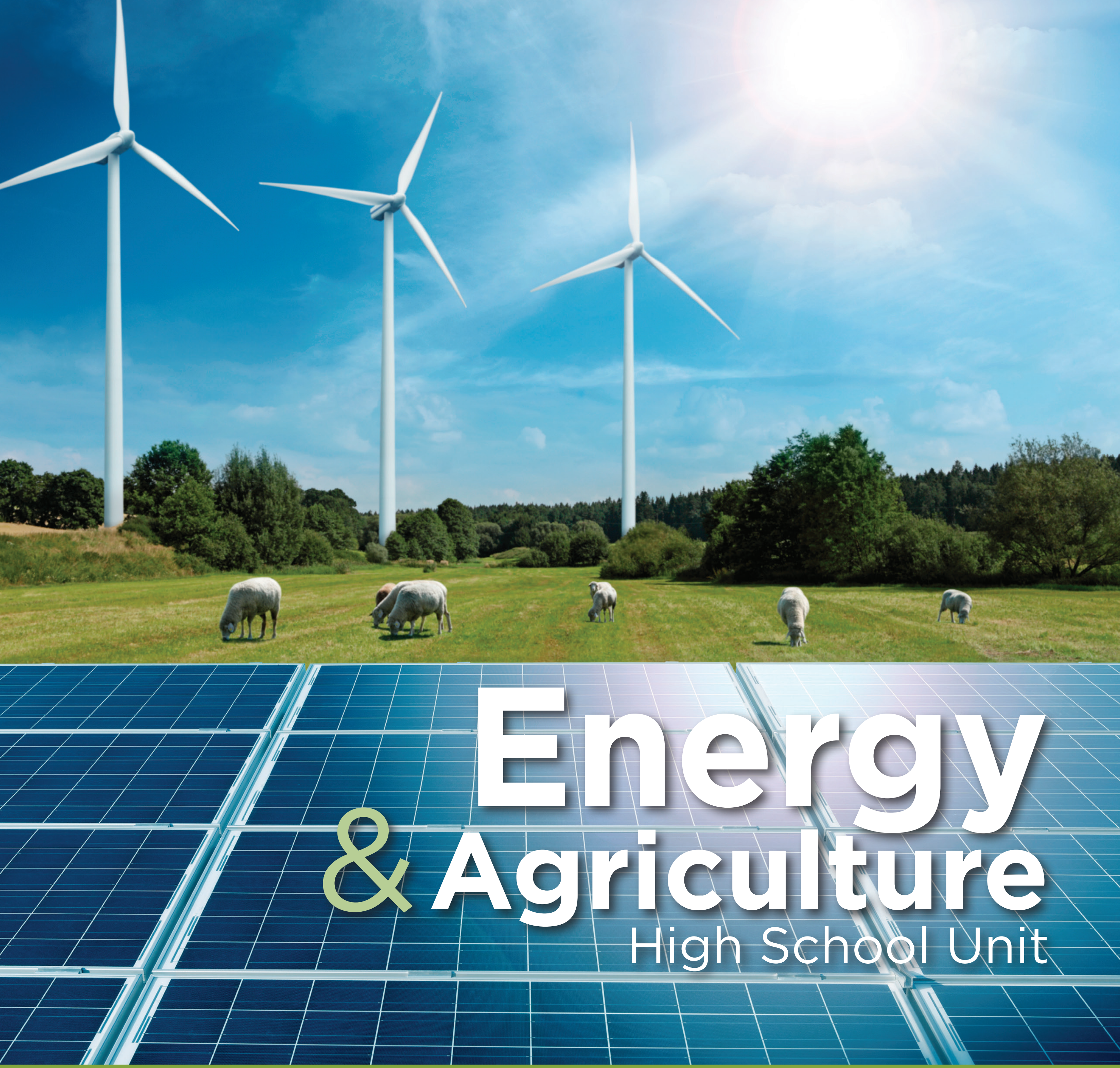

Energy & Agriculture

High School Unit

EDUCATOR'S GUIDE

California Foundation for Agriculture in the Classroom

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California Foundation for Agriculture in the Classroom

The mission of the California Foundation for Agriculture in the Classroom is to increase awareness and understanding of agriculture among California's educators and students. Our vision is an appreciation of agriculture by all.

This unit was funded by the United States Department of Agriculture's National Institute of Food and Agriculture to foster an appreciation for agriculture, reinforce STEM skills and abilities, and create an awareness of agriculture-related careers.

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OVERVIEW

LESSON 1: ENERGY FLOW

Standards

Next Generation Science Standards

HS-PS3.BEnergy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1) (HS-PS3-4) *Disciplinary Core Idea

HS-PS3-3Design, build and refine a device that works within given constraints to convert one form of energy into another form of energy.

Learning Objectives

At the conclusion of this lesson, students will be able to:

- Explain how energy is generated.
- Explain how energy is distributed.
- Develop a model demonstrating the flow of energy from generation to use.

Time

50 minutes, plus homework

Materials

- Energy Transmission Cards (1 set per group of 3-5 students)
- Note paper
- 3x5 index cards (1 per student)
- Take-home craft supplies (Optional. If you have students who may not have supplies at home, you may wish to lend common supplies such as glue or scissors, or make your room available for after/before school work time.)
- Access to YouTube, computer, projector and speakers
- PowerPoint file: O1_Energy Flow Power Point

INTRODUCTION (10 MINUTES)

Plugged In:

- As students enter the class, challenge them to silently think of five things they do each day that require energy. When they have five things in mind, they are to hold up a hand showing five fingers. (PPT 2)
- Draw a circle on the board or a large piece of paper with hash mark for hours, as if looking at the face of a clock.
- Without moving students, split the room into two teams, the "Midnight to 11:59 am" team and the "Noon to 11:59 pm" team. Ask each team to send up a volunteer to capture notes on the board.
- In a fast-paced, race environment, challenge teams to share things they do each day that require energy for their team's time frame only. As teams shout out ideas, the volunteer from their team will capture the answers on the board. The team with the most items written at the end of 1 minute wins.
- Ask students to look at the lists generated. Ask students to share any conclusions they can draw from this visual. Listen for observations such as, "There are certain times in the day when we use more energy." or "We use energy all day!"
- Preview the lesson by sharing with students that energy is something we depend on every day. Energy is amazing, because it is never created or destroyed. It also cannot be stored in large quantities, so it must be harnessed/generated when it is needed. By the time students leave class, they will know how energy is made and how it gets to their homes. (PPT 3)

OBJECTIVE 1 (15 minutes)

Explain How Energy Is Generated:

- Every time we plug something into an outlet, fuel our car or flip a switch, we are using energy. But where does that energy come from?

