GOVERNOR'S OFFICE OF ENERGY DEVELOPMENT

Advancing Utah's Energy Future

Impacting Utah's Air

Grade/Subject: 8th Grade Science

Strand/Standard 8.4.3: Design a solution to monitor or mitigate the potential effects of the use of natural resources. **Evaluate** competing design solutions *using a systematic process to determine how well each solution meets the criteria and constraints of the problem.* Examples of uses of the natural environment could include agriculture, conservation efforts, recreation, solar energy, and water management.

Lesson Performance Expectations (description):
Students will understand valley inversions and be able to explain why inversions occur. Students will identify the impact of PM 2.5. Students will develop a solution to use less energy and therefore produce less emissions.

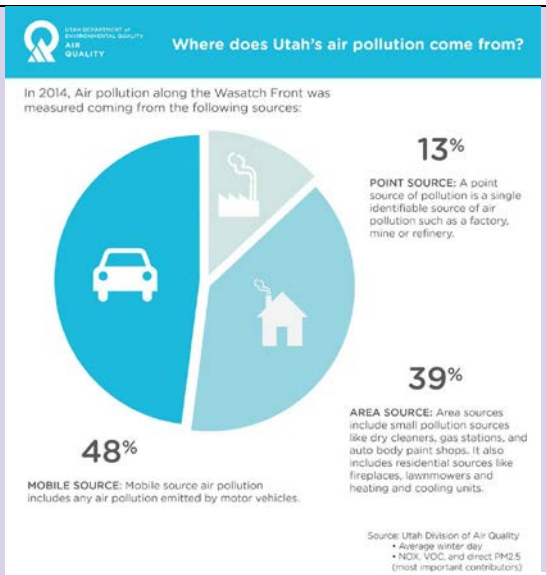
Materials:

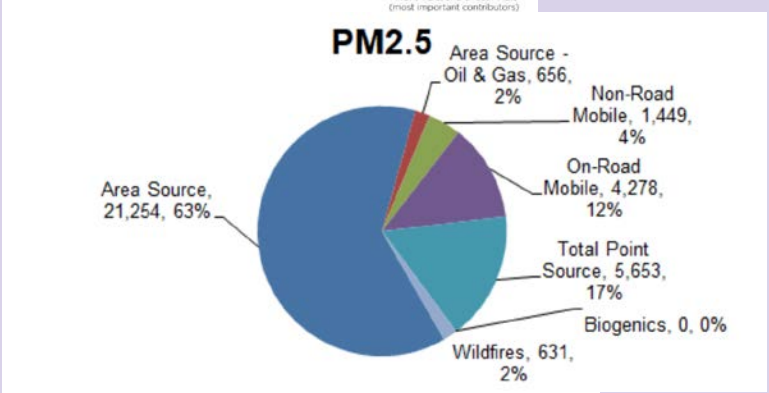
- Density Tank for demonstration
- Hot and cold water
- Food coloring (red, blue, green)
- Infrared temperature gun
- 3D printed forms of Utah Valleys, stl files. Utah Valley, Salt Lake Valley, Cache Valley.
- Slide show This slide show has more detailed information on the emissions and PM 2.5's
- Internet

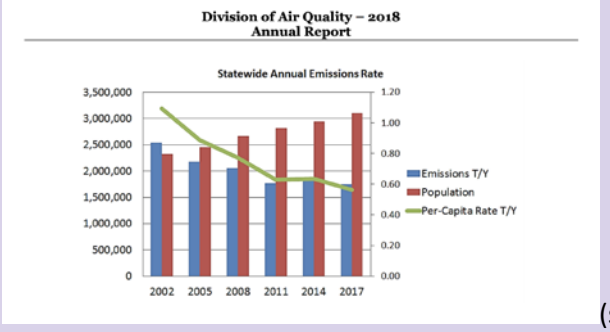
Time: (Two- three 50 minute periods)

Teacher Background Information:

- Utah's Air Quality: Causes of Inversions (1:28 min)
- Smart Energy Choices for Your Home (1:36 min)
- During the winter along the Wasatch Front a natural phenomenon called an inversion occurs because of the bowl like valleys. Inversions negatively impact air quality when cool air and particulates are trapped by a layer of warm air, leaving it to sit and build up. It takes strong winds or storms to stir up the air and lift the "lid." Inversions happen in Utah several times each year. We cannot control when they happen or how long they last.
- Three main groups of human activities contribute to elevated levels of PM 2.5. **Mobile sources** include cars, trucks and busses. **Point sources** are large stationary industrial or commercial facilities. **Area sources** are smaller, stationary sources like home heating, agricultural burning and harvesting, construction, biogenic (emissions from vegetation) and wildfires. To see which of these categories contributes the most of several common air pollutants, view page 25 of the Utah Division of Air Quality's 2018 Annual report at https://documents.deq.utah.gov/air-quality/annual-reports/DAQ-2019-000949.pdf In summary 13% comes from point sources like industry, 48% from mobile sources like vehicles, ad 39% comes from Area sources like home and buildings to keep them running.

