UTAH OFFICE OF
ENERGY DEVELOPMENT

Energy and Air Quality

Grade/Subject: Earth & Space

Strand/Standard ESS 4.3 Evaluate design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios on large and small scales. *Define the problem, identify criteria and constraints, analyze available data on proposed solutions, and determine an optimal solution.* Emphasize the conservation, recycling, and reuse of resources where possible and minimizing impact where it is not possible. Examples of large-scale solutions could include developing best practices for agricultural soil use or mining and production of conventional, unconventional, or renewable energy resources. Examples of small-scale solutions could include mulching lawn clippings or adding biomass to gardens. (ESS3.A, ETS1.A, ETS1.B, ETS1.C)

Lesson Performance Expectations:

- Students will evaluate design solutions related to air quality in Utah valleys.

Materials:

- Computers
- Large zip lock bag
- Car Exhaust
- Bromothymol blue
- Drinking straw
- Slide Deck link
- Poster board
- Link to resources https://energy.utah.gov/wp-content/uploads/Utahs-Energy-Landscape-5th-Edition.pdf

Time: 45 minutes

Teacher Background Information:

1. The phenomenon is based on a color change in a bromothymol blue solution. Bromothymol blue is an acid/base indicator that is blue in a basic or neutral solution and yellow in an acidic solution. When car exhaust is bubbled through a solution of Bromothymol blue, it changes the slightly basic solution to acidic and yellow. The only way to go wrong is to have the solution too basic to begin with.
2. Use 2 two gallon ziploc bags and gather air in one and car exhaust in another. The car exhaust is collected by placing an empty, flat bag on the tailpipe of a running car (make sure it is not hot) and filling it. In the classroom, place a straw in a small opening in the bag and ask a student to gently squeeze the gasses in the bag into a beaker with a solution of Bromothymol blue. The car exhaust will turn the Bromothymol blue to yellow but the room air will not.
3. If students are not familiar with the terms cost-benefit ratio, criteria and constraints, this would be a good time to provide them with that background information.

4. Make sure you are familiar with the terms in the solutions and can explain to students what each one entails.

Student Background Knowledge: Students need to know the terms criteria, constraint and cost-benefit ratio. Most students are aware of poor air quality. The purpose of the phenomenon is to help students understand that car exhaust is not just "air".

Teacher Directions: A standards-based lesson engages students' curiosity, interest and motivation to learn more. Time and space for the students to experience the phenomenon and ask questions is essential. The student sheet provided below provides guidance but is only one example of how students might respond.

1. Demonstrate the phenomenon and ask students to share their questions with the class or individually in groups.
2. As a class, discuss the air quality in your region and how it affects your students.
3. Ask students to brainstorm some solutions, they will most likely choose from those presented in the activity.
4. As a class, talk through the charts provided and make sure students understand what each chart is illustrating.
5. Describe how you would like the students to fill in the data table. They could use a numbering system for the criteria with a "1" for what they think is best for cleaning the air and so on to the least. The constraints will have to be explained but simple phrases like "too expensive", "people won't do this" or "not possible in my family" can be used.
6. Break the class into groups of 3-5 students. Each group will research an Energy Source in Utah, make a poster and present their findings to the class. The questions addressed will be: Where in Utah is it found? How does this energy and examine the energy transfers? How much energy is produced from this source? This link can be very useful.

Assessment of Student Learning.

1. What are harmful effects of poor air quality? Choose all that apply.
    a. Rain clouds hanging over valleys*
    b. Harmful chemicals in the air*
    c. Excessive rainfall possible
    d. Decreased visibility for drivers*
    e. Increases ground temperatures

2. An electric car can cost $5-10,000 more than a similar gas powered car. What is the financial incentive to buy one?
    a. Electric cars are lighter weight
    b. Electric cars are cheaper to operate.*
    c. Electric cars are better for snowy conditions.
    d. Electric cars have fewer moving parts.

3. What effect does lowering your thermostat on your house have on energy savings?
    a. You save 2% on your energy bill for each degree you decrease.*
    b. You save 40% on your energy bill for each degree you decrease.
    c. You save 60% on your energy bill if you decrease by 5 degrees.
    d. You save money but it cannot be estimated.