Top Ten:

- Using PowerPoint, display the Top Ten slide (PPT 4)
- Introduce a game called "Top Ten." Teams will review a list of 10 energy sources and race to put them in order of use in the United States. The energy source that is used the most should be at the top of the list. Teams will earn points for each answer that is in the correct order.

• Divide the class into teams of 3-5 students each. Give each team 2 minutes to quietly review the sources of energy and rank them.

• Using PowerPoint, display the Top Ten Ranked slide (PPT 5) to show the correct order and have teams calculate scores. Celebrate the winning teams.

U.S. Energy Consumption by Energy Source, 2012

1. Petroleum, 36% (20 points)
2. Natural Gas, 27% (18 points)
3. Coal, 18% (15 points)
4. Nuclear, 8% (10 points)
5. Hydropower, 2.7%(9 points)
6. Biomass/Biofuels, 2.43% (8 points)
7. Wood, 1.98% (7 points)
8. Wind, 1.35% (6 points)
9. Geothermal, 0.27% (5 points)
10. Solar 0.18% (4 points)

• Ask students to share observations about the list. Listen for observations about petroleum, which is high because of use in vehicles. Or observations about renewables, which make up just 9% of the total energy use.

• Clarify that energy is often generated in one form (i.e., wind) and converted into another form (i.e., electrical).

OBJECTIVE 2 (15 minutes)

Explain How Energy Is Distributed:

• One of the challenges of producing energy, just like producing our food, is that energy is often harnessed (generated) in a place other than where it is used. Energy, like food, must be transmitted/distributed.

Transmission Card Challenge:

• Break students into groups of 3-5.

• Each group will receive a set of energy transmission cards. Groups will have four minutes to review their cards and place them in order from the generation plant to the end user at home.

• Give each team a set of energy transmission cards.

• After teams have attempted to place cards in order, ask volunteers to share and defend why they placed the cards in this order. Listen for their rationale. The objective of this exercise is not accurate placement, but building awareness of the many factors that affect energy production and transmission.

• When sufficient volunteers have shared, reveal the correct placement and rationale using PowerPoint. (PPT 6)

• During this review, have students draw each component of energy transmission resulting in a pictorial flow chart.

OBJECTIVE 3 (3 minutes)

Energy Transmission Process:

• Using PowerPoint, introduce the homework assignment.

• Students are to create a mini-model of the energy transmission process which fits on the face of a single 3x5" index card.

• The mini-model must include the seven major steps in energy transmission:

- Power Plant (generation)
- Transformer: steps up voltage to allow energy to travel long distance
- Transmission Line: Carries electricity long distances
- Neighborhood Transformer: Steps down voltage so it can travel shorter distance
- Pole Transformer: Steps down voltage before entering the home
- Distribution Line: Carries electricity to homes

• Mini-models must have a three-dimensional component.

• Students will be expected to share the process of energy transmission using their model when they return.

CONCLUSION (7 minutes)

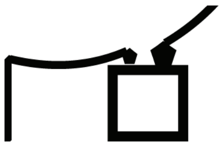
• If access to YouTube is available, play "Energy 101: Electricity Generation" (5:18) https://www.youtube.com/watch?v=20Vb6hlLQSg

• Challenge students to observe how energy is used and transmitted throughout the rest of the day.

• Preview Lesson 2: In Lesson 2, students will explore energy use in the food production system.

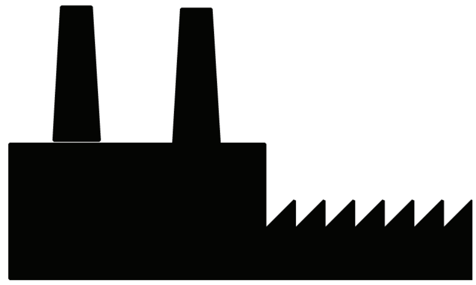
Transmission Cards

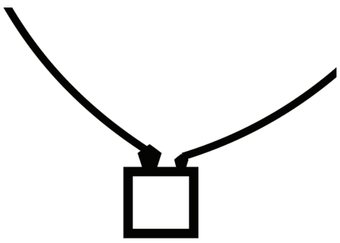
Print and cut out 1 set per group of 3-5 students.