- 

- 

- 

(source, pg. 26)
- We can't change our geography or population centers, but we can work to improve air quality. Not burning wood and coal as our primary energy resource has reduced the emissions from incomplete combustion of these fuels. Utah increased its use of natural gas, which has fewer emissions than other conventional fossil fuels. The development of alternative energy sources like biogas, wind, solar and geothermal energy have begun to help power our modern society with lower emissions. When the Tier 3 standard is fully implemented, following a phase-in period between 2017 and 2025, the average new passenger vehicle will emit 80 percent less nitrogen oxides (NOx) and volatile organic compounds (VOCs) than the average Tier 2 car emits today. (DEQ). These advancements in energy have contributed to cleaner air and increased access to reliable, affordable, energy.
- Vehicles are the largest contributor to poor air quality, accounting for 48% of total air emissions (DEQ). Being efficient and mindful with our transportation choices can make a big impact on our air quality, this includes: carpooling, avoiding idling and "cold starts" (starting a car engine when its temperature is lower than its normal operating temperature), walking or riding a bike, trip chaining (to plan your stops into a continuous circle), using

public transportation and driving alternative fuel (other than gas or diesel) vehicles. You can also switch from gasoline-powered lawn mowers to electric, and exchange wood-burning stoves or fireplaces to those powered by electricity or natural gas.

- Area sources come in second, accounting for 39% of emissions (DEQ). Our homes, schools and other community buildings like small businesses and fire stations all have an impact on air quality. This includes our appliances, heating and cooling systems, and lighting that we use daily in our communities.
- Industrial and large commercial sources contribute to 13% of emissions (DEQ). Power plants and oil refineries, as well as agricultural areas, industrial facilities and even dust, pollen and mold can contribute to poor air quality. Industries are encouraged through legislation to implementing new processes like carbon capture to clean up their processes and improve our air.
- Energy efficiency is using less energy to do the same thing. This can be achieved through the use of efficient technologies. Technologies such as programmable thermostats, insulation, low flow water devices, Energy Star® certified appliances LED lighting, smart power strips as well as advancements in the smart grid help increase energy efficiency.
- Energy use can also be decreased through and energy wise conservation behaviors. Our behaviors can reduce energy use, save money and reduce area source emissions. Taking shorter showers, turning off the lights, reducing phantom loads (any device that consumes electricity when turned off but is still plugged into an outlet) and setting thermostats to 68 F in the winter and 78 F in the summer are all examples of energy wise behavior to conserve energy (OED).
- Watch OED's 4 part video series on energy efficiency and your home.
- See how Utah is improving the transportation sector to help enhance air quality here.
- Check out OED's Renters Guide to Energy Efficiency for more tips on how to save energy at home.
- Check out Utah's first ever Net Zero Community.
- Visit *cleartheairchallenge.org* to see what a difference we can make when we all work together.
- Find out which Utah municipalities have pledged to be Idle Free.

Student Background Knowledge:

- An understanding of density.
- The chemical change of burning will convert the fuel into other products. Emissions in this case.

Teacher Step by Step: A 3D lesson should insist students do the thinking. Provide time and space for the students to experience the phenomenon and ask questions. The student sheet provided below provides guidance but is only an example of how students might respond.

1. Introduce Phenomenon: Show the students several pictures of inversions. (slide show)
2. Students will list several questions that they have about the pictures.
3. Students sketch a model of the inversion showing the particles.
4. Use the density tank and ask students to find patterns between the density tank and the pictures of inversion. Ask them what evidence the demonstration provides that we can use to improve our model? Write down observations as you watch on your worksheet. (Fill ½ of the tank with hot water and ½ with cold water. Fill at the same time. Add red coloring to the hot and blue to the cold. Pull the divider out and record the observation. Put the divider back in and add green to ½ of the tank. Stir the ½ that you added green to and pull the divider again. Use the IR gun to record the temperatures throughout the process)
5. Students sketch a second model of the inversion using their new knowledge.
6. Hand out the 3D printed valleys and encourage students to identify the 'edges' of the valley bowl.
7. Show the students the video clip (0:20 minutes) of an inversion over time.
8. Review the slide show with the students through slide 11.
9. Direct students to write three evidence statements for the claim: Poor air quality along the Wasatch front is created by a combination of natural and human causes.
10. Ask the students, "Why should we care?" show this video (2:31 min.)