4. What should a car driver do when they know they will be stopped for several minutes?
    a. Put the car in reverse.
    b. Push the brake firmly.
    c. Push the accelerator lightly.
    d. Turn the car off.*

5. Write down something that you feel you can do to clean the air.

Extension of lesson and Career Connections:

1. Air quality measurement stations are placed at many locations in Utah. To see the stations and their current readings, look at: https://air.utah.gov/ This site also has excellent information: https://www.ucair.org/
2. Investigate alternative renewable energy resources and their impact on air quality.

Title: Energy and Air Quality

Name_____

Phenomenon: Watch as your teacher demonstrates the effect of car exhaust on Bromothymol Blue (an acid/base indicator)

What questions do you have?

1.

2.

Introduction-Poor air quality affects the valleys of Utah during the winter for a variety of reasons. The picture below shows what an "inversion" looks like during a period of high pressure.

https://www.deseret.com/2010/12/3/20157865/mucky-air-blankets-northern-utah

Inversions may last days or weeks. They are harmful to human health and are monitored to warn people when they should avoid outdoor activities. Car exhaust is the number one factor (40%) in polluting the air followed by home heating and cooling (30%).

A variety of solutions have been proposed to develop, manage, and adapt energy resources based on cost-benefit ratios on large and small scales. In this activity, you will define the problem, identify criteria and constraints, analyze available data on proposed solutions, and determine an optimal solution. Read through the data provided and then fill in the table.

1. **Define the problem:**

2. **Possible solutions:**

Solution	3. Criteria (how effective will this be, will it clean the air)? 	4. Constraints (what will limit the application of this solution). Ie. Too expensive
Carpool whenever possible		
Limit cold starts and combine trips		
Use public transportation		
Purchase energy-efficient engines or electric cars		
Idle (leave the car running) less or not at all		
Ride a bike or walk		
Turn down the thermostat at home to 65 degrees		
Add solar panels to rooftops to reduce natural gas use.		

5. Summarize:

What solution or combination of solutions do you think will be best? Why?

6. Conclusion: Answer your questions from the phenomenon. If you can't, explain what information you still need to be able to answer them.

Part 2: Each group will research an Energy Source in Utah, make a poster and present their findings to the class. The questions addressed will be:

- Where in Utah is it found?
- How does this energy and examine the energy transfers?
- How much energy is produced from this source? This link can be very useful.
- As a class vote on which energy source may be the best one for Utah to use.

Slide Deck

Data:

