

A Commuter's Guide to Climate Change:

knowledge for a guilt-free future

Soheil Sassani

03.20.2018

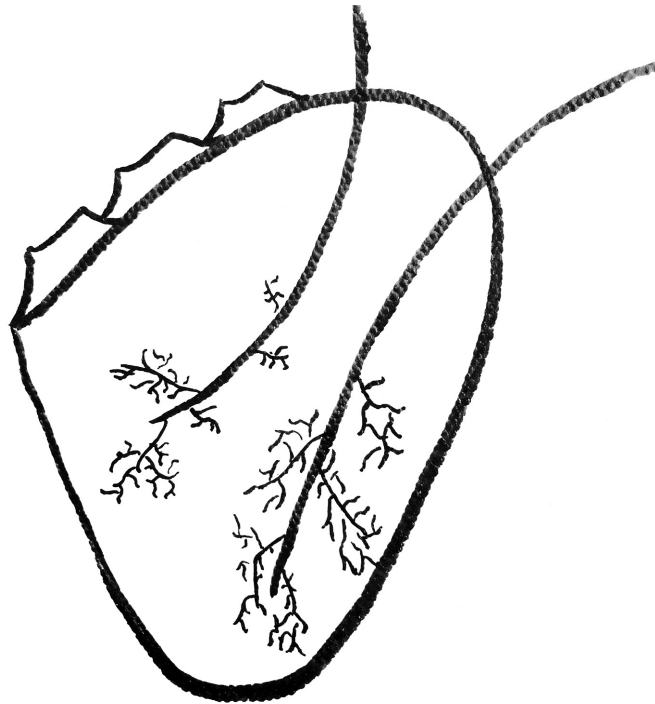


Table of Contents

ABSTRACT	3
1. Overview	4
1.1 The Commute	4
2. A Brief History of What We Breathe	5
3. Things At Work	8
3.1 Greenhouse Gases	10
3.2 A Brief History of Hot and Cold Global Temperatures	12
4. Things We Do	15
4.1 Consequences of a Warming Globe	20
4.2 Things to Do: A Conclusion	21
Sources	24

ABSTRACT

A Commuter's Guide to Climate Change: knowledge for a guilt-free future, is a literature-based research paper about human-induced climate change. An urgent topic, climate change has seeped into our social and political frameworks in such a way that it has created two sides: climate change believers and deniers. The reality of the matter, however, suggests that regardless of ideology or political views, due to our one hundred years of industrialization, our planet's chemistry as well as its function is fast changing. Rising atmospheric greenhouse concentrations causing a rise in surface temperatures has already presented us with snippets of what may lie ahead. While rising ocean levels is one outcome, deserts expanding, carbon dioxide concentration rising to poisonous levels, and mass extinctions are only a few other consequences that'll result from our pollution. The subject of climate change is complex and correlated with Earth's atmosphere-ocean-biosphere framework functions. This very reason may cause many who conceive the subject as too complex to simply deny it. To challenge this, A Commuter's Guide to Climate Change: knowledge for a guilt-free future, aims to combine history with science in order to create a lucid arrangement of events that have led to our current state. Furthermore the paper identifies our world's energy use and trends, pinpoints the facilitators of atmospheric pollution and ends by providing solutions to slow down the rate at which we are negatively impacting our planet.

1. Overview

1.1 The Commute

I live in Melbourne, Australia. Four days a week, I make the twenty-minute journey to work by train. I get off at Flinders St station where, upon setting foot on its platform, the soles of my feet receive the morse code of the human stamp.

Once I manage to maneuver my shoulders and put myself in a favorable position among those moving toward the exit, I can finally slip into the routine. Outside of the station, the cross section between Flinders and Elizabeth St. resembles a large, square pond. When the pedestrian light turns green, the entire forest crosses to drink.

Past the intersection, along the one-block journey from the station to the kebab shop, the 24/7 doughnut shop, the hamburger joint next to it, the Starbucks, the man playing the didgeridoo in front of Starbucks, the super market, the money exchange place, the liquor store, the KFC and the ice addicts sitting in front of it, the underground nude cinema and finally the 24/7 kebab shop, buzz with movement. This is my short city commute twice a day, four days a week.

The shop I work at is a tiny square with three kebab machines that turn nonstop.

Stacked on one is 10 kilos of marinated chicken breast and on the other, six lamb shoulders. The third, bears the weight of chicken and lamb combined.

Working at a kebab shop is enduring heat and breathing animal fat vapor. It's a place of service to those who have the luxury to ask "why are we here?" and those who find the answer in a generous coin toss.

What does all of this have to do with climate change?

No, it certainly is not about the coffee cup dragging along the side of the road, or the plastic bags, so full of wind, flying from one high-rise to another.

In the city, what we breathe and touch is no longer the flesh of our planet so much as it is our own reflection.

Climate change is a complex subject. It is at times intimidating and political – and ideological. And while we try to make sense of it, we are also challenged with the immediate need to either face the horrible consequences or take action. As minutes tick by, we contemplate.

2. A Brief History of What We Breathe

Our planet is roughly 4.5 billion years old. ^[1] Throughout its vast history, the Earth has experienced extraordinary climates – from it having tropical conditions near the poles to being completely covered in ice from pole to pole, a phenomenon referred to as Snowball Earth.