11. Students will predict where they think the emissions are coming from.
12. Use this PDS page 25 the PM 2.5 diagram. to confirm sources of emissions and have the students sketch the pie graph. Direct a discussion to show that there are three main sources; vehicles, industry, buildings.
13. In groups of 2-4, have students choose one of the three sources of emissions and create a plan to reduce the amount of emissions. Possible resources are listed below.
    a. OED's Renters Guide to Energy Efficiency
    b. OED's 4 part video series on energy efficiency
    c. How Utah is improving the transportation sectors contribution to Air Quality
    d. Utah's first ever Net Zero community
    e. https://www.dominionenergy.com/home-and-small-business/ways-to-save
14. The groups that choose the same area source will combine. In these larger groups they will peer evaluate to create a stronger and more effective plan.
15. The combined groups will present their plan to the class.

Assessment of Student Learning.

Use this image of an inversion to answer the questions:

1. Evidence from air quality studies shows which of the following are responsible for the phenomenon in the picture? Choose all that apply:
    a. Automobile emissions*
    b. Trapped cold air on the ground*
    c. Industrial sources*
    d. Home heating and cooling*
    e. A layer of cold air above the cloud
    f. Carbon dioxide released from plants
    g. Geography of the valley*

2. Which of the following are reasonable ways to help improve air quality during an inversion, like the one seen in the picture? Choose all that apply:
    a. Banning cars from the valley roads
    b. Carpooling when possible*
    c. Using alternative energy sources (solar, wind)*

d. Reducing the cold air mass trapped in the valley
e. Changing to electric or natural gas vehicles*
f. Insulating homes for efficiency*

3. People need to take their own precautions when an inversion happens. Which of the following are reasonable actions?
    a. Reduce the amount of time spent outside*
    b. Reduce the activity level when outside*
    c. Ask everyone to not drive that day.
    d. Do not attend any function outside the home.
    e. Stay updated on air quality reports from a trusted source.*

4. Anti-idling signs are posted at many schools. What are the advantages of turning off a car engine when the car is not moving? Choose all that apply.
    a. Saves gas*
    b. Helps improve air quality*
    c. Makes the driver more comfortable.
    d. Decreases the amount of time needed to leave the school.

Extension of lesson and Career Connections:

The energy industry presents many job opportunities. Energy efficiency is the largest employer and fastest growing sector in the Energy industry, both in Utah and in the nation (USEER). Energy efficiency careers contribute directly to improving air quality. Some careers in energy efficiency include; design/architecture, electrical engineer, energy code officials, strategic energy manager, data specialist or public policy and advocacy work. Have students research a job in the field of energy or energy efficiency and discuss how it could impact air quality. Present to the class or make a flyer about the occupation.

Impacting Utah's Air

Name_____

Phenomenon: Watch the phenomenon. Ask three questions about what they see.

1.

2.

3.

Create Model #1

Question #1: Why do inversions happen in Valleys?

Observe demonstration of the density tank.

What evidence does the demonstration provide that we can use to improve our model? Write down observations as you watch.

1.

2.

3.

New improved model-Use dots to show air particles and label the layers:

A-warm air B-cold air C-denser air D-less dense air E-pollution particles

Next Phenomenon: Watch the video clip of an inversion changing over time.

1. What new information does this provide?

1. What new questions do you have?

Explanation

Claim: Inversion in Utah Valleys is created by a combination of natural and human causes.
Evidence: 1. 2. 3.

Why should we care about our air? Watch this Video

Predict the 3 main sources of emissions in Utah valleys?

1.
2.
3.

Go to this website page 25, the PM 2.5 graphs and sketch the pie graph. What are the three main sources? https://documents.deq.utah.gov/air-quality/annual-reports/DAQ-2019-000949.pdf

1.
2.
3.

In groups choose one of these sources and create a plan to reduce the amount of emissions.

Source of emissions:	
Step one:	Why would this work?
Step two:	Why would this work?
Step three:	Why would this work?

Meet with another group that chose the same source. Evaluate both design solutions and create a stronger plan to decrease the emissions. Fill in the chart with your plan.

Source of emissions:	
Step one:	Why would this work?
Step two:	Why would this work?
Step three:	Why would this work?

Be ready to present your improved plan to the class.