

The goal for this year's REU project was to develop a website that would display the science, in a simplified manner, behind greenhouse gases and global heating. The Global Heating team consisted of Dr. Simon Billinge, Geraud Plantegenest, and myself.

The starting point for the project was an abstract idea proposed by Dr. Billinge, teach the public in a simplified manner the physics behind global heating using the Internet as our project medium. This simple idea was the bases for the whole project. The first question that had to be answered was what type of audience was our project going to be geared towards. We decided that the website should be developed in a way that high school students would be able to grasp the ideas in relatively little time. With this in mind, the information and ideas must be simplified, animated, and the text should be brief. The use of the website as a learning tool has given us the opportunity to reach several learning types. Those individuals that learn by reading can indulge in the text of the website. Those who are more visually stimulated would find the demonstrations and animations more fulfilling. Although there are various other types of learning styles, the text and visual components of the website compliment each other and give a broad base from which many people can learn.

With the Internet as our medium it then had to be determined what information was necessary to convey our message. In short, what does the public know about the world they live in? What we found was there is a small portion of the public that is informed

and educated concerning the facts about our project, while the majority of people have no idea about the delicate balance between the earth, sun, and air pollution. So, not only did we have to convey our message, but we also had to embed enough facts and information about our environment for a high school student to fully understand global heating.

To understand global heating, one must comprehend the relationship between the sun and the earth. For our purposes we needed to describe what the sun actually produces, electromagnetic waves. The sun is a giant nuclear reactor that produces all forms of electromagnetic waves, but most strongly radiates the wavelengths in the form of visible light. These waves carry energy from the sun to the earth. The website has animation that enables the user to toggle a bar back and forth from gamma waves through long wave waves. As the user toggles back and forth the picture in the animation depicting the waves changes to represent the electromagnetic waves that the user is viewing at that specific time. This animation is perfect to demonstrate the difference between the waves and their wavelength.

With the product of the sun demonstrated and explained the next challenge was to show how these electromagnetic waves interact with the earth. The sun continually emits electromagnetic radiation and these waves wash over the side of the earth facing the sun at all times. The earth can be simply considered in physics terms a "black body". A black body is an object that absorbs all of the radiation incident upon it and then proceeds to radiate a single wavelength of electromagnetic radiation. As a very simplified

model, the earth absorbs almost all of the various wavelengths of radiation coming from the sun and then emits infrared radiation, mimicking a black body. To visually display this concept the website has a three dimensional animation that displays the sun and the earth relative to one another. The sun can be seen radiating energy towards the earth where it is absorbed, while at the same time the earth is radiating infrared electromagnetic waves off into deep space.

It is this balance of absorption and radiation that determines the temperature of the earth. An analogy was needed to simplify the idea of the absorption and radiation of electromagnetic waves and the correlation to the earth's total amount of energy. The earth can be compared to a financial bank. Consider a bank account. If a person were to continually deposit money into the bank account, without withdrawing money, the amount of money in the account would steadily increase. In contrast, if money were continually withdrawn from the account, without ever depositing any money, the amount of money would start to dwindle. Now if money were deposited at the rate at which it is was withdrawn, then the bank account would have a constant amount of money. In relationship to a financial bank the earth can be considered an energy bank. The relationship between absorption and radiation of electromagnetic waves determines the energy of the earth and thus the temperature. Once again a visual demonstration proved a perfect way to display this concept. A large glass container with a spout at the bottom of the container was obtained. This glass container was perfect for the representation of the earth and it's balance between absorption and radiation of

electromagnetic waves. A constant water source was fed into the top of the container and at the bottom spout of the container a hose was attached to enable the adjustment of the out flow of water. The amount of water coming into the container remained constant while the amount of water released from the container was varied, simulating the "greenhouse effect". This demonstration showed that if the amount of water entering and leaving the glass container were equal the level of the water in the container remained the same, but if the amount of the water leaving the container was restricted then the water level increased. This simple demonstration mimics the earth and its' energy levels. When the absorption and radiation of the earth are in a steady state then the amount of energy that the earth contains is constant. If greenhouse gases are added to the atmosphere, this restricts the radiation of infrared electromagnetic waves, thus increasing the amount of energy the earth contains.

After the user becomes familiar with the idea of absorption and radiation of electromagnetic waves, it is then time to show the user how greenhouse gases specifically effect the earth's radiation of infrared electromagnetic waves. Greenhouse gases are adept at absorbing and reflecting infrared electromagnetic waves that the earth should be radiating off into space. Greenhouse gasses disrupt the earth's internal energy by increasing the amount of energy that the earth contains. The animation that we decided to use involves the user and enables them to control the radiation of the earth. With this animation we wanted to simulate a simple video game, where the user controls the action of the animation. In the animation the greenhouse gases randomly swirl and float above the earth while the

user determines when the earth radiates of infrared electromagnetic waves. These electromagnetic waves are then, absorbed by greenhouse gases, reflected back towards the earth by the greenhouse gases, or slip off into deep space. Hopefully, by this point in the website, the user now understands the relationship between the sun and earth and the earth's absorption and radiation.

