**PhET - Human Sustainability - Instructions and Worksheet**

**PhET Greenhouse Effect Instructions**

The PhET simulation that we will be using to explore the effects of increased CO2 in the atmosphere is the Greenhouse Effect simulation.

1. Navigate to <https://phet.colorado.edu/en/simulations/greenhouse-effect>
   1. If this link does not work, google PhET greenhouse effect simulation
2. Click the play button to start the simulation
3. Click on the Waves model to select the simulation graphics type.
4. Click “Start Sunlight” to start the simulation.
5. Click the “Energy Balance” checkbox to see the energy coming in, going out, and the net effect of these fluxes.
   1. You can also choose to click the “Show Surface Temperature” checkbox on the bottom left if you want to see a color associated with the surface temperature in each condition of the simulation.
6. Click the calendar icon underneath the “Greenhouse Gas Concentration” vertical slider.
7. Select “1750” if it is not already selected.
8. Select “1950” to change the simulation, such that the greenhouse gas concentration is equal to that of 1950 levels.
9. Select “2020” to change the simulation, such that the greenhouse gas concentration is equal to that of 2020 levels.
10. Select “Ice Age” to change the simulation, such that the greenhouse gas concentration is equal to that during the Ice Age.
11. Click the slider icon on the “Greenhouse Gas Concentration” box so you can see the slider icon again.
12. Move the slider to the minimum position, “None.”

**PhET Greenhouse Effect Worksheet**

1. When you use the calendar function and select 1750, what is the surface temperature?
   1. 13.6 ºC (56.4ºF)
2. Using the internet, or remembering back to the Legion 44 movie, what was the concentration of CO2 in the atmosphere in 1750, otherwise known as pre-industrial times?
   1. 280 ppm
3. When you use the calendar function and select 1950, what is the surface temperature?
   1. 13.8 ºC (56.8ºC)
4. Using the internet, what was the concentration of CO2 in the atmosphere in 1950? How does this compare to the concentration in 1750? How does that appear in the PhET Greenhouse Gas simulation?
   1. 311 ppm
5. When you use the calendar function and select 2020, what is the surface temperature?
   1. 14.9 ºC (58.8ºF)
6. Using the internet, what was the concentration of CO2 in the atmosphere in 2020? How does this compare to the concentration in 1750? What about 1950? How does that appear in the PhET Greenhouse Gas simulation?
   1. 415 ppm
7. When you use the calendar function and select Ice Age, what is the surface temperature?
   1. 7.5 ºC (45.5ºF)
8. Using the internet, what was the concentration of CO2 in the atmosphere in the Ice Age? How does this compare to the previous concentration in CO2 concentrations you’ve researched? How does that appear in the PhET Greenhouse Gas simulation?
   1. 200 ppm
9. When you use the slider function and set it to “None”, indicating no greenhouse gases, what is the surface temperature?
   1. -17.9 ºC (-0.2ºF)
10. Graph the points you found online for the CO2 concentration for each of the time frames, not including the ice age. Use a secondary axis, and a different color, or marker shape, on the same graph to do the same with the surface temperatures you recorded.
11. Compare the graph you made with the hockey stick curve, popularized by atmospheric and climate scientists. Do you see where the data you graphed fits in with this the hockey stick curve? What conclusions can you draw about the the industrial revolution, starting in 1750, through today, as it relates to the data you’ve collected from this simulation?
12. How do these conclusions about humanity’s previous and current use of energy sources influence what you think the next-generation of energy sources should be optimized for, if anything?
13. How does the data point from running the simulation with no greenhouse gases indicate to you about the presence of greenhouse gases in Earth’s atmosphere and it’s livability for plant and animal species?