Water played a big role in shaping our atmosphere. Water's story begins a trillionth of a trillionth of a second after the Big Bang when copious amounts of hot particles contained within the powerful swelling of space, formed simple nuclei. ^[2]

By a billion years after the Big Bang, space was twinkling with stars. At their core, stars are nuclear furnaces that can fuse Big Bang's simple nuclei with more complex elements such as hydrogen – the most abundant element in the universe – carbon and oxygen. When a star dies and goes supernova, the explosion discharges these more complex building blocks out into space. ^[2]

For billions of years, the birth and death of stars added new seasoning to an ever-changing, expanding universe. By nine billion years after the Big Bang, the swirling

dust particles that would shape our solar system was abundant with water molecules.^[2]

Earth's early atmosphere shaped during the first billion years of its formation. The emission of carbon dioxide (CO₂), water vapor, ammonia, and methane from Earth's molten core, surfaced by volcanic activity, were the first ingredients of this early, acidic atmosphere. When the water vapor condensed and collapsed back to the surface of the planet as rain, it cooled surface temperatures and provided young Earth with its first oceans. In addition, theories strongly suggest that a substantial amount of water also arrived by asteroids and comets – leftover materials from the formation of our solar system – bombarding the planet over millions of years.^[2]

Life on earth is approximately 3.5 billion years old. The earliest forms of life consisted of organisms known as prokaryotes that were able to draw energy from their environment or the sun. Bacteria and blue-green algae are among such organisms.^[1]

As basic life formed on our planet, photosynthesis – a process by which carbon dioxide is absorbed by organisms and turned into sugars, chlorophyll and enzymes to produce oxygen as waste – contributed to a rise in oxygen levels in the earth's atmosphere. Other big factors in rising oxygen levels were the absorption of CO₂ by sedimentary rocks and greenhouse gases dissolving in oceans. Today, the ocean continues this function in cold-water regions, the area of which is shrinking.^[3]

Rising oxygen levels paved the way for more complex life forms to roam a borderless Earth.

Our planet has withstood five mass extinctions in its history, dating as far back as 439 million years before present (BP).^[1] For a point of scale, the third mass extinction

called the Permian extinction or the “Great Dying,” occurred 251 million years BP and it wiped out 96% of earth’s species. ^[4] Due to the ocean floor recycling itself every 200 million years, much of the evidence for why the Great Dying occurred has been lost. However, theories range from asteroid impacts to increased volcanic activity. In either scenario, both events would have exposed the surface of our planet to material from its core, filling the atmosphere with CO₂, methane and other greenhouse gases.

According to Michael B. McElroy from Harvard University Center for the Environment, “There can be little doubt that large-scale environmental change played a major role in these epochal extinction events. On the flip side, elimination of maladjusted species contributed undoubtedly to opening up opportunities for new species to step in and take their place.” ^[1]

While we may never find the exact reasons for the Great Dying, what we do know for certain is that all species today evolved from the 4% that survived. ^[4]

Many factors contribute to the persistence of life on our planet, one of which is the way tectonic plates – landmasses that shape our continents – float and adjust themselves. ^[1] This, combined with Earth’s carbon recycling mechanism make up the foundations for a nutrient-rich planet.

This is how it works: when species die, parts of their bodies float to the bottom of the ocean and are buried in the sediment. However, without a means for this nutrient-rich material to resurface, Earth would be a dormant planet today. ^[1]

In the event of tectonic plates colliding, one of two events can occur: uplift or subduct. Uplift results in carbon being pushed to the surface in the form of rocks as

mountains. This carbon can then be lifted off the rocks by wind and mixed into our atmosphere.^[1]

In the event of plates subducting, sediment is pushed down toward the mantle of the Earth, is melted and returned back to the ocean-biosphere-atmosphere system through volcanic or hot spring activity.^[1]

Tectonic shifts as well as our planet's recycling function has over millennia provided our planet with landmasses, varying atmospheres and when in balance, life. Where the balance was tipped, extinctions ensued.

3. Things At Work

Our planet receives all of its energy from the Sun. Every second of every day, Earth receives approximately 304 Watts of shortwave radiation per its square meter (W/m^2).^[6] The sun emits shortwave radiation because it is very hot and has a lot of energy. Therefore, much of that radiation is intercepted by earth in the form of ultraviolet (UV) and visible light.^[5]

Once Earth's atmosphere, clouds and surface absorb what they will from the incoming solar radiation, the energy is re-emitted back into space. This is how our planet cools itself. However, because our planet is much colder than the Sun, the energy it emits into space is in the form of long wave radiation.^[1]

In radiative equilibrium, the energy received by our planet must equal to the energy returned to space. In this state, Earth reflects off 30% of the solar energy, while absorbing 70% of it.^[8] The amount reflected and absorbed depends on atmospheric gases and surface composition of the earth. Ice and snow for example are able to reflect more of this energy than forests and deserts. The albedo (reflectivity) of fresh

snow, for example, can be as high as 85%, while forests average between 5%-10% and desert regions 25%. [1]

As the Earth cools, it emits less long wave radiation. However, since we are constantly receiving energy from the sun, this give and take is continuous. Diagram 3.1 is a snapshot of the earth's energy budget in an equilibrium state.

As the representation suggests, every component of our planetary system is a functional force driving this balance. Where matters get complicated however, is in the contrast between short and long wave radiations.

Whereas short wave radiation is capable of passing through water vapor and other greenhouse gases present in our atmosphere, energy emitted back from the Earth, has a tougher time fleeing those same elements. [1]

While in an equilibrium, energy in equals energy out, if more water vapor and other greenhouse gases are added to our atmosphere more heat is trapped, forcing a rise in the land and ocean surface temperatures.

