The Mystery of the Three Scary Numbers

By Bill Bigelow

Every now and then an article comes along that takes such a novel approach to an issue, I feel like I'm seeing something with new eyes. Such was the case when I read Bill McKibben's 2012 *Rolling Stone* article, "Global Warming's Terrifying New Math." It made me see our climate predicament with such clarity that I knew immediately I had to figure out how to turn this article into curriculum.

The "terrifying new math" is pretty simple. McKibben, founder of 350.org and the world's most prominent climate campaigner, proposes that there are just three numbers that we need to pay attention to in order to reach some radical conclusions about the future of fossil fuels.

The first number is **two degrees Celsius**, or about 3.6 degrees Fahrenheit. In the 2009 Copenhagen Climate Accord, 167 countries, including the United States, pledged that "deep cuts in global [greenhouse gas] emissions are required . . . so as to hold the increase in global temperature below two degrees Celsius." The Copenhagen Accord was a timid, inadequate document. According to McKibben, even a two-degree rise in global temperatures is fraught with danger, but it's the only

Adam Mills Elliott

"Coal Oil Gas—None Shall Pass." Demonstration against fossil fuel exports from the Northwest, Columbia River between Oregon and Washington. July 27, 2013.

international consensus on a climate target—"the bottomest of bottom lines," he writes. The first scary number.

The second scary number is **565 gigatons**—or 565 thousand million tons. That's humanity's carbon "budget"—how much carbon dioxide we can pour into the atmosphere with a reasonable chance of keeping global temperatures to a two degrees Celsius increase. That 565 gigatons sounds like a lot until we hear that global carbon dioxide emissions rose by 31.6 gigatons in 2011, and that projections call for humanity to blast through our 565-gigaton quota in less than 16 years.

Which brings us to the final number that makes the other two numbers so frightening: **2,795 gigatons**. This number represents the stored carbon in reserves held by coal, oil, and gas companies, and the countries—Kuwait, for example—that act like fossil fuel companies. McKibben notes that this number was first highlighted by the Carbon Tracker Initiative, a group of London financial analysts and environmentalists. In other words, the fossil fuel industry already has plans to exploit five times as much carbon as can be burned without exceeding the two degrees ceiling. Burning these fossil fuels would enter the world into a dystopia of climate science fiction—a rise in sea levels not seen in human history, species extinction, droughts, superstorms, heat waves from hell, coral kill-offs, and consequences we cannot yet imagine.

"Here's another way of saying it: We need to leave at least 80 percent of that coal and gas and oil underground," McKibben writes. "The problem is, extracting and burning that coal and oil and gas is already factored into the share prices of the companies involved—the value of that carbon is already counted as part of the economy." This would be the equivalent of these companies writing off $20 trillion.

Not only is the fossil fuel industry not planning to write off any of this $20 trillion, it is using its immense wealth to add new reserves. Just as an example, according to the *Wall Street Journal*, Exxon plans to spend $37 billion per year through 2016 on increasing oil production.

The simplicity of McKibben's "three scary numbers" helped me put into perspective some of the "softer" responses to global warming. So many environmentalists—and students—want to "be positive" and concentrate on alternatives: everything from buying locally to stepped-up recycling, planting more trees, and developing greener sources of energy. No doubt, it's crucial to imagine and work for alternatives. But for any of this to make a difference, we need to recognize fossil fuels—and those who exploit them—as immediate and staggering threats to life on Earth. One clear implication is that we cannot nice our way out of this. We have to educate and enlist our students in imagining a very different future in terms of energy use and fighting to make that happen.

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Yes, a full curricular treatment of climate chaos needs to do more than merely frighten students with scary numbers. But these numbers of McKibben's invest our thinking about the climate with a two-plus-two-equals-four certainty. It's not probable that the route we're on leads to catastrophe—it's for sure.

The Mystery Activity

I love the structure of mixer/tea party activities that get students up out of their seats and talking with one another to figure out a bigger picture. Rather than asking students to assume the roles of individuals in history or around the world, I decided to write clues drawn largely from McKibben's *Rolling Stone* piece. Through talking with one another, I wanted students to solve the "mystery of the three scary numbers." Well, maybe not solve, but at least come to recognize why these numbers are, in fact, so scary and begin to reflect on their implications. Further activities or discussion about the climate

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People's Climate March, NYC, September 2014.

crisis would build from a common recognition of the mathematical fact that we are on an unsustainable trajectory.

