.
- Now glue both the complete house and the tower holding the entire turbine to the plywood board such that the entire project exists on a single platform.
- Then, connect the motor and LED wires together.

Step #7: Get the turbine turning

- Now that everything is set and ready to run, it's time to get the turbine turning to produce electrical energy and to provide light to the bulb hanging on the window.
- Use an external source of wind, preferably a table fan, to make the turbine blades rotate. These will then rotate the motor, which will, in turn, produce electrical energy, which will then flow through the wires and light the LED bulb!

(*How to Make a Wind Turbine for a School Project? | BikersRights*, n.d.)

Water Turbine (Hydroelectric Power)

Source: https://www.scienceworld.ca/resource/water-turbine-model/
Objectives: Build a model of a water turbine
Materials: cardboard or cardstock, corks, scissors, craft knife, pins, and running water

Key Questions:
What happens to the turbine when you change the speed of the water flow? How can you make your turbine spin in a different direction?

Directions:
Step# 1 Carefully make five or six slits lengthwise in the cork.
Step# 2 Cut out rectangular pieces of cardboard the same length as and a bit wider than the cork. These will be the blades of the turbine.
Step# 3 Slide the blades into the cork slits to form a propeller.

Step#4 Make a small cardboard frame by cutting a strip of cardboard, and bending it into a "U" shape.
Step# 5 Poke a pin into each end of the cork through the cardboard frame.
Step# 6 Hold the turbine model underneath a running tap (or use a jug of water over a bucket).

(*Water Turbine Model - Science World*, 2014)

## *Rubrics for Wind Turbine and Water Turbine*

**Rube Goldberg Project Grading Rubric** **Name** _____

**You were asked to create a Rube Goldberg Machine to complete a simple task in 10 or more steps using simple and complex machines. Below is the grading rubric I will be using to grade your final product. You will also be showing your product to your classmates during class as a sort of show-and-tell informal presentation.**

| | 10 | 9 8 7 6 | 5 4 3 2 1 | 0 | Total Points |
|---|---|---|---|---|---|
| 10+ Steps | Includes at least 10 discreet steps. | Includes fewer than 10 steps | Includes fewer than 10 steps or repeats some steps multiple times | No machine created | _____ |
| Functionality | All 10 steps function to complete the final goal without any human intervention once started. | All 10 steps function to complete the final goal with one or two human interventions once started. | Requires multiple interventions to complete or fails to complete specified task. | No machine created | _____ |
| Repeatability | Can be fully reset and run again with minimal effort in a short period of time. | Can be fully reset and run again with significant effort. | Can be at least mostly reset with significant effort or fully reset by replacing components with new ones. Or Can only ever be used once. | No machine created | _____ |
| Biography | >500 word biography of Rube Goldberg containing pertinent information and free from significant grammatical or spelling errors. | 500 word biography containing some pertinent information with minimal grammatical or spelling errors. | Less than 500 word biography, lacking pertinent information, or with significant grammatical or spelling errors. | No biography submitted or biography contains plagiarism. | _____ |
| Work Log | A detailed work log that clearly shows describes all work done on the Rube Goldberg Project with dates clearly recorded. | A partial log that includes most of the work done and the dates it was done on. | A log that shows minimal entries that only generally outlines some of the work done or is missing dates | Work log missing. | _____ |
| Original Design | Original design of the Rube Goldberg Machine submitted with steps and parts labeled. | Original machine design submitted but is unclear or missing some labels. | A design submitted but is unclear, missing labels, or missing steps. | No design included | _____ |
| Machine Design | A clearly detailed design of the final Rube Goldberg Machine submitted with steps and parts labeled. Either printed or carefully drawn to scale. | A design of the machine submitted but is unclear or missing some labels. | A design submitted but is unclear, missing labels, or missing steps. | No design included | _____ |

Activity 5: Group Presentations about Renewable Source of Energy

*Strategy/Approach: Cooperative Learning*

This activity focuses on creative presentations of students on renewable sources of energy using different means. The time allotted for this activity is one day.