Transformer
steps up voltage
for transmission

Power plant
generates electricity

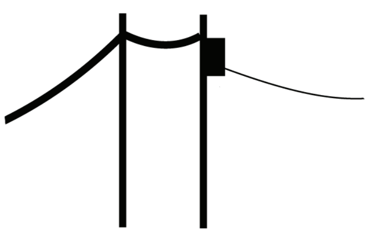




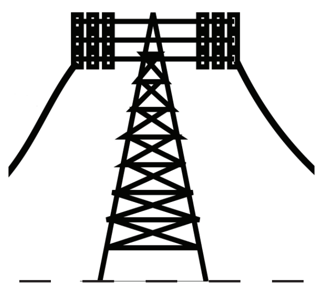
Neighborhood
transformer
steps down voltage

Transformer on pole
steps down voltage
before entering house

Distribution line
carries electricity
to house



Transmission line
carries electricity
long distances



Answer Key:
(1) Power Plant (2) Transformer (3) Transmission Line (4) Neighborhood Transformer
(5) Transformer on Pole (6) Distribution Line

1 U.S. energy consumption by energy source, 2012. (2012, January 1). Retrieved October 14, 2014, from http://www.eia.gov/

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OVERVIEW

LESSON 2: COMMODITY TRACE-BACK

Standards

Next Generation Science Standards

PS3.A	Definitions of Energy *Disciplinary Core Idea
HS-PS3-3	Design, build and refine a device that works within given constrains to convert one form of energy into another form of energy.
PS3.B	Conservation of Energy and Energy Transfer (HS-PS3-4) Uncontrolled systems always evolve toward more stable states. *Disciplinary Core Idea
PS3.D	Energy in Chemical Processes *Disciplinary Core Idea
HS-ESS3-3	Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations and biodiversity.

Learning Objectives

At the conclusion of this lesson, students will be able to:

- Describe the domestic food supply chain
- Identify the use and types of energy involved in the growth, harvest, processing, transportation and marketing of an agricultural commodity

Time

50 minutes

Materials

- Hardboiled or plastic eggs (1 per group of 3-5 students)
- Note paper (1 per group of 3-5 students)
- Computer lab access (1 computer per group of 3-5 students)
- Energy in the Food Chain Handout (1 per student)
- PowerPoint file: 02_Commodity Trace Back PowerPoint

Review from Previous Lesson

If you are completing the entire unit, begin with this exercise.

- In Lesson 1, students discovered the primary sources of energy in the United States and how energy is transmitted from generation facilities to homes.
- In pairs or triads, have students share their mini-models and talk through the process of transmission.

INTRODUCTION (10 MINUTES)

The Backwards Egg:

• Organize students into groups of 3-5 and distribute one hardboiled or plastic egg to each group.

• Have students place the egg in the center of their notepaper and create a mind web around the egg, brainstorming all of the points where energy was used to produce it. If students have trouble starting this activity, provide them with a few of the items in the example list below. Ask them to place these items on the mind web and continue brainstorming.

• Have students think backward first. How has energy been used to produce this egg and get it here? (PPT 3)

Example list:

- Egg
- Refrigeration at grocery store
- Grocery store employee stocking shelves
- Transportation of eggs
- Cleaning and packaging egg
- Chicken
- Feeding the chicken
- Housing and lighting, cooling, heating
- Water for chicken/energy to pump water
- Delivering feed for chicken
- Growing feed for chicken
- Sun

• Then ask students to think forward. How will energy be used with this egg, before it is consumed?

Example list:

- Refrigeration
- Mixer
- Electrical or gas stove

Back and Forth:

• After groups have completed their mind webs, ask groups to share by playing "Back and Forth."

• One group starts by saying the first item on their list.

• The next group shares one of their energy inputs without repeating.

• Write energy inputs on the board as each group shares them.

• Continue calling on groups around the room until groups have shared all they can. The group that adds the last energy input to the list wins!

OBJECTIVE 1 (5 minutes)

Describe the domestic food supply chain.

The Chain:

• All food products go through a similar path from producer to consumer.

• Using Power Point (PPT 4) introduce the domestic food supply chain[1]:

1. Farm production
2. Food processing and brand marketing (processing)
3. Food and ingredient packaging (packaging)
4. Freight services (transportation)
5. Wholesale and retail trade and marketing services
6. Away-from-home food and marketing services (food service)
7. Household food services (households)

The Value of the Chain:

• Ask students to consider how food preparation has changed in the past 100 years. Ask volunteers to share.

- Background: Research was conducted on adults between ages 18 and 64. The study found that time per day spent cooking at home dropped from 65 to 31 minutes per day between 1965 and 1995. People spend less time preparing food at home now, because we have access to "convenience foods" — foods that are ready to go right out of the package. This means that, while there is less energy spent at home preparing meals, more energy is spent by manufacturers who are preparing convenience foods.[2]

• Ask students why they think it might be valuable to look at energy use in the food supply chain. Listen for observations that reference the cost of energy or the environmental impact of energy used at each step.

OBJECTIVE 2 (30 minutes)

Identify the use and types of energy involved in the growth, harvest, processing, transportation and marketing of an agricultural commodity.

Commodity Investigation:

• You may wish to do the next activity with groups or individual students.

• Assign a commodity to each group (or individual student). Possible commodities include corn, soybeans, rice, potatoes, oranges, grapes, strawberries, steak, apple,

flour, milk and so on.

• Give each student one "Energy in the Food Chain" handout.

• Using PowerPoint (Slide 5), remind students that there are multiple types of energy.[3]

Potential Energy: stored energy and energy of potential	Kinetic Energy: the motion of waves, electrons, atoms, molecules, substances and objects
Chemical Energy: Stored in bonds of atoms and molecules. Ex: batteries, petroleum, natural gas, coal	Radiant energy: Energy that travels in transverse waves. Ex: sunlight, x-rays, radio wave
Mechanical energy: Stored in the tension between objects. Ex: compressed springs, stretched bands	Thermal energy: Heat energy from the movement of atoms. Ex: energy from fire
Nuclear Energy: Stored in the nucleus of an atom and generated at nuclear power plants.	Motion energy: Energy that is stored in the movement of objects. Ex: A wrecking ball releasing stored energy as it breaks a building.
Gravitational Energy: Stored in an object's height. Ex: hydropower, moving objects down a hill	Sound: Energy that travels in longitudinal waves.
	Electrical energy: Energy from charged electrons moving through a wire or space. Ex: electrical outlet in home, lightening

• Instruct groups to research the energy involved in each step of producing their assigned commodity and they type of energy used. Groups should address the following questions as they complete their "Energy in the Food Chain" handout.