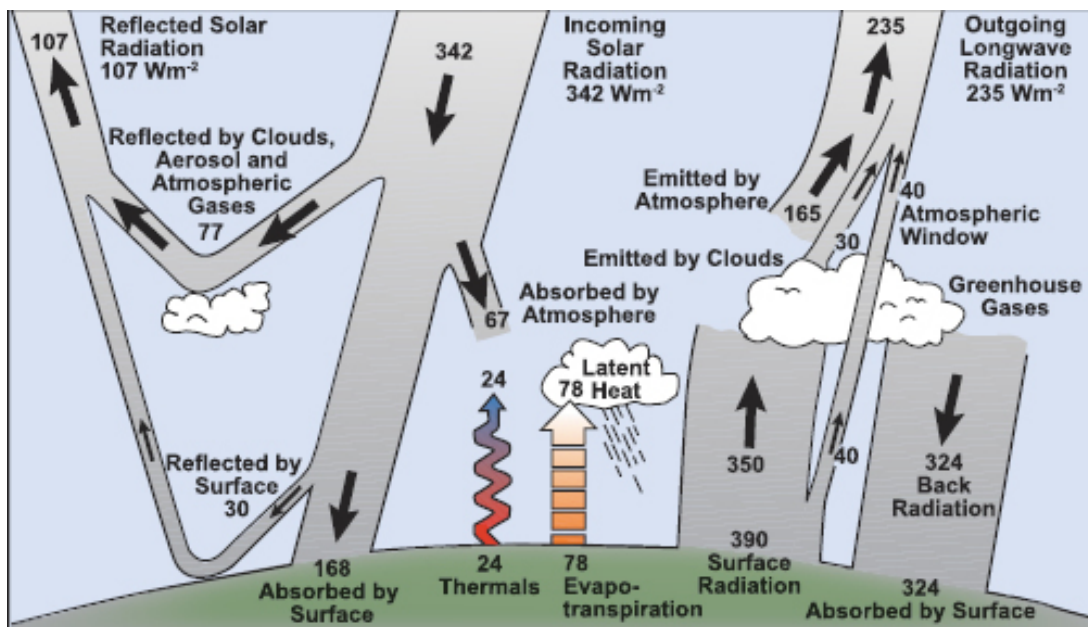


Diagram 3.1 – Earth's Energy Budget – IPCC, 2007

3.1 Greenhouse Gases

Our atmosphere is not an isolated system hovering above the surface of the earth.

Rather, as we've observed the role of the atmosphere in balancing our planet's energy budget, it is certain that without a functioning atmosphere, conditions for life can change from favorable to disadvantageous.

Earth's atmosphere is composed of greenhouse gases that insulate the surface of our planet from the chill of the space beyond. The most abundant of these gasses and amplifier of global warming is water vapor. ^[7]

Historically, the amount of water vapor present in our atmosphere correlated with our planet's equilibrium. However, in the past one hundred years or so, as our emission of greenhouse gases have increased surface temperatures, its subsequent result has been increased atmospheric humidity. ^[7] Reasons for the frequent and violent weather patterns such as hurricanes in recent years are due to this increase in atmospheric water vapor.

This trend, however, is continuing. Today, the concentration of CO₂ in the atmosphere is higher than it has ever been in the past 800,000 years, and it will continue to grow to levels not experienced since dinosaurs roamed our planet. To illustrate the damage done in a snippet of our industrial history, between 1995 and 2007, our combustion of coal, oil and natural gas added 89.3 billion tons of CO₂ to the atmosphere. That is 13 tons for every man, woman and child on the planet. ^[1]

According to Michael B. McElroy in *Energy and Climate: Vision For the Future*, "CO₂ is not the only climate-impacting greenhouse gas we have to worry about.

Concentrations of methane (CH₄) and nitrous oxide (N₂O), even more potent

greenhouse agents than CO₂, are also at record high levels and likely to increase further in the future.”

In short, we are unleashing energy captured by our planet back into our atmosphere-ocean-biosphere systems at a rate that competes with Earth’s natural forces.

Throughout the planet’s existence, global temperatures have fluctuated, leading many skeptics of climate change to believe our planet is going through a warming phase.

However, a brief history of earth’s climate may shed light on just how powerful our actions in the past century have been to disrupt the natural progression of things.

Diagram 3.2 indicates the increase in global average surface temperatures from 1880 to present.

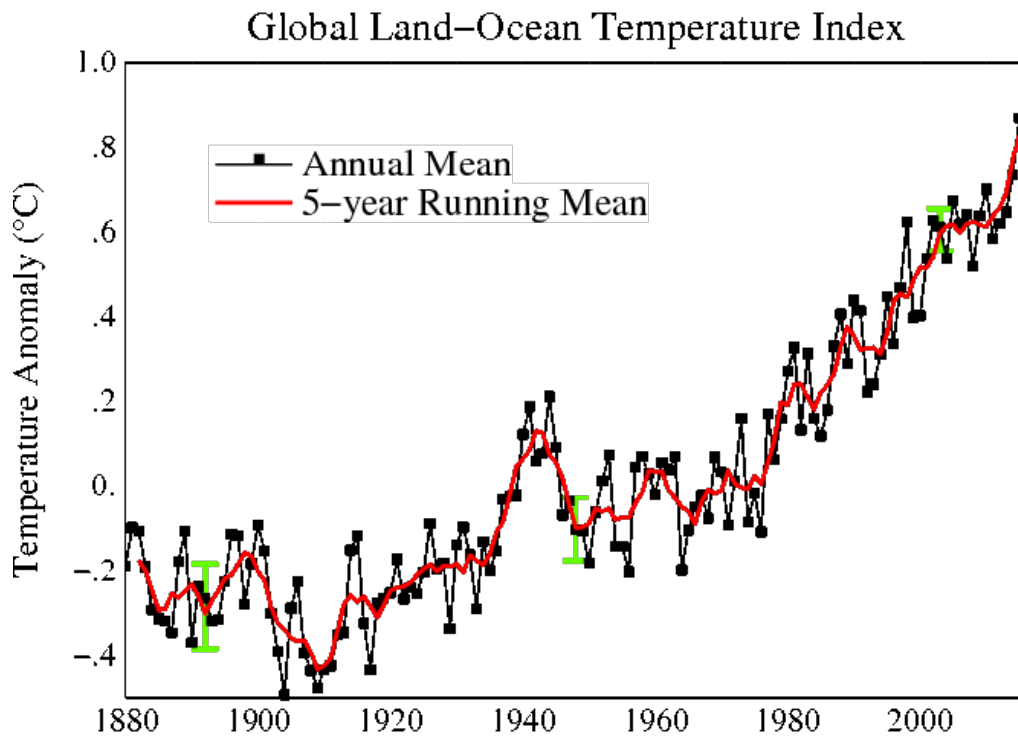


Diagram 3.2 – Global Temperature Index source – https://data.giss.nasa.gov/gistemp/graphs_v3/