My friend and colleague Tim Swinehart, who teaches at Lincoln High School in Portland, Oregon, invited me into his economics class to teach a couple of "Three Scary Numbers" sessions with him.

I held up a copy of *Rolling Stone*. "Anyone familiar with this magazine?" Maybe a third of the students raised a hand. "I began reading *Rolling Stone* in 1968, when I was about your age. Last year, the magazine published an article that generated more interest, more likes, more shares, more Twitter mentions, than any article *Rolling Stone* had ever published. And here's the thing: The article is about just three numbers, three very scary numbers.

"So we're going to do an activity that we call the 'Mystery of the Three Scary Numbers.' And, basically, you have just two tasks: figure out what the three numbers are and why they're scary. Afterward, we'll talk about the meaning of these scary numbers and what we can do about them."

We distributed a question sheet to everyone, and each student also received a clue. There are 28 clues. In the clues, each of the three scary numbers was in 16-point bold type so students were sure to spot these "this is a big deal" numerals.

The handout asked questions like:

- Find someone who has one of the three "scary" numbers (in large, bold type). What is the number?
- List as many details as you can find out about this number (at least three).
- Find three other numbers about climate change. What is the number and why is it important?

Some of the clues stuck faithfully to describing something about one of the three scary numbers, for example:

> **Two degrees Celsius** *is about 3.6 degrees Fahrenheit. In 2009, 167 countries signed on to the Copenhagen Accord. These 167 countries are the biggest polluters in the world, responsible for 87 percent of all greenhouse gas emissions. The accord states that we cannot raise the Earth's temperature more than* **two degrees Celsius** *without risking planetary disaster. All 167 countries, including the United States, pledged: "We agree that deep cuts in global [greenhouse gas] emissions are required . . . so as to hold*

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> *the increase in global temperature below* **two degrees Celsius**."

Other clues focused on different numbers:

> *Over the past 30 years, permanent Arctic sea ice has shrunk to half its previous area and thickness. As it diminishes, global warming increases. This is due to several things, including release of the potent greenhouse gas methane trapped under nearby permafrost, and because ice reflects the sun's energy whereas oceans absorb it. Oil companies see the disappearance of Arctic ice as an opportunity to make more profit by drilling for more oil—which will create even more global warming. For example, Royal Dutch Shell has spent $4.5 billion preparing to drill in the Arctic. One of the world's leading environmentalists, David Suzuki, calls this "insane."*

One clue featured the "Keeling curve"—the graph that depicts the inexorable rise in atmospheric carbon dioxide that Charles David Keeling began measuring in 1958 at Mauna Loa in Hawaii. When Keeling first began his measurements there, he recorded 313 parts per million; in 2013, it passed 400 parts per million.

Obviously, the more one knows about basic climate science, the easier time one will have with this activity. When teacher (and *Rethinking Schools* editorial associate) Adam Sanchez did this activity with 9th graders across town at Madison High School, he realized that his students needed a bit more initial familiarity with the concept of greenhouse gases and the relationship between burning coal, oil, and gas and releasing carbon into the atmosphere.

I introduced the mixer by reminding students that each of them had a different clue and that each clue offered important information that would help them figure out the mystery of what makes these three numbers so scary. Tim and I encouraged the students not to wait until the very end to begin making sense of this, but to talk with one another about the big picture as they circulated throughout the class. The rules of the game were simple: Clues could only be shared verbally—no handing over clues to anyone—and conversations had to be one-on-one (to encourage maximum participation). Finally, this was a get-up-and-mingle activity, so no just hanging out at one's desk waiting for "callers" to arrive.

Students wasted no time: "I need a bold number! Who has a scary number?"

One student encountered 2,795 gigatons. "That's a lot," she said in a quiet voice.

"So what are these numbers saying?" another asked.

"The numbers are important because we only have a couple of years."

"Well, we're already in trouble."

Toward the end of the activity, I watched a student cock her head and ask no one in particular: "So is this saying that we're going to die?"

Students were fully engaged throughout the half hour or so of the clue hunt. When it felt that conversations were winding down, Tim and I asked everyone to form a large circle and continue to discuss the final assignment sheet questions, which asked: Why are these numbers important? What actions should be taken?

We wanted students to feel free to share whatever occurred to them, and so did not overdirect the conversation. After this activity, students would continue to study the climate crisis with Tim and connect real human beings with these numbers. For now, we simply wanted to hear how they made sense of this new information.