- Where is this commodity primarily grown/raised? What energy is used?
- When is it planted/harvested? What energy is used?
- How is it planted/harvested? What energy is used?
- How is the raw product commonly processed and/or packaged? What energy is used?

• Optional enrichment: If time allows, you may wish to have groups create a diagram mapping the flow of energy for their commodity.

CONCLUSION (5 minutes)

• Almost everything takes energy, and our food production system is no exception! To maintain a stable food supply, it is important to have a variety of energy sources available for these activities that feed, clothe and house us.

• Challenge students to mentally walk through the same questions they responded to on their handout with another food item they consume throughout the day.

• Preview Lesson 3: In the next lesson, we will explore various forms of renewable energy.

Energy in the

Sources

[1] Canning, P., Charles, A., Huang, S., Polenske, K., & Waters, A. (2010). Energy Use in the U.S. Food System.*USDA Economic Research Service*, 94, 3-5. Retrieved October 15, 2014, from http://www.ers.usda.gov/media/136418/err94_1_.pdf

[2] Canning, P., Charles, A., Huang, S., Polenske, K., & Waters, A. (2010). Energy Use in the U.S. Food System.*USDA Economic Research Service*, 94, 3-5. Retrieved October 15, 2014, from http://www.ers.usda.gov/media/136418/err94_1_.pdf

[3] Forms of Energy. (n.d.). Retrieved October 15, 2014, from http://www.eia.gov/KIDS/energy.cfm?page=about_forms_of_energy-basics

Food Chain Handout

Name: ______________________________ Date:________ Class Period: ________

Energy in the Food Chain

Potential Energy: stored energy and energy of potential	**Kinetic Energy:** the motion of waves, electrons, atoms, molecules, substances and objects
Chemical Energy: Stored in bonds of atoms and molecules. Ex: batteries, petroleum, natural gas, coal	**Radiant energy:** Energy that travels in transverse waves. Ex: sunlight, X-rays, radio waves
Mechanical Energy: Stored in the tension between objects. Ex: compressed springs, stretched bands	**Thermal energy:** Heat energy from the movement of atoms. Ex: energy from fire
Nuclear Energy: Stored in the nucleus of an atom and generated at nuclear power plants.	**Motion energy:** Energy that is stored in the movement of objects. Ex: A wrecking ball releasing stored energy as it breaks a building.
Gravitational Energy: Stored in an object's height. Ex: hydropower, moving objects down a hill	**Sound:** Energy that travels in longitudinal waves.
	Electrical energy: Energy from charged electrons moving through a wire or space. Ex: electrical outlet in home, lightening

Commodity: ______________________________

Where in the United States is this item grown/raised?	What form of energy is used to produce it?
When is it planted/harvested?	**What form of energy is used?**
How is it planted/harvested?	**What form of energy is used?**
How is the raw product commonly processed and/or packaged?	**What form of energy is used?**

OVERVIEW

LESSON 3: RENEWABLE ENERGY COMPARISON AND ANALYSIS

Standards

Next Generation Science Standards

HS-ESS3-2 Evaluate competing design solutions for developing, managing and utilizing energy and mineral resources based on cost-benefit ratios.

ESS3.A Natural Resources *Disciplinary Core Idea

ETS1.B Developing Possible Solutions *Disciplinary Core Idea

Common Core State Standards for Mathematics
Mathematics – High School – Modeling

Interpreting Categorical and Quantitative Data S-ID: Summarize, represent and interpret data on a single count or measurement variable.

Learning Objectives

At the conclusion of this lesson, students will be able to:

- Describe the benefits and drawbacks of renewable energy
- Analyze data comparing different forms of renewable energy, drawing conclusions about cost and feasibility of each type under variable circumstances

Time

50 minutes

Materials

- Gummy bears (1 per student)
- Role Play Resource Cards (1 set per group of 5 students)
- Paper (graph paper is best, but not essential)
- PowerPoint file: 03_Renewable Energy
- Supporting background resources:
  - National Energy Education Development Project (NEED.org): Secondary Energy Infobook 2013-2014
  - U.S. Energy Information Administration (www.eia.gov); energy KIDS Renewable Energy Sources
  - Energy 101 on YouTube

Review from Previous Lesson

If you are completing the entire unit, begin with this exercise.

- In Lesson 2, students identified the food supply chain and identified energy inputs through the food supply process.
- Ask students to turn to a partner and share about a food item they ate the previous day and identify 2 points of energy input with that food item.

INTRODUCTION (5 MINUTES)

Gummy Bear Power:

• Immediately after students arrive to class, present them with a physical challenge. For example, you may challenge them to a 60 second wall sit, 20 jumping jacks, jogging in place for 30 seconds or rubbing their hands together as fast as they can to release energy. Consider physical limitations of students when selecting an activity.

• After students have completed the first challenge, ask them how long they think they could repeat the activity. Let students know they'll have one more chance to complete the challenge, but before they do, give each one a gummy bear to eat.

• Have students complete the physical challenge a second time and then return to their seats.

• Preview the lesson: Our physical energy is renewable! While a gummy bear isn't the healthiest food, the sugar provides quick energy for our bodies. Eating nutritious food, getting rest and drinking water help our energy continually replenish. But all energy is not the same. Some of the energy sources we use are non-renewable; they cannot naturally regenerate. Other energy sources are renewable — they can be replenished over and over again. Today, we will explore the pros and cons of renewable energy sources.

OBJECTIVE 1 (20 minutes)

Describe the benefits and drawbacks of renewable energy.

Role Play Resource Cards:

• In this activity, students will each receive a card with a renewable resource. The card will include a description, as well as pros and cons for using the resource.

• Students will review their card and assume the role of an expert for their form of renewable energy (i.e., a solar equipment dealer would discuss reasons why this resource may or may not be the best fit for a given situation).

• Break students into groups of 5. Give each group 1 set of Resource Cards.

• Instruct students to sit in a circle, and place cards facedown in front of them.