3.2 A Brief History of Hot and Cold Global Temperatures

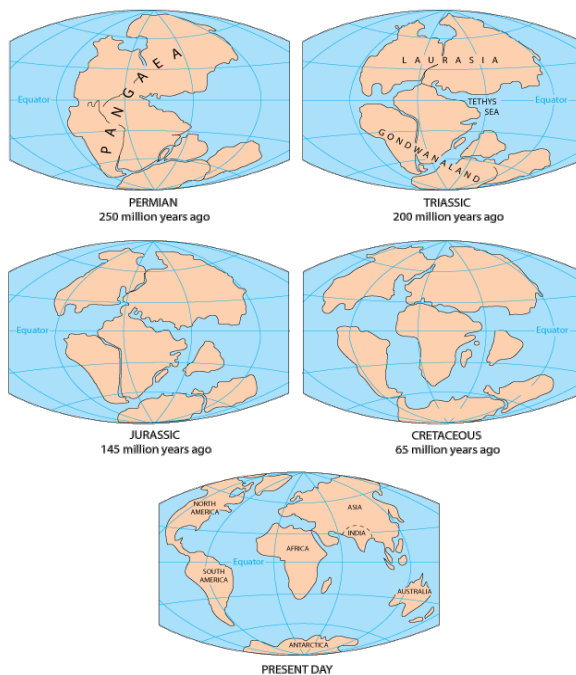
Throughout its entire climatic record, Earth has fluctuated between two systems: greenhouse and icehouse earth, each lasting for millions of years.

As the names suggest, greenhouse earth refers to periods of warm global climates while icehouse earth refers to the occurrence of ice ages.

Between 145 to 66 million years BP, during the Cretaceous period, when dinosaurs roamed the planet, earth was warm and had an atmosphere more abundant with carbon dioxide. These warm conditions persisted to roughly 5 million years BP, during which time forest-tundra occupied regions of Greenland. These were periods in which the Earth did not have ice sheets at its poles; when palm trees grew in Central Asia and alligators lived as far north as Elsmere Island. ^[1]

During early Cretaceous period, Pangaea – a supercontinent from which all our current continents extracted – was still intact. By mid-Cretaceous, however, it had broken into several smaller continents.

Diagram 3.3 – Pangaea – <https://pubs.usgs.gov/gip/dynamic/historical.html>



As a result of tectonic movements opening gaps in Earth's crust and releasing energy from our planet's core, the atmosphere filled with greenhouse gases and warmed the planet. ^[22]

Other reasons for earth's warming during the greenhouse earth period

may also have been due to the Hadley circulation – a global scale, tropical atmospheric system that dominates climatic conditions in tropics today. At the time, it would have extended further north toward the poles. ^[1]

Through time, however, geologic changes as well as adjustments to the Earth’s orbital framework that impacted the tilt of the planet’s axis, significantly changed global weather patterns. ^[1]

With these modifications, Earth in the past several million years has more often been cold than warm to the point where in the past 800,000 years, there have been eight ice ages, each lasting on average for 100,000 years. The last ice age reached its maximum nearly 20,000 years BP, during which time so much ice was accumulated that ocean levels dropped by roughly 120 meters. ^[10]

To put things into human perspective, our species’ migration out of Africa began roughly 60,000 BP. By 20,000 BP, a small group of hunters entered the East Asia Arctic. “At this time the great ice sheets covering the far north had literally sucked up much of the Earth’s moisture in their vast expanses of white wasteland, dropping sea levels by more than 300 feet. This exposed a land bridge that connected the Old World to the New, joining Asia to the Americas.” ^[21] Such were the conditions that allowed man to set foot in previously undiscovered territories.

In *Energy and Climate: Vision for the Future*, Professor McElroy suggests that the climate’s recovery after the previous ice age was intermittent.

In about 15,000 BP, a period of warming occurred both in Greenland and the tropics, but in 13,000 to roughly 11,700 BC warm conditions were abruptly followed by a climate reversal referred to as “Little Ice Age”. ^[1]

Since then, the Earth has entered an era referred to as the Holocene Epoch – a period of relative warm conditions between ice ages – a gap. ^[11]

It is during this era that mankind has settled, learned to domesticate animals, farm and invent for civilizations to bloom. However, even within the warm conditions of the Holocene Epoch, due to the wobbly nature of the Earth's axis, the planet and its inhabitants have experienced big shifts in climate. ^[1]

Since the start of this warm era, global temperatures gradually fell, but moderate climates returned again between 1068 BP and 768 BP (AD 950 and 1250) in what is called the Medieval Warm Period. ^[1] During this episode Vikings took advantage of the melting ice sheets, became master sailors and rose to prominence. ^[12] However, this episode, too, was temporary and was followed by much cooler temperatures between 518 BP and 168 BP (AD 1500 and 1850) termed the “Little Ice Age”. ^[1]

According to Professor McElroy, “The longer record of past climates and the role imputed to change in the Earth's orbital properties suggest that by the time of the Little Ice Age the Earth might have been well on its way to the next Big Ice Age.”

We stopped it. Since 1850, a quest for industrialization, made possible by burning of fossil fuels, has warmed our planet to an extent as to prevent it from entering the next ice age. ^[1] But how far have we gone?

In a study published in 2016, Scientists at Potsdam Institute for Climate Impact Research suggested that human induced climate change has gone too far. The study notes that the addition of CO₂ to our atmosphere is cause for the skipping of a glacial cycle. According to the scientists, current levels of CO₂ in the atmosphere are sufficient to push back the next ice age by 50,000 years. The research further predicts

that “moderate future anthropogenic CO₂ emissions of 1000 to 1500 Gigatons of Carbon are bound to postpone the next ice age by at least 100,000 years.”^[13]

In summary, within one hundred years of industrialization, humans have changed the fate of our planet for a very long time to come. While this may have saved us from an ice age, the continued warming of our planet will have catastrophic effects never before experienced by our species. Remember, humans came onto the scene during an icehouse earth.