Activity#1 <u>Puppet Show</u>
Students will make puppets in the shape of pine trees, coyotes, clouds and water. They will develop a skit about the causes and effects of climate change.
Activity#2 News Casting
Students will newscast about the descriptions and benefits of renewable source

of energy.

Activity#3 Poem

Students will make a poem about the parts and functions of power plants such as wind mills, hydroelectric power plants and geothermal power plants.

Activity#4 Quotation

Students will make a quote about the benefits of using renewable sources of energy.

Activity 6: Individual Activity on Global Warming and Climate Change

*Strategy/Approach: Problem-Based Approach*

This is an individual activity where students will compare and contrast global warming and climate change using a Venn Diagram. For the second part of this activity, students will write a poem on the causes and effects of climate change.

**NAME:** _____
**GRADE AND HOUR:** _____

# LECTURE NOTES FOR GREENHOUSE EFFECT, GLOBAL WARMING AND CLIMATE

SCIENCE 7
October 27-28, 2021

## GREENHOUSE EFFECT

- the trapping of the sun's warmth in a planet's lower atmosphere, due to the greater transparency of the atmosphere to visible radiation from the sun than to infrared radiation emitted from the planet's surface.

- a warming of Earth's surface and troposphere (the lowest layer of the atmosphere) caused by the presence of **water vapour, carbon dioxide, methane, and certain other gases in the air**. Of those gases, known as greenhouse gases, water vapour has the largest effect.

## GLOBAL WARMING

- is **the long-term heating of Earth's climate system observed** since the pre-industrial period (between 1850 and 1900) due to human activities, primarily fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth's atmosphere

Cause #1: Variations in the Sun's Intensity.
Cause #2: Industrial Activity. ...
Cause #3: Agricultural Activity. ...
Cause #4: Deforestation. ...
Cause #5: Earth's Own Feedback Loop.

**Effects:**
Damage to your home. ...
More expensive home insurance. ...

- Outdoor work could become unbearable. ...
- Higher electric bills and more blackouts. ...
- Rising taxes. ...
- More allergies and other health risks. ...
- Food will be more expensive and variety may suffer. ...
- Water quality could suffer.

## CLIMATE CHANGE

Climate change includes both **human-induced global warming** and its large-scale impacts on weather patterns. There have been previous periods of climate change, but the current changes are more rapid than any known events in Earth's history. The main cause is the emission of greenhouse gases, mostly carbon dioxide (CO.