Figure 1: Contributors to Utah Air Pollution

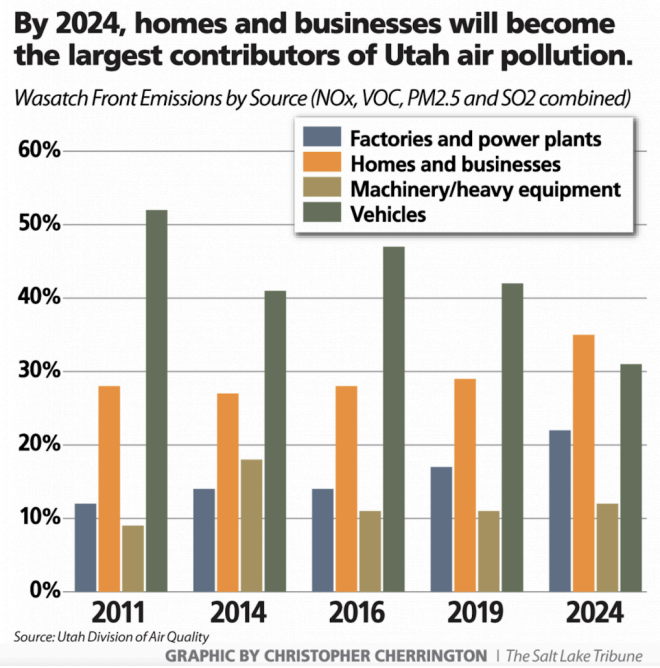
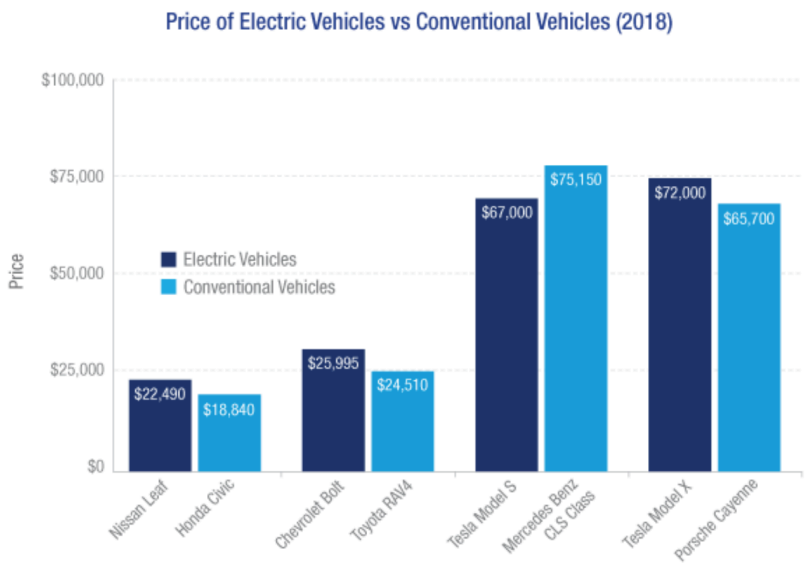
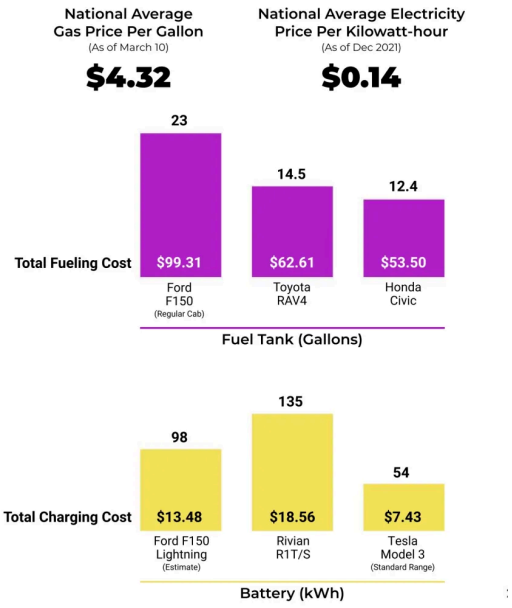


Figure 2: Price of Electric Vehicles vs Gas-Powered Vehicles



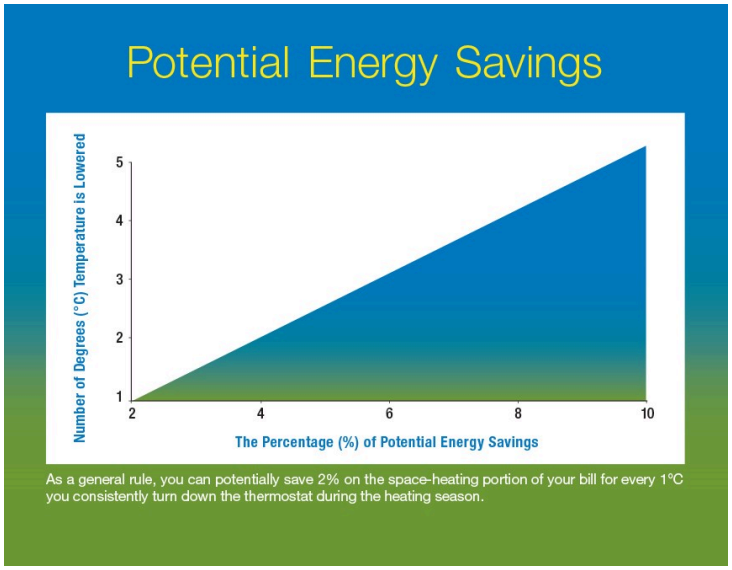
https://www.energysage.com/electric-vehicles/electric-car-cost/