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"These are insane numbers," Matt said. He mentioned the potential species extinction and the rising seas. Cory pointed out that, at current rates, "We're on track to hit two degrees quickly, it's not some far-off endpoint"—which was exactly the sensibility we hoped students would draw from the activity: Climate change is not about the future, it's about now. Michele was struck by the possibility of widespread desertification. Even James, a confirmed libertarian, argued that there was no reason to think that the market would somehow on its own be moved by these numbers: "I've never had it quantified like this, or had such a grim picture painted. . . . This has to be a shift that *we* make."

Not surprisingly, when it came to what "we" should do, students were all over the map. There was the student offering a techno-fix: "NASA is thinking about Mars." Sonia and many other students thought as responsible consumers: We should "use more local products and make permanent changes, not just 'I rode the bus one day'"; we should recycle and compost more; we should cut down on meat and travel; we should walk more; we should stop wasting water. And there were students whose "we" extended to what the government should do: start taxing coal, find alternative sources of energy; "the government should lead a 'war on climate change.'" Interestingly, the more students talked, the more distant their solutions became. When a couple of students began criticizing the Chinese government for its alleged climate crimes, I pointed out how the conversation had drifted from changes that were more in our power to influence to those that weren't.

For homework, we gave the class an abbreviated version of McKibben's "Global Warming's Terrifying New Math" article to reinforce the information they encountered in the mystery activity. McKibben does not write with high school readers in mind, but having encountered much of his argument in the mystery, we knew students would find it more accessible. McKibben's strategic punch line is the need to launch a campaign to demand that colleges, retirement systems, and cities divest from holdings in fossil fuel companies—borrowing from the important divestment activism of the anti-apartheid movement during the 1980s.

Given the terrifying math McKibben presents, Tim and I did not seek to suggest that there was a single "do this" answer. We wanted to raise the question of what we should do—not answer it. So, in addition to McKibben's divestment proposal, we introduced students to a *Huffington Post* critique by Christian Parenti, author of *Tropic of Chaos*, who argues that attacking fossil fuels through the stock market is misguided for a host of reasons and that we need to focus our

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energies on "the important things government can do, right now, if pressured by grassroots action."

We weren't looking for students to take sides. But we did want them to recognize the urgency of activism. Maria wrote: "The three scary numbers are very scary. What scares me the most is how well this information is known without any action."

Of course, people are acting, and more study would introduce students to a range of strategies and actions. For now, we were content simply to have students "do the math," in the words of the 350.org campaign that built from McKibben's *Rolling Stone* article. Do the math, and recognize the profound immorality of leaving the future of life on Earth to the profit-driven choices of the fossil fuel industry. As Matt wrote, "This made me want to change how this country functions. We are past the time of oil and coal."

Student Handouts

- Three Scary Numbers Clues
- Three Scary Numbers Questions
- "Keeling Curve" Graph

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Clues to accompany "The Mystery of the Three Scary Numbers"

Note to teacher: Attach the "Keeling Curve" Mauna Loa Observatory graph to starred clue.

Two degrees Celsius is about 3.6 degrees Fahrenheit. In 2009, 167 countries signed on to the Copenhagen Accord. These 167 countries are the biggest polluters in the world, responsible for 87 percent of all greenhouse gas emissions. The accord states that we cannot raise the Earth's temperature more than **two degrees Celsius** without risking planetary disaster. All 167 countries, including the United States, pledged that: "We agree that deep cuts in global [greenhouse gas] emissions are required . . . so as to hold the increase in global temperature below **2 degrees Celsius**."

Former NASA scientist James Hansen, the world's most prominent climatologist, believes that the Copenhagen target of keeping global warming under **two degrees Celsius** is not good enough. He says: "The target that has been talked about in international negotiations for two degrees of warming is actually a prescription for long-term disaster."

At the 2009 Copenhagen climate summit, a spokesman for small island nations warned that many island nations would not survive if the planet warmed by **two degrees Celsius**: "Some countries will flat-out disappear."

Many scientists believe that allowing the Earth to warm by **two degrees Celsius** could be a disaster. "Any number much above one degree involves a gamble," writes MIT's Kerry Emanuel, a leading authority on hurricanes, "and the odds become less and less favorable as the temperature goes up." Thomas Lovejoy, once the World Bank's chief biodiversity advisor, says this: "If we're seeing what we're seeing today at 0.8 degrees Celsius [for example, Superstorm Sandy], two degrees is simply too much."