4. Things We Do

In 1850, the planet on the cusp of the industrial revolution had a population of 1.2 billion people. In 2018, this figure has risen by over 500% to 7.6 billion individuals.^[23] Furthermore, the United Nations estimates our numbers to grow to 9.7 billion by 2050.^[24]

A growing population equals more energy needed to meet demands. To put it in perspective, in 2011, China with a population of 1.3 billion, was responsible for 49.3% of coal consumption worldwide. But it’s not just one country. It’s the entire world acting as one unit.^[1]

According to British Petroleum’s 2017 Statistical Review of World Energy, global energy consumption last year was 13.27 billion tons oil equivalent.

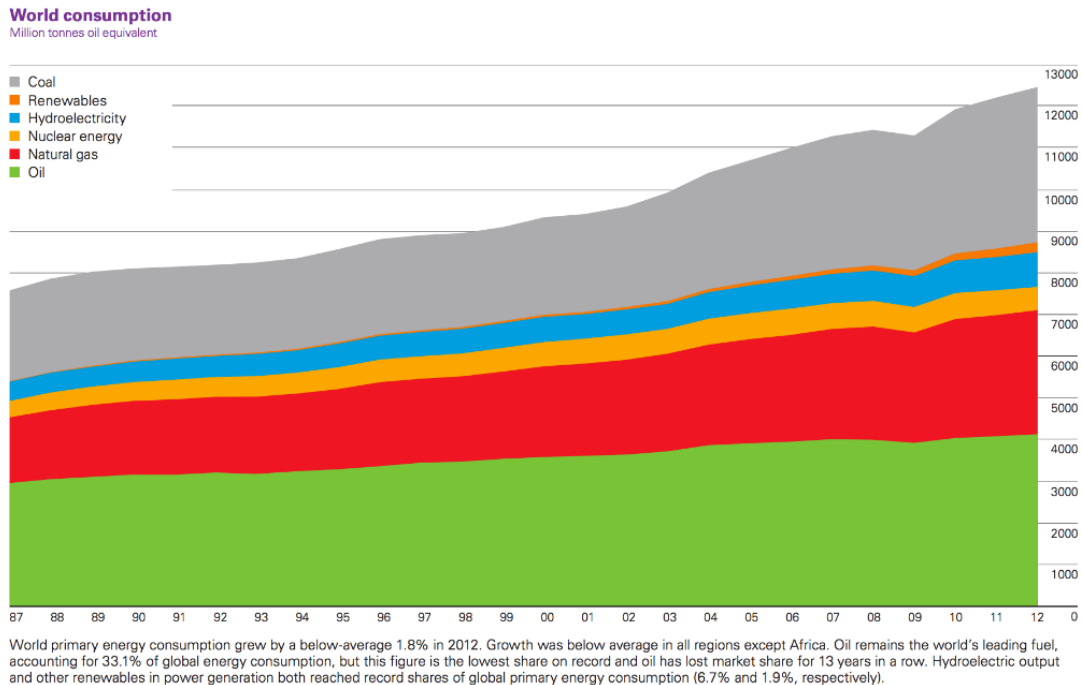


Diagram 4.1 – World Energy Consumption – <https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html>

Diagram 4.1 breaks down the production of this energy by fuel type. As figures suggest, the two primary sources for producing energy are coal and oil, contributing to the emission of 33.4 billion tons of carbon dioxide in 2016. ^[14]

Diagram 4.2 digs further in and breaks down greenhouse emissions by economic sector.

As production of electricity is the largest contributor of greenhouse emissions, the 2017 report released by British Petroleum ranks five regions as top users and producers of electricity: China (6142 terawatts*), European Union (5373 Terawatts), United States (4350 terawatts), India (1400 terawatts) and Russian Federation (1087 terawatts). ^[14]

Appropriately, the 2016 world ranking of countries with the most CO₂ emissions are as follows: China (10151 tons of CO₂), United States (5312 tons of CO₂), European

Union (3499 tons of CO₂), India (2431 tons of CO₂), and Russian Federation (1635 tons of CO₂).^[15]

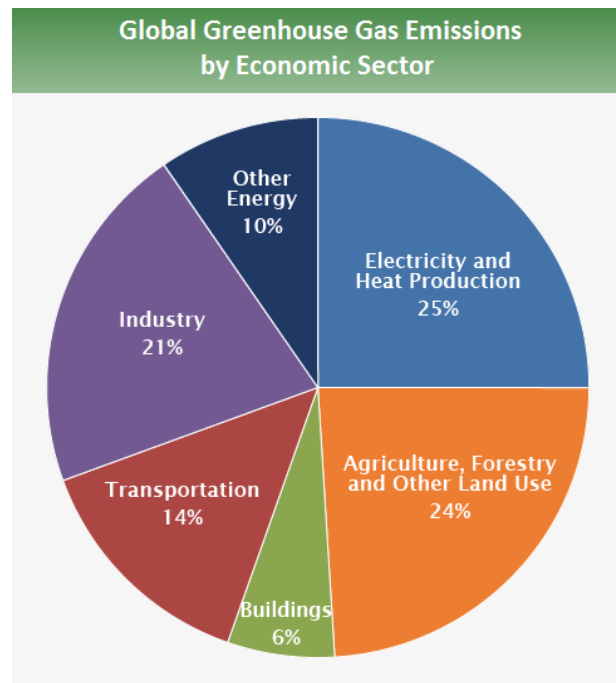


Diagram 4.2 – Global Greenhouse Gas Emissions – <https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data>

* Terawatt is a unit of power equal to 10¹² watts.

Carbon dioxide takes roughly one year to extend throughout the Earth's atmosphere.