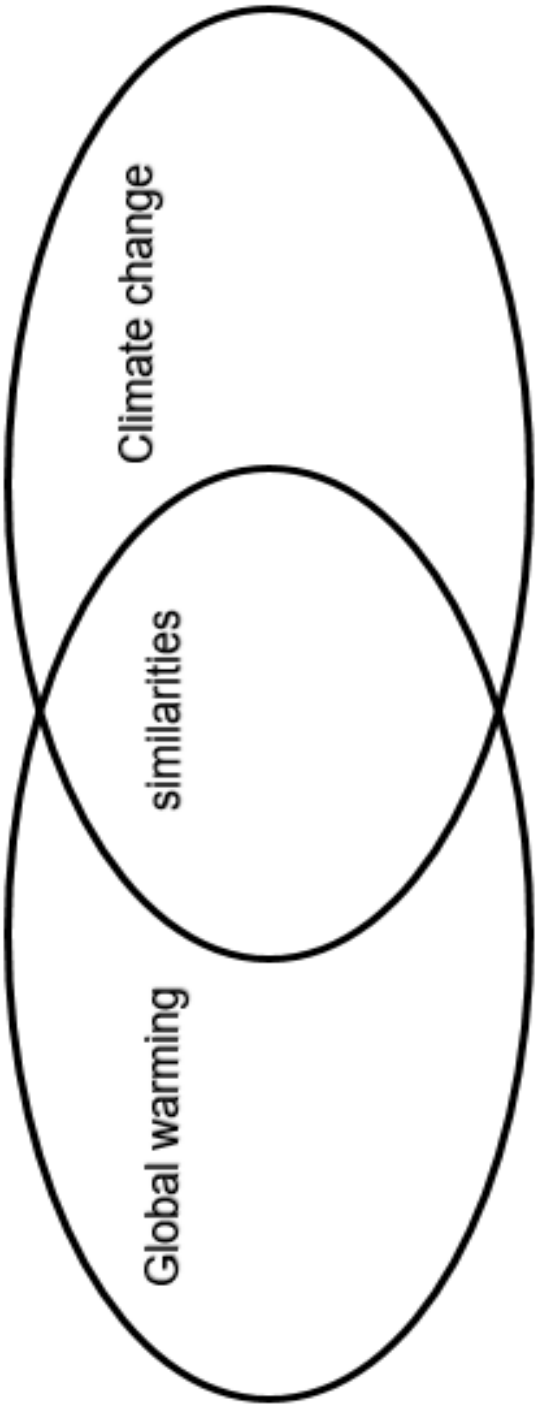
Humans are increasingly influencing the climate and the earth's temperature by **burning fossil fuels**, cutting down forests and farming livestock. This adds enormous amounts of greenhouse gases to those naturally occurring in the atmosphere, increasing the greenhouse effect and global warming.

**CAUSES:**

- Power Plants. Forty percent of U.S. carbon dioxide emissions stem from electricity production. Use of fossil fuels
- Transportation. ...
- Farming. ...
- Deforestation. ...
- Fertilizers. ...
- Oil Drilling

## ACTIVITY 1

### COMPARISON BETWEEN GLOBAL WARMING AND CLIMATE CHANGE




## ACTIVITY 2

**Make a POEM about the causes and effects of CLIMATE CHANGE**

Procedures:

1. Use the lecture notes to develop your idea.
2. Make at least 3 paragraphs in your poem.
3. Make sure you have 4 lines in each paragraph.

**CRITERIA IN WRITING A POEM**

- Relevance to the theme - 50%
- Creativity/Style and Originality - 30%
- Coherence of form and structure (harmony of words, presentation) - 10%
- Clarity of imagery and language - 10%

**TOTAL:100%**

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**(Title)**

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Activity 7: Human Renewable Energy (HRE) Squirrel and Ladder

*Strategy/Approach: Cooperative Learning*

In this activity, students will follow the typical snakes and ladders procedures. They will identify renewable energy described on selected boxes where the points are printed. If they answer it correctly, they will get points. Students need to roll the dice to get to higher steps to reach the last square with 100 points. Instead of using chips, they will use themselves as the players of the game.

Reference: https://www.wikihow.com/Play-Snakes-and-Ladders

Procedures:

First, students will need to understand the object of the game. The object of the game is to be the first player to reach the end by moving across the board from square one to the final square. Most boards wrap back and forth, so they will move left to right across the first row, then up to the second row where they will move right to left, and so on. Follow the numbers on the board to see how to move forward. For example, if a student rolled a five and was on space number 11, then they would move their game piece to space number 16.

Students will have to decide who goes first. Each player should roll one die to see who gets the highest number. Whoever rolls the highest number gets to take the first turn. After the first player takes a turn, it will be the person sitting to that player's left turn. Play will continue in a circle going left.

Students will roll the dice and move. To take their turn, they will roll the dice again and read the number that they rolled. They will pick up their game piece and move forward that number of spaces. For example, if a two is rolled a two, the student will move their piece to square two. On their next turn, if they roll a five, they will move their piece forward five squares, and will end up on square seven.