To prevent a planetary catastrophe—rising sea levels, melting glaciers, disrupted food production, a scarcity of freshwater, more violent and deadly storms, more frequent droughts, increased warfare over scarce resources, etc.—the climate may not be allowed to rise more than **two degrees Celsius**. This is the *only* number that the vast majority of the world's nations have agreed to about the climate.

Scientists estimate that humans can pour about **565** more **gigatons** of carbon dioxide into the atmosphere by 2050 and still have some hope of staying below two degrees Celsius. [A gigaton is 1 billion tons—that is, one thousand million tons.] The **565-gigaton** figure was derived from one of the most sophisticated computer simulation models that have been built by climate scientists around the world over the past few decades.

Computer models calculate that even if we stopped all CO_2 (carbon dioxide) releases now, the temperature would likely still rise another 0.8 degrees Celsius, as previously released carbon continues to overheat the atmosphere. That means we're already three-quarters of the way to the **two-degree Celsius** limit—because we've already heated the planet 0.8 degrees Celsius.

In late May 2012, the International Energy Agency published its latest figures of how much carbon dioxide is being released into the atmosphere: CO_2 emissions in 2011 were 31.6 gigatons, up 3.2 percent from emissions the year before. [A gigaton is 1 billion tons—that is, one thousand million tons.] Study after study predicts that carbon emissions will keep growing by roughly 3 percent a year—and at that rate, we'll blow through our **565-gigaton** allowance in 16 years, around the time today's preschoolers will be graduating from high school.

Fossil fuel companies—and countries like Venezuela or Kuwait that act like fossil fuel companies—already have a huge amount of coal, oil, and natural gas in the ground that they own or have access to. The amount of these "reserves"—when burned for energy—would release an estimated **2,795 gigatons** of carbon dioxide into the atmosphere. [A gigaton is 1 billion tons—that is, one thousand million tons.] That is the number calculated by the Carbon Tracker Initiative, a team of London financial analysts and environmentalists.

2,795 gigatons is higher than **565 gigatons**. *Five* times higher.

If just two giant oil companies, Russia's Lukoil and the U.S. corporation ExxonMobil, burned all the fossil fuel that they own, ***each*** would release more than 40 gigatons of carbon dioxide into the atmosphere.

Energy corporations and big energy producing countries like Saudi Arabia and Kuwait, have estimated reserves of coal, oil, and gas that—if burned for energy—would release **2,795 gigatons** of carbon emissions. John Fullerton, a former managing director at JP Morgan who now runs the Capital Institute, calculates that at today's market value, the **2,795 gigatons** of carbon emissions are worth about $27 trillion—that's 27 thousand billion dollars: $27,000,000,000,000.

Ken Salazar, President Obama's former secretary of the interior, opened up a huge area of Wyoming for coal extraction. The total basin contains 67.5 gigatons worth of carbon, if all that coal is burned for energy.

According to NOAA, the National Oceanic and Atmospheric Administration, the average temperature in the lower 48 United States in 2012 was the hottest ever recorded. It was 55.3 degrees, one degree above the previous record and 3.2 degrees higher than the 20th-century average, scientists at the NOAA said.

According to James Hansen, former climatologist with NASA, the U.S. National Aeronautics and Space Administration, the "tar sands" of Alberta, Canada, contain as much as 240 gigatons of carbon—which, if burned, would take up almost half of the available atmospheric space if we take the **565 gigatons of carbon** limit seriously. The company, TransCanada, has proposed that it build a pipeline from Canada through North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas to export oil around the world.

"Lots of companies do rotten things in the course of their business—pay terrible wages, make people work in sweatshops—and we pressure them to change those practices," according to writer and journalist Naomi Klein. "But **these [three] numbers** make clear that with the fossil fuel industry [coal, oil, and natural gas], wrecking the planet is their business model. It's what they do."

If the oil reserves of just six companies—Exxon, BP, Chevron, ConocoPhillips, Shell, and the Russian firm Gazprom—were burned for energy, this would use up more than a quarter of the **565 gigatons of carbon** limit that is needed to keep the planet from warming more than **two degrees Celsius.** (Each of these companies continues to search for more oil.)

In early March 2012, Exxon CEO Rex Tillerson told Wall Street analysts that the company plans to spend $37 billion a year through 2016 (about $100 million *a day*) searching for ***more*** oil and gas.

Two-thirds of wheat grown in poor countries, and almost a quarter of the wheat grown in rich countries—nearly half the world's total crop—is at risk from global warming. In order to keep up with the world's growing population, global wheat production needs to rise 50 percent.