^[25] Therefore one country's pollution is responsible for the entire globe's. For a visual of global trends in atmospheric carbon dioxide click on the following link:

<https://www.esrl.noaa.gov/gmd/ccgg/trends/ff.html>

Next to transportation and electricity, a growing population also needs space to live.

Cities expanding their reach out toward rural landscapes has one obvious trade off: loss of plant life.

Home to millions of species, Earth's flora-rich landscapes play a major role in the carbon cycle of the planet. Photosynthesis, the power behind increased oxygen levels

in Earth's early atmosphere, is still as vital a force in absorbing carbon dioxide from the atmosphere. When a tree is cut down and burnt or left to rot, not only does its carbon absorption cease, but its stored carbon is also released into the atmosphere as CO₂.^[26]

According to the Environmental Defense Fund (EDF), deforestation of tropical forests contributes to 20% of annual global greenhouse emissions.^[18] And that's only the tropical forests.

Data identifying countries with highest deforestation rates between 2001-2016 are as follow: Russia (49.51 million hectares (Mha)), Brazil (46.37 Mha), Canada (36.01 Mha), United States (33.75 Mha) and Indonesia (23.09 Mha).^[27]

To follow the rate of deforestation in near-to-real-time, visit

<http://www.globalforestwatch.org/countries/overview>.

Furthermore, to fully grasp the consequence of the things we do, it may help to view ourselves as a point in history. The following charts indicate the global carbon dioxide, methane and nitrous oxide concentration from 800,000 BCE to 2015, and from 1950 to 2015.