• Inform students that in a moment they will each draw a card. After reviewing the card, they will assume the role of an expert for this renewable resource. Give students 2 minutes to review their cards and ask questions.

• Once questions have been answered, pose a scenario to the group, such as: "I am a hay farmer. I use electrical pumps to irrigate 5,000 acres of hay. I need to cut the cost of running my pump. What should I do?" You may wish to use PowerPoint. (PPT 03)

• Challenge groups to debate, within their group, the best solution for this scenario. Allow students 3-4 minutes to debate. When time is up, ask teams to share the solution they came to. Important note: The solution is less important than the "why." We are not looking for a right or wrong answer, but rather a thought process and ability to defend why a certain resource was selected.

• Repeat this process using 2-3 of the following scenarios, or create your own!

- "I am nurseryman. I have to heat and cool my greenhouses throughout the year to make sure my plants have the ideal growing conditions. What can I do?"
- "I am a vegetable processor. We sort, slice and bag carrots. We use water to transport carrots in man-made rivers around the factory. We live in a hot sunny environment."
- "I am a cattle rancher. We have 1,000 head of cattle on range-land and in a confined feeding area. We live in a cool region with stormy winters."

• Using PowerPoint, review the primary sources of renewable energy as needed. Ask students what they observed about all forms of renewable energy. Listen for comments about the cost of implementation or the lack of consistent energy production in many cases. Reinforce the need for a variety of energy sources to maintain consistent energy production.

OBJECTIVE 2 (20 minutes)

Analyze data comparing different forms of renewable energy, drawing conclusions about cost and feasibility of each type under variable circumstances.

• Ask students to consider the following question, "If renewable resources are free, then why isn't renewable energy free?" Listen for answers that suggest there is a significant cost to collect, process and transport the energy from these renewable resources.

• To account for the cost of setting up renewable energy equipment and the cost to run this equipment, economists have developed a formula that identifies the *levelized cost of energy* (LCOE) for different renewable technologies.

• Display the following table of LCOEs using PowerPoint

(PPT 04). Students are to review the data in the table, select an appropriate graph format to represent the data and write a 3-5 sentence statement summarizing what the data suggests. Information is adapted from the 2014 U.S. Department of Energy Annual Outlook.[1] Note: If students struggle identifying the type of graph to use, ask them to think about the data they are representing. Does each of the data points represent part of a progression (line graph) or separate data points (bar graph)? (Answer: Bar Graph) Ask students to consider what the x and y axis labels could be by looking at the variables (plant type, cost).

U.S. Average LCOE (2012 $/MWh) for Plants Entering Service in 2019

*Including Subsidies

Plant Type	Total System LCOE
Conventional Coal	95.6
Integrated Coal-Gasification Combined Cycle (IGCC)	115.9
Natural Gas-fired (Conventional Combined Cycle)	66.3
Natural Gas-fired (Advanced Combustion Turbine)	103.8
Advanced Nuclear*	86.1
Geothermal*	44.5
Biomass	102.6
Wind	80.3
Wind-Offshore	204.1
Solar PV*	118.6
Solar Thermal*	223.6
Hydroelectric	84.5

- You may wish to have students work independently or in pairs to complete this task.
- After students have completed their graphs and explanatory statements, ask students to voluntarily share. Collect and display work.

Extension (Optional)

Have students research renewable energy options in their community. Students should report back on the options available and relative cost.

CONCLUSION (5 minutes)

- Poll students to see if/how their perceptions of renewable energy have been altered by the discussion and lecture.
- Preview Lesson 4: In the next lesson, we will conduct an experiment to test biodiesel and petroleum diesel.

Sources

[1] Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014. (2014). *US Energy Information Association*. Retrieved October 1, 2014, from http://www.eia.gov/forecasts/aeo/pdf/electricity_generation.pdf

[2] YOUR GUIDE TO RENEWABLE ENERGY. (n.d.). Retrieved October 16, 2014, from http://www.renewable-energysources.com/

Resource: Role Play Resource Cards[2]

Solar Energy

What: Just like plants use the sun to create energy through photosynthesis, equipment can turn the energy from the sun into chemical energy.

Things We Like:

- Highly renewable- The sun is always shining somewhere in the world!
- A low level of solar energy can be generated even on cloudy days.
- Solar panels do not produce any pollution.

Considerations:

- Sunlight is not constant. The amount of energy generated is highly impacted by the amount of sunlight.
- Solar energy cannot be stored, unless in extremely large batteries.
- Requires space.
- Unless used solely for heating water, solar energy should be supported by a more consistent source of energy.

Wind Energy

What: Wind energy is kinetic energy that can be harnessed by wind turbines and used to create electricity.

Things We Like:

- There is an endless supply of wind – it is highly renewable.
- No greenhouse gasses or pollutants are released when converting wind energy to electricity.

Considerations:

- Setup costs are extremely high.
- Wind varies depending on where you live.
- Wind varies from day to day.
- Concern that wind turbines can have a negative impact on bats and birds.
- Often the best areas for wind turbines are far from areas that need electricity, so energy must be transported.

Resource: Role Play Resource Cards[2]

Biomass Energy

What: Biomass energy is anything that was once living, which can be used as fuel. Burning a log is the simplest form. Alcohol is a more complex form.

Things We Like:

- Renewable
- Easily used to heat homes and even power vehicles.
- Waste, such as leftover oils, can be converted to biodiesel and other usable forms of energy.
- Can improve forest health by using material, such as fallen trees or limbs, to create energy. These would be waste products if not used!

Considerations:

- Facilities should be placed near the fuel source to minimize transportation impact.

Geothermal Energy

What: Geothermal energy refers to the natural, internal heat in the earth. It is mainly used to produce electricity or heat.

Things We Like:

- Renewable because it uses steam or water
- Does not rely on fossil fuels
- Low maintenance cost

Considerations:

- Setup costs are very high.