Figure 3: Costs of Fuel for Electric vs Gas-Powered Vehicles



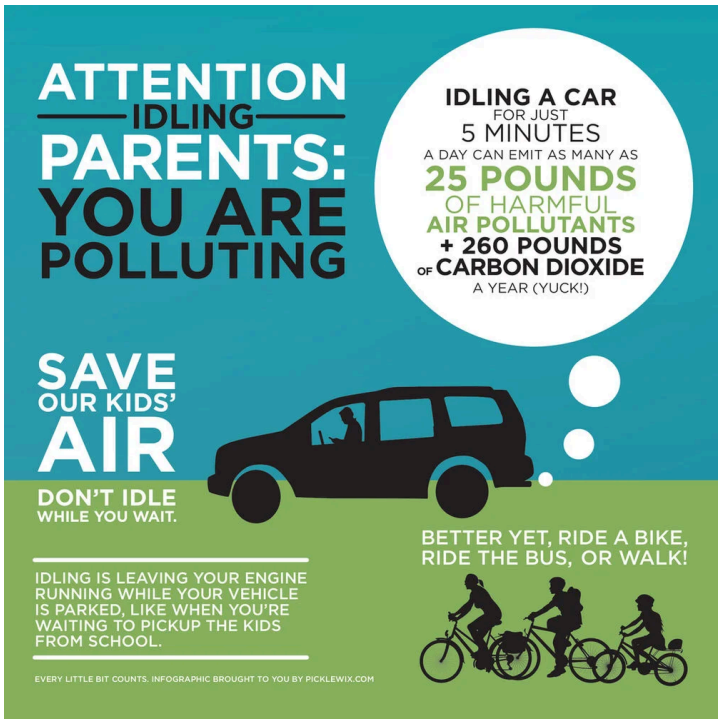
https://electrek.co/2022/03/22/electric-cars-3-to-6-times-cheaper-to-drive-us-high-gas-prices/

Figure 4. Energy Savings for Thermostat Lowering



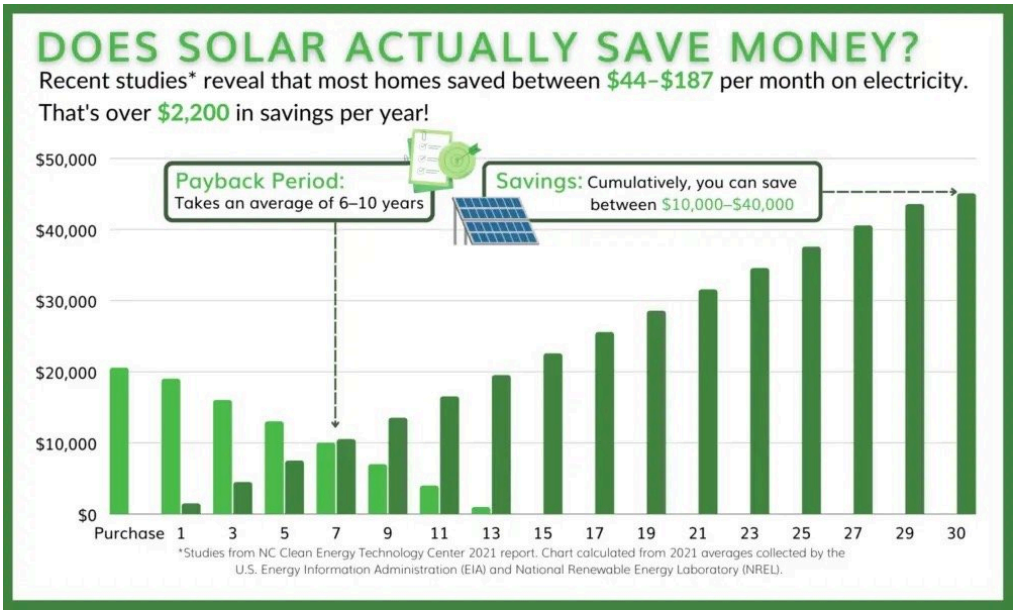
https://www.warmup.com/blog/avoided-thermostat-key-energy-savings

Figure 5. Savings for Less Idling in a Car



https://www.picklewix.com/post/idling-cars-outside-schools

Figure 6: Solar Energy Savings



https://www.esssolarpower.com/blog/is-solar-worth-it-ut

Figure 7: Effects of Cold Start