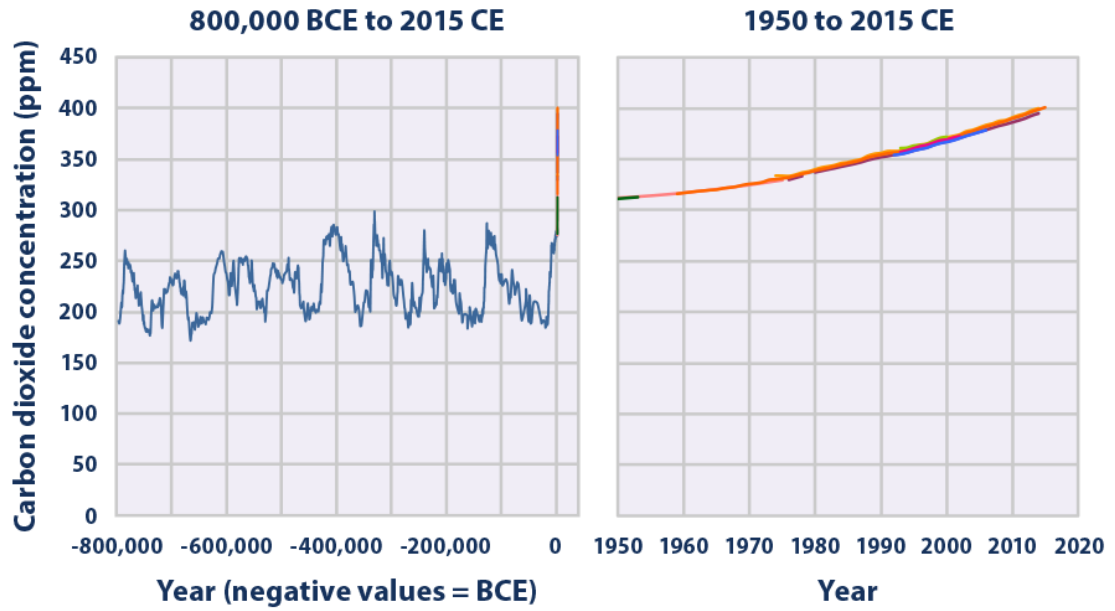


Diagram 4.3 – Carbon Dioxide Concentration

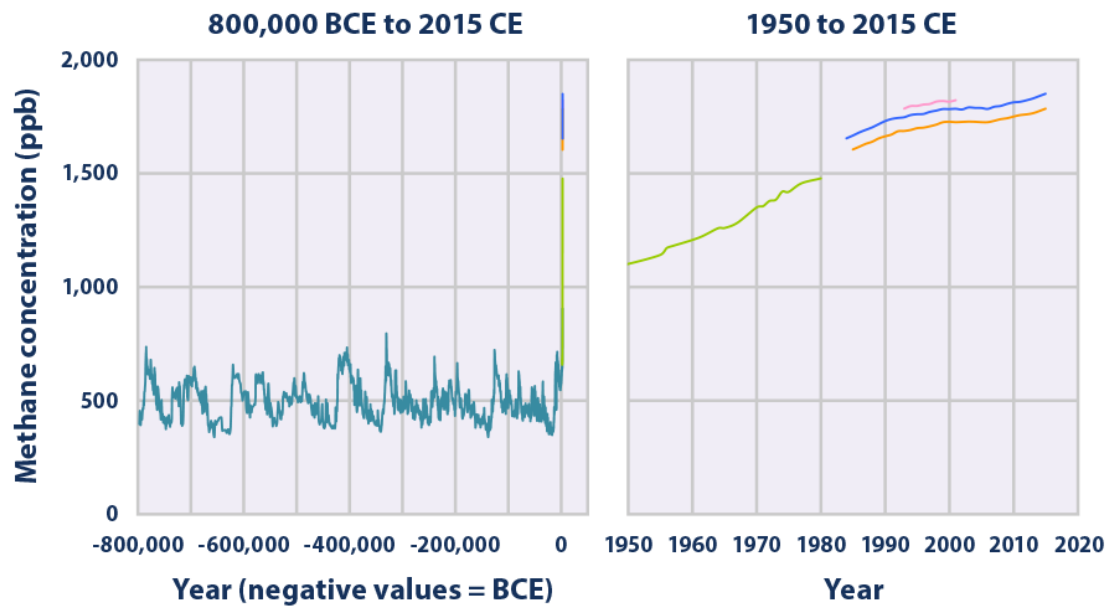


Diagram 4.4 – Methane Concentration

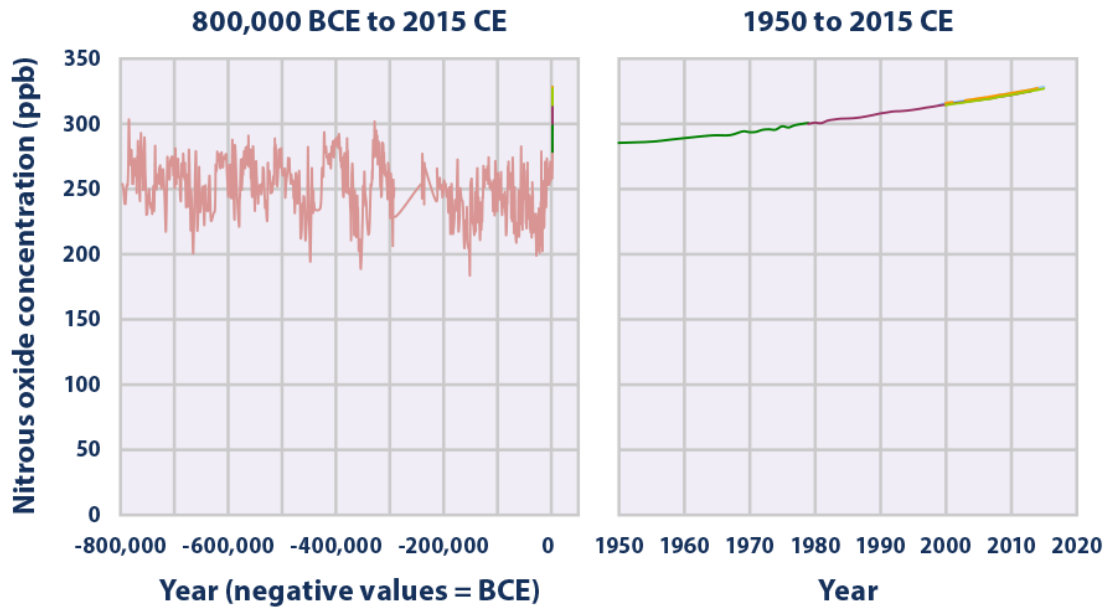


Diagram 4.5 – Nitrous Oxide Concentration

<https://www.epa.gov/climate-indicators/climate-change-indicators-atmospheric-concentrations-greenhouse-gases>

As the data will forever be etched in history, it is interesting to speculate about what our descendants – if our species survives human-induced climate change – will wonder about our share of time on Earth. What would we have thought of our ancestors if they'd pushed the planet as far as we have?

4.1 Consequences of a Warming Globe

Scientists have high confidence that global average temperatures will continue to rise for decades to come. The Intergovernmental Panel on Climate Change (IPCC) forecasts a temperature rise of 2.5 to 10 degree Fahrenheit over the next century. The IPCC also predicts that an increase of less than 1.8 to 5.4 degrees Fahrenheit (1 to 3 degrees Celsius) above 1990 levels, would bring substantial changes to the dynamic of our world. ^[19]

While we most often associate global warming with rising ocean levels, there is simply a lot more to it. As Professor McElroy lists, “we can anticipate an increase in the incidence of floods and droughts, storms that become increasingly more destructive, weather systems for which our infrastructure is ill prepared, an increase in the incidence of extreme heat waves, a decrease in the extent and thickness of sea ice in the Arctic, deserts migrating to higher latitude, and all of this combined with a damaging rise in global sea level.”^[1]

Moreover, record levels of carbon dioxide, methane and nitrous oxide to the atmosphere, not only undoes the ancient radiative equilibrium, it also changes the composition of our ocean waters as well as our atmosphere. Warmer, more acidic waters and deserts pushing forests toward mountains all have serious implications for our planet’s species. It pushes them toward extinction. Humans are not exempt as the rate with which we are moving toward a greenhouse earth is unknown territory for us. There is a man-made epidemic caught within the planet’s interweaving systems. The question is whether we will reduce or exacerbate the fever.

4.2 Things to Do: A Conclusion

If we were to stop greenhouse gas emissions today, the planet would still warm by another degree Fahrenheit. This is due to a delay in ocean’s response to atmospheric changes. However, what we do from this point on can determine whether our planet will be hotter by as little as 2.5 degrees or as much as 10 degrees Fahrenheit.^[19]

This depends on our population’s relation with the energy it uses as well as its awareness of how this energy is produced.

A commonly cited goal is to keep greenhouse gas concentrations at 450-550 parts per million (ppm). This is the point where the most devastating damage can be avoided.

However, since our current atmospheric greenhouse gas concentration is close to 400ppm, time is of the essence. ^[28]

The good news is that there are solutions, if we choose them.

During the 2008 economic recession for example, CO₂ concentrations fell. ^[1] This was mainly due to people's inability to meet fuel prices for transportation. Therefore, a good place to start is the introduction of a carbon tax. Unfortunately as of today, while many industrial countries do have some form of carbon tax set in place, the United States, China and Russian Federation, three countries with the highest greenhouse gas emissions, are not among them. ^[29]

Furthermore, overconsumption and waste must cease. Every layer of the onion counts.

Today, one third of the food produced in the world, which amounts to 1.3 billion tons is wasted. ^[30] Every unattended light bulb illuminating an empty room and every unnecessary car ride is equivalent to wasting another layer of our energy bank.

Improvements in fuel efficient modes of transportation, as well as transitioning from fossil fuels to natural gas then on to wind, solar and renewable sources of energy is the path to a less-warm future. ^[28]

However, at the moment it does not look too good. In 2016, United States and China produced 364.8 and 1685.7 million tons of coal respectively. Compare that with their production of renewable energies of 83.8 and 86.1 million tons respectively. ^[14] This harmful pattern can shift if enough of us commuters want it to.