Around the world, the Earth's average temperature has risen more than one degree Fahrenheit (0.8 degrees Celsius) since 1880, and about twice that in parts of the Arctic. That may not sound like much, but we're already starting to see more intense rainstorms; severe droughts and heat waves are becoming more frequent. Rising seas are damaging homes near the water. Some populations of animals are starting to die out.

There is overwhelming evidence that our climate is warming due to pollution from human activities. That's the conclusion reached by 97 percent of climate scientists and every major national academy of science in the world. When we burn dirty fossil fuels like oil and coal, and when we cut down forests that store carbon, we pollute our atmosphere with greenhouse gases and warm our planet. This is not controversial among scientists.

*This graph shows the increase over time of the carbon dioxide concentration in the atmosphere. Every major scientific organization in the world, and 97 percent of climate scientists, attribute this increase to human causes—mostly burning fossil fuels like coal, oil, and natural gas. The higher the concentration of carbon dioxide in the atmosphere, the warmer the planet becomes. [See attached "Keeling Curve" graph.]

Since 1980, permanent Arctic sea ice has shrunk to half its previous area and thickness. As it diminishes, global warming increases. This is due to several things, including release of the potent greenhouse gas methane trapped under nearby permafrost, and because ice reflects the sun's energy whereas oceans absorb it. Oil companies see the disappearance of Arctic ice as an opportunity to make more profit by drilling for more oil—which will create even more global warming. For example, Royal Dutch Shell has spent $4.5 billion preparing to drill in the Arctic. One of the world's leading environmentalists, David Suzuki, calls this "insane."

Because of global warming, the world's glaciers are melting. All scientific organizations and the vast majority of climate scientists (97 percent) believe that global warming is caused by human activity. Here is how *National Geographic* magazine describes it: "Everywhere on Earth ice is changing. The famed snows of Kilimanjaro have melted more than 80 percent since 1912. Glaciers in the Garhwal Himalaya in India are retreating so fast that researchers believe that most central and eastern Himalayan glaciers could virtually disappear by 2035. Arctic sea ice has thinned significantly over the past half century, and its extent has declined by about 10 percent in the past 30 years. NASA's repeated laser altimeter readings show the edges of Greenland's ice sheet shrinking. Spring freshwater ice breakup in the Northern Hemisphere now occurs nine days earlier than it did 150 years ago, and autumn freeze-up 10 days later. Thawing permafrost has caused the ground to subside more than 15 feet (4.6 meters) in parts of Alaska. From the Arctic to Peru, from Switzerland to the equatorial glaciers of Man Jaya in Indonesia, massive ice fields, monstrous glaciers, and sea ice are disappearing, fast." The results include rising sea levels and putting at risk the freshwater supply of billions of people.