Ladders:
The ladders on the game board allow players to move upwards and get ahead faster. If they land exactly on a square that shows an image of the bottom of a ladder, then they may move their game piece all the way up to the square at the top of the ladder.If they land at the top of a ladder or somewhere in the middle of a ladder, they'll just stay put. Players never move down ladders.

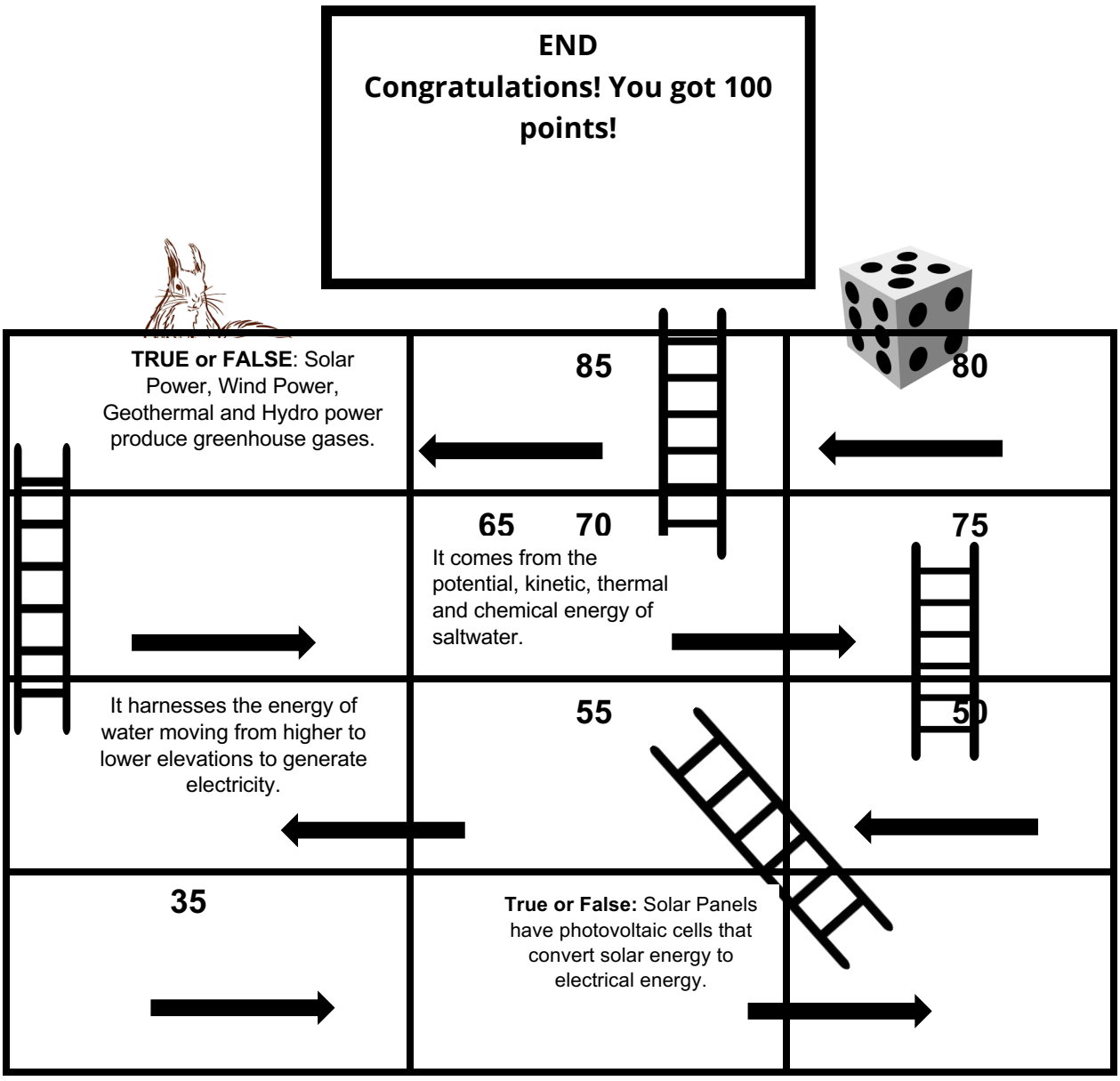
Snakes and Chutes:
Some versions of this game have squirrels on the board, while others have chutes (which are like slides). The squirrels move players back on the board because they have to slide down them. If they land exactly at the top of a squirrel or chute, they will slide their game piece all the way to the square at the bottom of the squirrel or chute.