After displaying and explaining the effects of greenhouse gases, we had to show the scientific evidence that greenhouse gases are actually increasing. The increase of greenhouse gases is undisputed. There are numerous ways of determining the atmospheric levels of gases in the past and the present. The most convincing, being ice core samples taken from areas like Antarctica, Greenland, or the North Pole. Ice core samples are little windows into the past. Gases become trapped in the snow and ice. As more snow and ice fall the gases become buried. The deeper the ice core sample is taken, the older the sample, thus researchers and scientists can determine with good accuracy what the levels of gases in the atmosphere were in the past. The Carbon Dioxide Information Analysis Center is the primary global-change data and information analysis center of the U.S. Department of Energy. The CDIAC, being a reliable source, provided the project with very useful graphs that displayed the increase in greenhouse gases in the atmosphere. These graphs make a very strong statement, before the industrial revolution the amounts of greenhouse gases in the atmosphere were either nonexistent or at a stable minimal level. Since the industrial revolution, the amounts of greenhouse gases in the atmosphere have been increasing exponentially.

Mankind, by pumping greenhouse gases into the atmosphere, is disrupting the earth's natural carbon cycle. We are taking carbon that was sequestered in oil, natural gas, and coal and using it in combustion engines. This action, releases what was once stored carbon into the atmosphere to act as greenhouse gases. We are quickly reverting the atmosphere to primordial conditions.

Before there was animal life on the land there were plants. The condition was perfect for plants, high carbon dioxide in the atmosphere. Plants take atmospheric carbon and use it as their building blocks for growth and life. These plants took carbon from the atmosphere and when they died carried the carbon with them into the ground, lowering the atmospheric concentrations of carbon in the atmosphere. These plants were then converted into what we know as our energy sources, oil, coal, and natural gas. Originally, the earth had a high level of carbon in the atmosphere, but plants reversed that. Humans live optimally in an atmosphere that is high in oxygen and low in carbon. By burning the stores of carbon in the ground we are producing an atmosphere that is inhospitable for humans.

The stumbling block for most people and their ability to comprehend global heating is the difference between heating and warming. We found that the public is aware that we are increasing the amount of greenhouse gases in the atmosphere, but with no observable results and disagreement between scientist about whether the earth's temperature is actually increasing, leaves the public confused and untrusting. The fact is; it is possible to increasing the amount of energy the earth contains without there being a

noticeable increase in temperature. This is a subtle, but very important point that enables policy makers to twist the facts, if the projected audience is uneducated concerning heating and warming. Once again a simplified model will suffice to explain the necessary concepts. The earth has a large area covered with ice, the North and South poles. Our model is a beaker with ice and water. If a source of heat is placed under the beaker that contains ice and water, there is initially no change in the temperature of the water. It is only when the ice is totally melted, that the temperature starts to increase (See attached graph). So it can be understood why there is disputes about whether or not the temperature of the earth is actually increasing. The earth, similar to the model, has poles that are covered in ice and this would be enough to mask a potential increase in temperature. In the model after the ice is melted the temperature of the water increases drastically. This is a foreboding warning, if the ice at the Poles melts there will be a drastic, uncontrollable increase in temperature.

While the basic science of global heating is fairly easily understood, producing the final product was riddled with complications. The first setback came when we realized that a gas outlet was needed to produce the necessary flame to perform the heating versus warming experiment. The Biomedical Physical Science building contains no gas outlets, so I was forced to perform the heating versus warming demonstration in the Chemistry building. Anne Fischer and her professor let me use their lab to perform the demonstration. The lighting and background for the demonstration were also very important. The flame produced by the Bunsen burner

was blue and barely able to be seen. Also, we wanted to be able to see the ice melt in the demonstration. To be able to see both the ice and the flame was quite difficult. We decided to use a black background and indirect lighting. The black background was perfect and contrasted well with the blue flame from the Bunsen burner. The indirect lighting did the job of highlighting the edges of the ice, which gave it enough contrast to stand out from the water in the beaker. The key to performing the heating versus warming demonstration well was to let the ice equilibrate to roughly 32 degrees F and mix the water and ice continuously while heat was applied.

The second demonstration that had to be digitally videotaped was the analogy of the earth as an energy bank. Once the materials for the demonstration were procured it was observed that as the water level rose in the glass container it became difficult to see. The answer, we found was to use a blue background and direct lighting along with a graded marker that signified an increase in the level of water contained within the jar. With these changes the water level is visible even as it reaches the top of the glass jar. The only other complexity was that it was difficult to create an unchanging level of water contained within the glass container. While it appears that the amount of water flowing from the tap is constant, this is not the case. To combat this problem, the demonstration was digitally videotaped multiple time, as well as, the adjustments that controlled both in flow and out flow were adjusted to be as accurate as possible. With these steps the demonstration was videotaped successfully.

One of the concerns was that there is an enormous amount of information that pertains to the earth and greenhouse gases. We needed to keep our message very focused so that the user would not be confused by additional information. In addition to what should be discussed on the Global Heating webpage, we needed to present the material in a form that holds the users attention and arrives speedily to the conclusion. To obtain this flow throughout the website, the team decided to load the beginning of the page with stimulating, thought provoking information concerning the difference between heating and warming. After explaining this difference and how it relates to the earth and greenhouse gases, the webpage proceeds to explain the detail behind global heating and its' relationship to the increases in greenhouse gases. The beginning of the webpage is designed to capture the users' attention and spark enough interest in the topic to proceed throughout the rest of the website.

In conclusion, the final product is very close to what the team originally set out to create. The animations and demonstrations complement the text well. If there was more time to work on the project, I am sure that there would be some additional information added to the webpage and other adjustments would be made to enhance the flow and esthetic components of the webpage. Hopefully, the public will be made aware of our work and this will effects the public's view of pollution and the use of oil, coal, and natural gas. If this project makes it easier for the public to understand the world they live in and stimulates thought, then this project should be labeled a success.