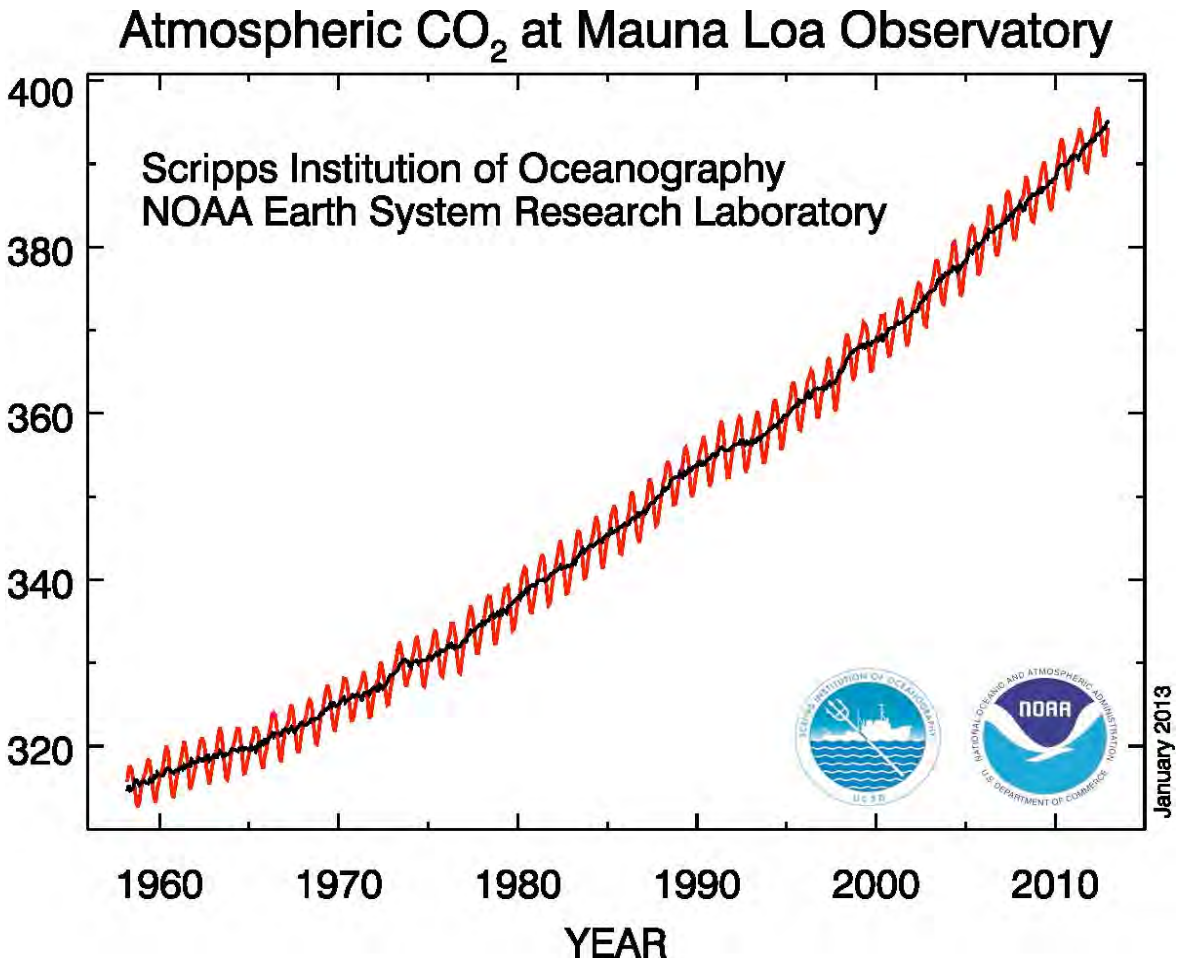
The U.S. Department of Defense has said that global warming will create more instability and warfare around the world. Global warming is already creating more violent storms, drought, lack of food and water, mass migration, and the spread of disease. All these will create tension between people around the world and lead to increased military conflict. According to the *New York Times*, Secretary of State John Kerry (then a U.S. senator) has argued that the continuing conflict in southern Sudan, which has killed and displaced *tens of thousands* of people, is a result of drought and expansion of deserts in the north. "That is going to be repeated many times over and on a much larger scale," he said. Global warming is killing people in many different ways.

According to an estimate of the Congressional Budget Office in 2007, the top 20 percent of the wealthiest people in the country are responsible for consumption that releases three times the carbon dioxide—the main greenhouse gas—as the bottom 20 percent of the population.

According to climate scientists at Oxford University in Great Britain, humanity could probably keep the Earth's average temperature rise below **two degrees Celsius** in the future if we cut carbon emissions every year by 2.4 percent. For true safety, scientists estimate that humanity would need to cut carbon emissions by twice that rate.

As of 2014, there were three proposals to export coal through the Columbia River Gorge to Asia. The Sightline Institute, an environmental think tank in Seattle, estimated that if just *two* of these coal export terminal proposals were approved—in Longview and Bellingham, Washington—it would add 199 million tons of carbon dioxide to the atmosphere, every single year. And this includes just the actual burning of the coal: not the "mining, processing, rail shipping, storing, maritime shipping, constructing new port or rail facilities, or any other related activities." Over 10 years, the coal burned in Asia from the coal exports would be equal to two gigatons of carbon dioxide. [A gigaton is a billion tons.]

"Keeling Curve"



The Mystery of the Three Scary Numbers

1. Find someone who has one of the three numbers (in large **boldface**). What is the number?

2. What are as many details as you can find out about this number? Try to find at least three.

3. Find someone who has a different one of the three numbers (in large **boldface**). What is the number?

4. What are as many details as you can find out about this second number? Try to find at least three.

5. Find someone who has a different one of the three numbers (in large **boldface**). What is the number?

6. What are as many details as you can find out about this final number? Try to find at least three.

7. Find three other numbers that are not directly connected to one of the Three Scary Numbers. What is each number and why is it important?

8. Once you have finished questions 1 through 7, find someone who has also finished and discuss why these numbers are important, and what actions should be taken. Write your thoughts here: