**En-ROADS - Human Sustainability - Instructions and Worksheet**

**En-ROADS Simulator Instructions**

The En-ROADS simulation is meant to illustrate how the deployment and use of different energy sources, transportation, industries, carbon removal, and other greenhouse gases impact the global average temperature, in addition to other parameters.

1. Navigate to https://www.climateinteractive.org/en-roads/ and click “Explore the En-ROADS Simulator”
   1. If this link does not work, google En-ROADS Simulator
2. The default graphs that are displayed are the “Global Sources of Primary Energy” and “Greenhouse Gas Net Emissions.” You can leave these as they are for now.
   1. If you ever navigate away from these graphs, feel free to return using Graphs > Reset to Default Graphs, or by clicking the home icon at the top
3. Some handy short-cut buttons at the top:
   1. Reset Policies and Assumptions: resets the entire simulator to the default values.
   2. Reset Default Graphs (Home Icon): resets graphs to the default ones in the simulator, the Global Sources of Primary Energy and the Greenhouse Gas Net Emissions.
   3. Undo: undoes the last change
   4. Redo: redoes the last change
   5. Replay Last Change (circular arrows): the simulator will replay your last change without you clicking, so you can see the impact your choices had in real-time on the graphs.
4. Each slider is equipped with “Detailed Settings,” which are accessed using the three dots on the right side of each slider.
5. After you complete the questions posed throughout the En-ROADS Simulator Worksheet, you are encouraged to continue exploring the simulator, revising your scenarios, and digging into the advanced options, as you wish.

**En-ROADS Simulator Worksheet**

**Part 1: Fossil Fuel Reliance**

1. Since the industrial revolution, we’ve been reliant on biomass and fossil fuel (coal, oil, and natural gas) energy sources. What happens when we continue this reliance? Move the sliders for coal, oil, natural gas, and bioenergy to the right, so they show a status of “subsidized.”
2. Now, keeping the energy sliders where they are, move the “Transportation” and “Buildings and Industry” energy efficiency sliders all the way to the right, where they are highly increased. How does the change in energy efficiency change the results of the simulation? Think about the global energy production (exajoules/yr), the net greenhouse gas emissions, and the temperature changes over time. How does this scenario relate to the baseline scenario?

**Part 2: Electrification**

1. When addressing clean ways to operate the economy, the solution of electrification is one that is often discussed. Move the “Transportation” and “Buildings and Industry” electrification sliders all the way to the right, indicating they are highly subsidized. How have the results of the simulation changed? Are the changes greater or less than you expected, explain.
2. Increase the energy efficiency for both “Transportation” and “Buildings and Industry.” How did changing the energy efficiency change the results of your scenario? How do these results compare to the high-efficiency fossil fuel reliance scenario from Part 1?
3. As the world moves more toward electrification, this is often talked about in conjunction with generating electricity in a cleaner way. In the Energy Supply category, move the sliders for “Renewables”, “Nuclear”, and “New Zero-Carbon” all the way to the right. How does this impact the results of the scenario?

**Part 3: The Impact of Growth**

1. Return all the sliders back to the original positions. Use the “Population” and “Economic Growth” and slide them to their maximum values, individually first, then together. How does this change the results displayed on the graphs and the overall temperature increase by 2100? What does this say about the assumptions made in the model with respect to population and economic growth? Do you agree or disagree with these initial assumptions, why or why not?
2. To date, economic growth has come at the expense of using fossil fuels for energy, how do the results for increased economic growth scenarios (Economic Growth slider is in the maximum position) change as you change the energy mix (varied Energy Supply sliders)? Which of the energy supply sliders seemed to impact the results the most? Why do you think that is?

**Part 4: Carbon Dioxide Removal**

1. Return all the sliders back to their original positions. Use the “Nature-Based” and “Technological” Carbon Dioxide Removal sliders and set them to their maximum values, individually first, then together. What does the impact of implementing carbon removal have on the net greenhouse gas emissions and the temperature rise by 2100?
2. Carbon removal activities require energy. Go the “Energy Supply” sliders and increase all the fossil fuel energy sources. How does impact the effectiveness of carbon removal activities? How does this change, if you change the energy mix to be non-emitting sources?

**Part 5: Other Sources of Greenhouse Gases**

1. Return all the sliders back to their original positions. Explore the “Other Sources of Greenhouse Gases” sliders, individually and together. Are there any sources in this category that surprised you? Did adjusting any of these sliders have more or less of an impact on the results than you expected? Which one and why was it different than you expected?

**Part 6: Individual Exploration**

1. In the previous parts, we explored how different category and technology changes influence the scenarios first by themselves, then in tandem with other changes. Spend the next 15 - 20 minutes exploring the other components built into the En-ROADS simulator tool, and see if you can:
   1. Get to a scenario that meets the Paris Climate Agreement of limiting global average temperature increase to less than 2ºC, what about 1.5ºC? Take a screenshot for the scenario that gets you the closest, or meets either of these objectives.
   2. What slider are you most interested in? Select the three dots on the far right, read about the slider and the assumptions that go into it. Explore what minimizing and maximizing the slider do. Then Toggle the “Use detailed settings” and explore how the related graphs on the right side are impacted. Write a brief summary of which slider you chose and why, the changes you saw using the default slider, and how you refined your approach, and the results when you used the “detailed settings.”
2. After interacting with the En-ROADS simulator, what kinds of people do you think would benefit most from a tool like this? How could you see this being used to teach others about these innovative technologies and human sustainability?