As we strive to reduce greenhouse gas emissions, we must also not lose sight of powerful forces that help us take these gases out of the atmosphere. Reducing the rate of deforestation is one of the most powerful actions we can take as a species on our

quest to surviving the century. Increasing forestland as well as sustainable farming can help us efficiently store carbon in a clean and efficient way.

Finally, remember those 10 kilos of chicken and the six lamb shoulders stacked behind me four days a week? According to a UN report, crop and livestock production grew from 4.7 billion tons of carbon dioxide equivalents to more than 5.3 billion tons between 2001 and 2011. The methane produced by livestock during and after digestion accounts for 39% of this sector's total greenhouse output. From here on, it matters more and more to our planet what we promote as food for our bodies.

[20]

Given these solutions, our level of involvement depends on our will to improve the function of our planet by reducing pollution. The future of life on Earth depends on our conscious preservation and use of energy. The ball is in our court and the question is whether we will push another generation of species toward extinction or help provide them with a chance at life.

Sources

1. McElroy, Michael B.. *Energy and Climate: Vision for the Future*. Oxford University Press.
2. *The Smithsonian*, 2013, “How Did Water Come to Earth?”, <https://www.smithsonianmag.com/science-nature/how-did-water-come-to-earth-72037248/>
3. BBC science, “Changes to Earth and Its Atmosphere”, 2014, http://www.bbc.co.uk/schools/gcsebitesize/science/aqa_pre_2011/oils/changesrev7.shtml
4. *World Atlas*, “Timeline of Mass Extinctions”, <https://www.worldatlas.com/articles/the-timeline-of-the-mass-extinction-events-on-earth.html>
5. *North Carolina Climate Office*, “Long Wave and Short Wave Radiation”, <http://www.nc-climate.ncsu.edu/edu/RadiationTypes>
6. IPCC, “What Factors Determine Earth’s Climate?”, https://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-1-1.html
7. NASA, 2008, “Water Vapor Confirmed as Major Player In Climate Change”, https://www.nasa.gov/topics/earth/features/vapor_warming.html
8. IPCC, 2007, “IPCC Fourth Assessment Report: Climate Change 2007”, https://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-1-1.html
9. USGS, 2012, “Historical Perspective”, <https://pubs.usgs.gov/gip/dynamic/historical.html>
10. UCSD, Calspace, 2002, “Climate Change: Past and Future”, http://earthguide.ucsd.edu/virtualmuseum/climatechange2/01_1.shtml
11. University of California Museum of Paleontology, 2011, “The Holocene Epoch”, <http://www.ucmp.berkeley.edu/quatarnary/holocene.php>
12. *Earth Magazine*, 2016, “Did the Medieval Warm Period Welcome Vikings to Greenland?” Mary Caperton Morton, <https://www.earthmagazine.org/article/did-medieval-warm-period-welcome-vikings-greenland>
13. Potsdam Institute for Climate Impact Research, 2016, “Human-made Climate Change Suppresses the next ice age”, <https://www.pik-potsdam.de/news/press-releases/human-made-climate-change-suppresses-the-next-ice-age>
14. *British Petroleum*, 2017, “Statistical Review of World Energy”, <https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html>
15. *Global Carbon Atlas*, 2017, <http://www.globalcarbonatlas.org/en/CO2-emissions>
16. *The World Bank*, 2018, <https://data.worldbank.org/indicator/EG.USE.COMM.FO.ZS?view=chart>
17. *Environmental Protection Agency*, 2016, “Climate Change Indicators”, <https://www.epa.gov/climate-indicators/climate-change-indicators-atmospheric-concentrations-greenhouse-gases>
18. *Environmental Defense Fund*, “Measuring Carbon Emissions from Tropical Deforestation: An Overview”, https://www.edf.org/sites/default/files/10333_Measuring_Carbon_Emissions_from_Tropical_Deforestation--An_Overview.pdf
19. NASA, “The Consequences of Climate Change”, <https://climate.nasa.gov/effects/>

20. UN News, 2014, "Agriculture's greenhouse gas emissions on the rise, warns UN agency", <https://news.un.org/en/story/2014/04/466012-agricultures-greenhouse-gas-emissions-rise-warns-un-agency>
21. National Geographic, *Map of Human Migration*, <https://genographic.nationalgeographic.com/human-journey/>
22. UCMP, *The Cretaceous Period*, 2009, <http://www.ucmp.berkeley.edu/mesozoic/cretaceous/cretaceous.php>
23. Worldmeters, 2018, "Population of the Earth by Year", <http://www.worldometers.info/world-population/world-population-by-year/>
24. United Nations, 2017, "World Population Prospects: The 2017 Revision", <https://www.un.org/development/desa/publications/world-population-prospects-the-2017-revision.html>
25. *The Washington Post*, 2014, "NASA video shows how carbon dioxide spreads in our atmosphere," Nick Kirkpatrick, https://www.washingtonpost.com/news/morning-mix/wp/2014/11/19/nasa-video-shows-how-carbon-dioxide-spreads-in-our-atmosphere/?utm_term=.c6ce19e612fe
26. *Climate & Weather*, 2017, "Deforestation", <https://www.climateandweather.net/global-warming/deforestation.html>
27. *Global Forest Watch*, 2018, <http://www.globalforestwatch.org/countries/overview>
28. National Geographic, "Global Warming Solutions", <https://www.nationalgeographic.com/environment/global-warming/global-warming-solutions/>
29. Carbon Tax Center, "Where Carbon is Taxed", <https://www.carbontax.org/where-carbon-is-taxed/>
30. Food and Agriculture Organization of the United States, "Key facts on food loss and waste you should know!", <http://www.fao.org/save-food/resources/keyfindings/en/>

Corrections: Final paragraph of Section 1.1 Commute on 03/26/20018.