Resource: Role Play Resource Cards[2]

Hydropower

What: Hydropower is energy harnessed from the kinetic energy of moving water.

Things We Like:

- Renewable – There are many places on earth with moving water!
- Minimal pollution is released.
- Technology is extremely efficient.
- Can be used on a very small or very large scale

Considerations:

- A lot of land is needed for water reservoirs.
- Hydropower is affected by rainfall.

OVERVIEW

LESSON 4: LAB INVESTIGATION: BIODIESEL

Standards

Next Generation Science Standards

HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Learning Objectives

At the conclusion of this lesson, students will be able to:

- Determine the amount of energy released from biodiesel through a laboratory exercise
- Compare the energy released from biodiesel to other energy sources

Time

50 minutes

Materials

- 10-mL graduated cylinder (1 per lab group)
- Test tube rack (1 per lab group)
- 12-oz empty, clean aluminum soft drink can with pull tab (1 per lab group)
- Ring stand and ring (1 per lab group)
- Thermometer (1 per lab group)
- Stir rod (1 per lab group)
- Matches (1 per lab group)
- Balance (1 per lab group)
- Teal light candle with metal cup and wick (2 per lab group)
- Watch glass (1 per lab group)
- 5 ml biodiesel, purchased from a local gas station (1 per lab group)
- 5 ml petroleum diesel, purchased from a local gas station (1 per lab group)
- Lab sheet (1 per lab group)
- Cat litter or spill cleanup sand
- PowerPoint file: 04 Biodiesel Lab

- Additional Resources:
  - o This lab was adapted from "Energy Foundations for High School Chemistry," a project of the American Chemical Society Education Division made possible by funding from BP. http://highschoolenergy.acs.org/ Check out this resource for more information and great labs for learning.
  - o For additional biofuel information, visit http://www.agmrc.org/renewable_energy/

Review from Previous Lesson

If you are completing the entire unit, begin with this exercise.

- In the previous lesson, students evaluated renewable energy sources and analyzed data comparing cost.
- Ask students to identify one "a-ha!" moment they had in the last class, when they learned something new. Have students share with a partner and then ask for volunteers to share.

**Note: This lab may take longer for students who are less comfortable in a hands-on lab setting. Allow for time to fully discuss results of lab experiment.*

INTRODUCTION (5 MINUTES)

• Ask students to recall what energy source is used the most in the United States (Introduced in Lesson 1).

• Set context: Petroleum alone makes up 36% of U.S. energy consumption.[1] What is petroleum primarily used for? Transportation! Gasoline, diesel fuel, heating oil and jet fuel all come from petroleum, which is refined from crude oil. Farmers and ranchers rely on petroleum to fuel tractors and other equipment, which is a major expense in the food production process. In 2013, the United States consumed an average of 18.89 million barrels of crude oil each day. That's more than 793 million gallons — enough oil to fill more than 44,000 swimming pools every day.[2] (PPT 03)

• Crude oil is not considered renewable because it takes so long to replenish. So how does renewable fuel, like biodiesel, compare to petroleum diesel?

• Preview lesson: In this lab, students will compare the effectiveness of biodiesel and petroleum diesel.

OBJECTIVE 1 AND 2 (40 minutes)

Biodiesel Lab (PPT 04):

• Review safety procedures with class. DO NOT use burners with this exercise, due to the flammability of the fuel being test. Maintain control of matches used in exercise.

• Break students into lab groups.

• Distribute lab sheet, which contains step-by-step directions. Lab procedure is adapted and reprinted with permission from Energy Foundations for High School Chemistry, Copyright © 2013, American Chemical Society.

CONCLUSION (5 minutes)

• Collect lab sheets or have students complete as homework and submit the following day.

• Ask students to momentarily assume the role of a Farm Advisor. Considering what you know now, what advice would you give to farmers who are interested in using biodiesel? Why? Students can respond by journal writing or discussing.

• Optional Extension: Have students create a sales poster for biofuel that appeals to farmers. Students should consider all information farmers would need to know in order to make a decision to purchase biofuel.

• Preview Lesson 5: In the next lesson, we will discover real farms using renewable energy!

Sources

[1] U.S. energy consumption by energy source, 2012. (2012, January 1). Retrieved October 14, 2014, from http://www.eia.gov/

[2] FAQ - How Much Oil is Used in the United States? (2014, May 13). Retrieved October 16, 2014, from http://www.eia.gov/tools/faqs/faq.cfm?id=33&t=6

Lab Sheet
Fueling up with Biodiesel

How does renewable fuel stack up to petroleum diesel?

Procedure adapted and reprinted with permission from Energy Foundations for High School Chemistry, Copyright © 2013, American Chemical Society.

Procedure

1. Set up test apparatus.
   a. Bend up the pull-tab of an empty, clean aluminum soft drink can.
   b. Slide a glass stir rod through the top hole of the pull tab.
   c. Hold the glass stir rod horizontally and set it on a ring attached to a ring stand so the aluminum can is suspended underneath it.
   d. Raise or lower the ring stand sot he bottom of the can is about 2cm above the wick of the metal sample cup (tea candle).
2. Prepare the sample of biodiesel.
   a. Take a tea light candle in a metal cup. Remove the candle from the cup.
   b. Remove the metal circle and its attached wick from the bottom of the candle.
   c. Set the candle aside. Place the metal circle and its attached wick back in the metal cup, so the wick stands upright.
   d. Place 5ml of biodiesel sample in the metal cup using a dropper or plastic pipette.
3. Record initial observations.
   a. Measure and record the initial weight of the biodiesel with the cup and wick.
   b. Record observations of the sample's color, odor, viscosity, etc.
4. Weigh 100 g of cold water, recording the weight to the nearest gram. Pour the water into the soft drink can. Measure and record the initial temperature of the water to the nearest degree Celsius.
5. Ignite the biodiesel sample using the wick. Once it is ignited, immediately move the metal cup underneath the soft drink can.
6. As the water in the can heats, stir it gently. Allow the biodiesel sample to burn for ~5 min.
7. Extinguish the flame by placing a watch glass over the metal cup.
8. Measure and record the highest temperature reached by the heated water to the nearest degree Celsius.
9. Allow the metal cup and sample to cool. Measure and record the final weight of the biodiesel sample with the cup and wick to the nearest 0.1 g.
10. Repeat steps 2-9 with a sample of petroleum diesel.
11. Safely return or dispose of fuel samples according to your teacher's directions.