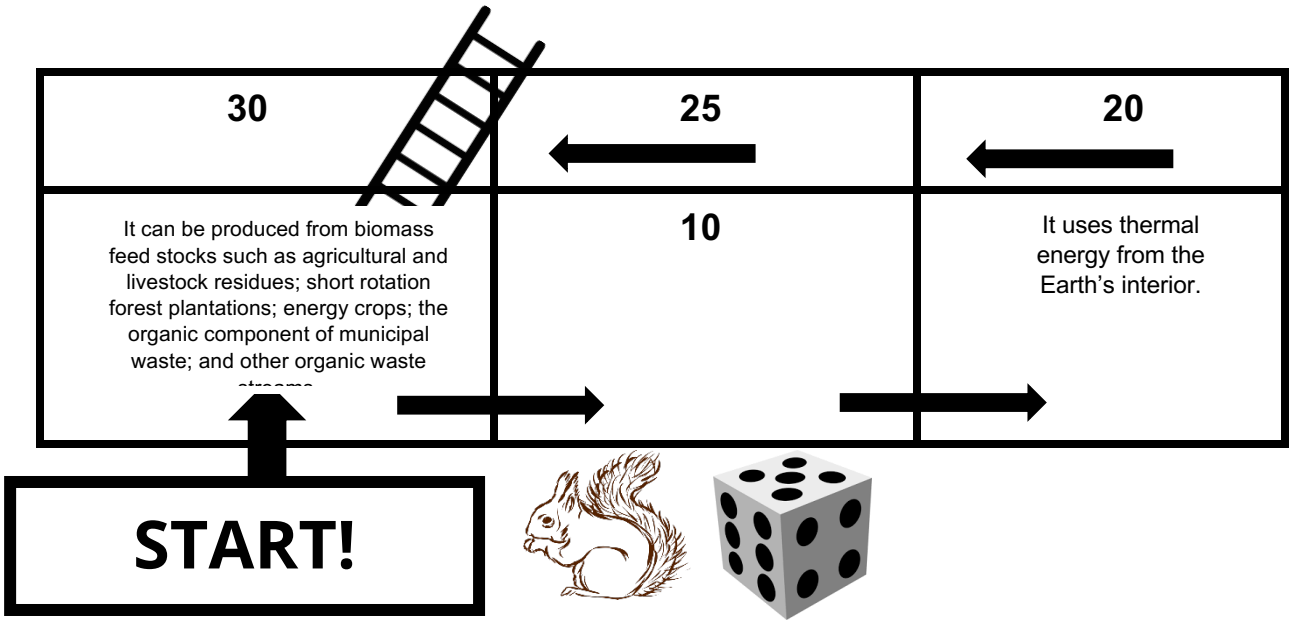
If players roll a six, then they get an extra turn. First, move the piece forward six squares and then roll the die again. If they land on any snakes or ladders, follow the instructions above to

move up or down and then roll again to take any extra turn. As long as players keep rolling sixes, they can keep moving!

Players must land exactly on the last square to win. The first person to reach the highest square on the board wins, this is usually square 100. But there's a twist! If players roll too high, their piece "bounces" off the last square and moves back. Players can only win by rolling the exact number needed to land on the last square.

For example, if a player is on square 99 and they roll a four, they will move their game piece to 100 (one move), then "bounce" back to 99, 98, 97 (two, three, then four moves). If square 97 is a squirrel head, then slide as usual.



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