Optimal and Sustainable

Renewable Energy Revamp

About this Lesson

In this lesson, students will be challenged with an optimization problem. The fictitious town of Solutionville has decided to replace coal, their current source for electricity, with more sustainable energy sources. In designing Solutionville's sustainable energy future, students must consider not only the geographic constraints of various renewable energy options—wind energy, hydroelectric power, geothermal energy, and solar energy—but they must also meet specific energy production requirements and budgetary constraints.

While this challenge can be solved using a variety of mathematical skills, the lesson comes with an Excel spreadsheet that has been pre-loaded with all of the cost and energy production parameters that students must work within. The spreadsheet allows students to more efficiently manipulate their energy source options to see what combination maximizes energy production while minimizing cost.

Students should have a basic understanding of fossil fuels and their impacts on the environment before approaching these challenges. It is recommended your students watch the video **What's the Deal With Fossil Fuels?** and complete the accompanying lesson **The Heat is On: Cause and Effect and Climate** before tackling this challenge.

Grade levels: 6-8

Total activity time: 120 minutes

Materials needed:

- Video: **Renewable Energy: Clean Tech Solutions**
- Computer with internet access and projector
- Fossil Fuels Reading (1 per student)
- Renewable Energy Readings (1 per group)
- U.S. Energy Potential Maps (1 per group)
- Student Activity Guide (1 per student)
- Computers or laptops loaded with the Spreadsheet Tool (1 per pair)
- Calculators
- Rulers
- Sticky notes
- *(Optional)* Butcher paper (1 piece per pair)
- *(Optional)* Markers, tape

Focus Questions

1. Why might we want to replace fossil fuels with renewable energy sources to power our cities?
2. What does it mean to 'optimize' something, like a plan or solution? What kinds of tools can we use to efficiently solve an optimization problem?
3. What are the benefits and drawbacks of different renewable energy technologies?

Learning Objectives

1. Students will examine some of the benefits and drawbacks to using renewable energy sources instead of coal.
2. Students will explore the geographic conditions that favor or restrict the use of various renewable energy technologies in a particular place.
3. Students will create an optimal renewable energy plan for a community that meets specific constraints and criteria.

Teacher Prep

1. The day before the activity, print out pages 1-2 of the **Fossil Fuels Reading** for each student. Ask students to read page 1 and fill in the Benefits and Drawbacks chart on page 2 for homework.

2. Print out one set of **Renewable Energy Readings** per group (minus the completed Benefits and Drawbacks charts).

3. Print out one set of **U.S. Energy Potential Maps** per group.

4. Print out one **Student Activity Guide** per student.

5. Make sure that students have the **Spreadsheet Tool** downloaded as a Microsoft Excel file (.xls) on their computers or laptops (the spreadsheet will initially open in Google Drive).

Activity Procedure (120 minutes)

Pre-Activity Homework

The day before the activity, print out one Fossil Fuels Reading for each student. Ask students to read page 1 and fill in the Benefits and Drawbacks chart on page 2 for homework.

Part I: Introduction to Renewable Energy (60 minutes)

1. Ask students to talk to a partner for 1-2 minutes about what they know about *renewable energy*.

2. Show students the video **Renewable Energy: Clean Tech Solutions**.

3. Spend a few minutes discussing the video. You might need to replay it once or twice more for students.

4. **Expert jigsaw:** Divide students into groups of four and give each group one set of Renewable Energy Readings. Tell students to pick one renewable energy source to become the 'expert' on in their group: geothermal, wind, hydroelectric, or solar.

5. Students will individually read through the one-page summary of their energy source, then fill in the Benefits and Drawbacks chart.

6. Each student will take a turn explaining their renewable energy source to their fellow group members, including some of the benefits and drawbacks.

7. Group members who are listening should write the benefits and drawbacks that they hear on sticky notes (one per note), and stick them on a class table on the board in the appropriate row/column. The table will not only serve as a reference for students, but as an assessment for common thinking:

	Benefits	Drawbacks
Solar energy		
Wind energy		
Geothermal energy		
Hydroelectric power		

8. Give each group one set of U.S. Energy Potential Maps.

9. As a team, students should decide which city (or cities) would be the best and worst places to use each renewable energy source.
    - *Are there any cities that could potentially use more than one renewable energy source?*
    - *Tomorrow, your task will be to design a renewable energy plan for a town. Thinking about the benefits and drawbacks of the renewable energy sources we explored today, do you think using just one of these energy sources to power a community or city is enough? Why or why not?*

10. Complete Part I by having a class discussion about how fossil fuels compare to renewable energy sources. Before moving on to Part II, students should be able to explain why a city or community might want to use renewable energy sources for electricity over fossil fuels.

Part II: Optimization Challenge (60-90 minutes)

1. Begin with a discussion recapping nonrenewable energy sources (fossil fuels) and renewable energy sources (e.g., wind power).

2. Divide students into pairs. Give each student a Student Activity Guide and go over the instructions for the activity outlined on the worksheet. Be sure students can access the Spreadsheet Tool on their computer or laptop, and practice manipulating the spreadsheet as a class to get students comfortable using it. Then, give students time to work through the activity with their partners.

3. At the end of the activity, groups can either present their plans to the class, or students can do a gallery walk around the classroom. Discuss the activity:

    - *What did you notice about the renewable energy plans of the other groups? Why do you think they made the choices they did?*

    - *Do you think it is better to choose just one renewable energy source to power a community, or more than one?*

- *What other factors do you think you might need to take into account in your designs? (E.g., cost to run and maintain infrastructure, community member concerns)*

- *How do engineering and technology impact society? How does society influence engineering and technology?*
  - **Examples**: *Engineering and technology can impact people's quality of life by affecting the environment they live in. Society can control how quickly technology can advance or what kinds of technology can be used by implementing cost constraints.*

- *How do engineering and technology impact the natural world/environment? How does the environment influence engineering and technology?*
  - **Examples**: *Engineering and technology can cause damage to the environment if it creates pollutants, or can help the environment if clean technology replaces dirty technology. Environmental conditions can constrain what kinds of technology can be used in a particular area.*

> ***Teacher Tip:*** *In this activity, there is more than one renewable energy plan that fulfills the outlined cost and energy production needs and meets the environmental constraints. Instead of focusing on what the 'right' answer is, ask questions to make sure your students can clearly justify and articulate their choices.*

Extensions

- Explore the U.S. Energy Mapping System

- Explore innovative renewable energy use in real communities around the world:
  - Smithsonian Interactive: Mapping Renewable Energy Around the World
  - A renewable energy success story above the Arctic Circle
  - Why a small German village bet big on renewables

Connections to Standards

NGSS Disciplinary Core Ideas (Grades 6-8)

- MS-ESS3.A: Natural Resources
- MS-ESS3.C: Human Impacts on Earth Systems
- MS-ESS3.D: Global Climate Change
- MS-ETS1.B: Developing Possible Solutions

NGSS Science and Engineering Practices (Grades 6-8)

- Designing solutions
- Using mathematics and computational thinking

NGSS Crosscutting Concepts (Grades 6-8)

- Influence of Science, Engineering, and Technology on Society and the Natural World
- Energy and Matter: Flows, Cycles, and Conservation

Up Next in *Flipside Science* Exploring Energy

The Heat is On:
Cause and Effect and Climate

Optimal and Sustainable:
Renewable Energy Revamp

Building Better Buses:
Transportation Design Challenges

Nuclear Energy:
What's Your Reaction?