Data Collection: What did we do?

	Biodiesel	Petroleum Diesel
Initial Mass of Sample and Cup (g)		
Mass of Water Sample (approximately 100g)		
Initial Temperature of Water (degrees Celsius)		
Highest Temperature of Water (degrees Celsius)		
Final Mass of Sample and Cup (g)		

Data Analysis: What can we learn?

1. Using the temperature and weight data from heating the water in the can, calculate how much thermal energy was used to heat the water. The specific heat capacity of water is 4.18 J/(g · °C), meaning it takes 4.18 J to raise the temperature of 1 g of water by 1 °C.

2. Calculate the heat of combustion in kJ/g for the sample of biodiesel you burned. The heat of combustion is the quantity of thermal energy given off when a certain amount of a substance burns. Assume that all of the energy released by the burning biodiesel is absorbed by the water.

3. Petroleum diesel (from crude oil) produces 43 kJ/g of thermal energy when burned. Compare this to the thermal energy your biodiesel and ethanol samples produced when it was burned.

4. Compare your calculated heat of combustion with those calculated by the rest of the class. What is the class mean?

Reflection: What does this mean?

1. Would you recommend biodiesel as an alternative to petroleum diesel? Why or why not?

2. What considerations should be made when shifting cropland used for producing food crops to land for producing crops for biodiesel?

3. What do you foresee as the future of biodiesel?

Lab Answer Key:

Data Analysis: What can we learn?

1. Using the temperature and weight data from heating the water in the can, calculate how much thermal energy was used to heat the water. The specific heat capacity of water is 4.18 J/(g · °C), meaning it takes 4.18 J to raise the temperature of 1 g of water by 1 °C.

Answers will vary. A sample calculation is: Data:

Mass of biodiesel burned: 3.4 g (difference between biodiesel sample, metal cup, and wick before and after burning)

Mass of water: 1.00 x 102 g water
Initial water temperature: 5 °C
Final water temperature: 67 °tC
$E = mC\Delta T = (1.00 \times 102\ g)(4.18\ J/(g \cdot °C))(67\ °C - 5\ °C) = 26\times103\ J$

2. Calculate the heat of combustion in kJ/g for the sample of biodiesel you burned. The heat of combustion is the quantity of thermal energy given off when a certain amount of a substance burns. Assume that all of the energy released by the burning biodiesel is absorbed by the water.

Answers will vary. The method of gathering data for the heat of combustion is somewhat inefficient. A sample calculation, using the data from Analyzing Evidence question 1, 26×103 J, or 26 kJ, is given off by the burning biodiesel. The heat of combustion = 26 kJ / 3.4 g = 7.6 kJ/g

3. Petroleum diesel (from crude oil) produces 43 kJ/g of thermal energy when burned. Compare this to the thermal energy your biodiesel and ethanol samples produced when it was burned.

Gram for gram, biodiesel produces less energy.

4. Compare your calculated heat of combustion with those calculated by the rest of the class. What is the class mean?

Answers will vary, depending on class data.

OVERVIEW

LESSON 5: FARMING WITH RENEWABLE ENERGY

Standards

Next Generation Science Standards

PS3.A	Definitions of Energy *Disciplinary Core Idea
HS-ESS3-2	Evaluate competing design solutions for developing, managing and utilizing energy and mineral resources based on cost-benefit ratios.
HS-ESS3-4	Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Learning Objectives

At the conclusion of this lesson, students will be able to:

• Evaluate the renewable energy strategies of individual farms by examining real-life case studies.

Time

50 minutes

Materials

• Introduction video

• Farm case studies (1 set per group of 2-3 students)

• Renewable Energy Plan Handouts

• News props (i.e., microphone, sports jacket) *optional

• Poster paper with lesson titles (5)

• Markers (1 per student)

• Optional: Student tablets to record news report

• PowerPoint file: "05 Renewable Farming"

INTRODUCTION (5 MINUTES)

• Play brief videos that introduce students to farms that have incorporated renewable energy strategies. The following link provides two short videos that illustrate renewable energy in agriculture. You may also find additional videos online.

- • Ventura County Star: http://www.vcstar.com/business/farmers-turn-to-alternative-energy-despite-money Limoneira Solar Video (0:51), Gills Onions Bio-digester (1:07). The supporting article has additional information. (PPT 03)

• Ask students to think back on the second lesson, when they identified energy requirements in the food processing chain. Why would renewable energy be of interest to a farmer, processor, packer or other person involved in the food processing chain? Listen for comments that indicate cost savings, stewardship of resources, and ability to use waste product.

OBJECTIVE 1 (35 minutes)

Students will evaluate the renewable energy strategies of individual farms by examining real-life case studies.

Case Study Evaluation (PPT 04):

• Break students into groups of 2-3. Give each group a set of case studies.

• Ask groups to quickly review the case studies, and randomly assign groups one case study to evaluate in-depth.

• Provide directions:

- • In groups, students will read their selected farm profile aloud to the group.
- • Groups will work together to fill out Renewable Energy Plan handout. (You may wish to have groups submit one handout for the group, or each student submit individually.)
- • Groups will prepare a 60 second news report to present to the class. All members of the group must be involved in the news report.

News Reports:

• Set context that students are reporting live from farms and ranches that are using renewable energy. The teacher,

or student volunteer, should act as the news anchor.

• To create a fun, fast-paced environment, instruct all students to be ready to go as soon as their name is called. Have each team put one "reporter's" name on a slip of paper and drop in a hat. The anchor can randomly pull a name and jump to that team's presentation.

• Optional Technology Enhancement: If iPads or other tablets are available, have students record their news reports to share with the class.

CONCLUSION (10 minutes)

• This activity is intended to help students recall key information from each of the lessons in this unit. Prior to class, write the following prompts (1 each) on five separate sheets of poster paper. If replicating for multiple class periods, you may wish to print the prompts and simply hang a new blank poster sheet next to it for each period.

- Lesson 1: Energy generation and distribution
- Lesson 2: Energy and the food supply chain
- Lesson 3: Comparing renewable energy sources
- Lesson 4: Biodiesel Lab
- Lesson 5: Renewable energy on farms

• Give each student a marker (pens/pencils may also be used). Give students four minutes to rotate throughout the room, writing down anything they recall from each lesson.

• After writing, allow students two minutes to do a "Gallery Walk" of the room, observing what classmates have written.

• Ask students to share new information they have learned, and how their opinions may have been reinforced or adjusted because of this unit.

Optional Extension: Have students review and evaluate an additional case study from the case study packet. Students may also research other farms/ranches online using renewable energy.

Renewable Energy Plan

1. Farm's name and location:

____

2. What do they farm?

____

3. Describe the energy needs of the operation (irrigation, processing, transportation, etc.).

____

4. What type(s) of renewable energy do they utilize?

____

5. What factors do you think led them to choose that strategy? Explain each.
    a. Geographic:

    b. Available resources:

    c. Weather:

    d. Cost:

6. What opportunities/challenges do you see for implementing this on a larger scale?

____

7. How would you improve their energy system?

____

Farm Case Studies

Roberti Ranch	**Loyalton, California**	**www.robertiranch.com**

Summary: The Roberti Ranch sits on 6,000 acres of beautiful land in the Sierra Valley of Northern California. On the farm, 2,000 acres are used to grow alfalfa, 1,500 of which are irrigated. The Roberti family raises beef cattle, and the hay is used to feed the cows.

The Situation: Several years ago the Roberti family began looking into solar options. It takes a lot of electricity to run the nine 100-horsepower pumps on their land that pull up water to irrigate the hay. Without irrigation the hay won't grow. Without hay, the cows won't grow.

The Solution: The family decided on a 500-kilowatt solar system. They received a USDA Rural Energy for America Program (REAP) grant to help pay for the system. Three acres were converted to solar panels, which rotate throughout the day to follow the sun. The family estimates that the solar panels will pay for themselves in 10 years as a result of saving on the cost of electricity. The solar panels should have an expected life of 25 years.

Dixon Ridge Farms	**Winters, California**	**www.dixonridgefarms.com**

Summary: Dixon Ridge Farms grows, buys and processes organic walnuts in Winters, California.

The Situation: Walnuts must be dried before they are ready to package and eat. This process uses a lot of energy. Dixon Ridge Farms wanted to find a way dry their walnuts while saving money and helping the environment.

The Solution: In 2007, Dixon Ridge Farms became the first farm to use a biogas powered generator that converts walnut shells into energy. The shells are removed from the walnuts and turned directly into energy that powers the drying facility, provides electricity to the farm, and heats buildings in the winter. The BioMax 100 produces about 643,000 kWh (about $102,000) worth of electricity, and $24,000 worth of gas each year.

Farm Case Studies

Alger Ranch | **Stanford, Montana** | **www.mopcoop.org/producers/alger-ranch**

Summary: The Alger Ranch raises beef cattle, spring wheat, barley, Kamut® grain, peas, lentils, winter wheat and alfalfa hay. The 1,200-acre family ranch started in 1917, and Jess Alger is now the 3rd generation to manage the land.

The Situation: Electricity is necessary on a ranch. Three wells on the Alger ranch require electricity to pump water for the cows. Welders in the shop and augers that move grain also need electricity. The Alger Ranch was looking for a sustainable way to ranch while saving money.

The Solution: In 2003, Jess Alger put in a wind turbine. The turbine now supplies 99% of the ranch's electricity. It cost $37,000 to purchase the wind turbine. Mr. Alger installed the 100-ft tower himself. He received funding support from the USDA and the National Center for Appropriate Technology (NCAT). [1]

Brookfield Farm | **Amherst, Massachusetts** | **www.brookfieldfarm.org /**

Summary: Brookfield Farm was the third community-supported farm established in the U.S. In a community-supported farm, member households pay a portion of the operating costs for the farm and in return get as much produce as they need. The farm has 30 acres in production and 525 members (shares). They grow more than 50 different crops like cabbage, carrots, squash, onions, kale and melon, based on the season.

The Situation: Brookfield Farm uses electricity to power walk-in coolers, greenhouse fans, the farm office and lighting around the farm. They were looking for an environmentally sustainable way to support their electricity needs.

The Solution: When Brookfield Farm built a new barn in 2003, they realized an opportunity to install photovoltaic (PV) solar panels on the new barn roof. They installed a 3.8 kW solar electric system, which now supplies 35% of the farm's electricity needs. [3]

Farm Case Studies

West Orchards	Macon, Missouri	www.west-orchards.com

Summary: West Orchards is a family business in north central Missouri. The 10-acre orchard sits on a larger, 170-acre farm. The orchard has 17 varieties of apples and several varieties of peaches, apricots, pears and plums.

The Situation: In an orchard, there is often fruit left on trees after harvest. This fruit eventually drops to the ground and begins to break down. Farmers then have to decide what to do with all of the waste fruit. At the same time, farmers like the Wests have to balance growing fuel costs for trucks and equipment.

The Solution: Dan West saw this abundance of waste as an opportunity. He turned the waste fruit into wine and designed a system to remove the alcohol from the wine to produce ethanol. The resulting ethanol powers the farm mower and tractor.

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