

A Treatise on Climate Change: Frequently Asked Questions, Personal Lifestyle Responses and Observed Impacts

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Frequently Asked Questions about Climate Change

Sometimes I hear people talk about “global warming” and at other times I hear people talk about “climate change”. Why the difference?

Both of these terms are used correctly to describe the current situation, but there is an important difference. Global warming of the atmosphere is the basic type of climate change, which in turn can drive other forms of climate change. For example, warmer atmospheric temperatures can cause increased soil temperatures, increased evaporation and more severe drought conditions. Increased snowmelt and ice melt, more severe storms and floods are other types of climate change which can be caused by global warming.

I also have heard that the “greenhouse effect” causes global warming. How does that work?

The “greenhouse effect” is so named because the atmosphere replicates what happens inside a greenhouse (or a closed automobile) on a sunny day. Short wave length solar radiation passes through the glass and warms the interior surface of the greenhouse. The surface then gives off long-wave radiation, but the latter cannot penetrate and is trapped inside the glass, which causes warming to take place. Similarly several “greenhouse gases” in the atmosphere, most notably carbon dioxide and methane, trap and prevent long-wave radiation which is emitted from the earth’s surface from escaping back into space.

Isn’t some carbon dioxide increase in the atmosphere and some temperature increase beneficial to life on earth?

In general, the Intergovernmental Panel on Climate Change notes that some increase in the concentration of greenhouse gas carbon dioxide is beneficial towards providing additional nutrients for plant life and that small increases in temperature may reduce the incidence of frost and extend the growing season in cooler climates (www.ipcc.ch/publications_and_data/ar4/wg2/en/ch55-4-1-1.html) (At the same time, it should be noted that relatively small changes in the *average* global temperature can translate to more severe temperature increases and effects at regional levels, such as is occurring with ice melt in the arctic region.) However, severe impacts occur when the temperature increases too much and too rapidly. Many scientists believe that when temperature increases beyond 1-3 °C (2-5°F) that there will increasingly negative impacts.

(www.ipcc.ch/publications_and_data/ar4/wg2/en/spmssp-c-3-food-fibre.html)

Individual species and whole ecosystems cannot adapt quickly enough, and many species will die. (www.ipcc.ch/publications_and_data/ar4/wg2/en/spmssp-c-2-ecosystems.html) Changes in soil conditions, including erosion, and more severe droughts may cause widespread crop failures and famines, frequently with devastation of poorer agricultural countries .

Why is global warming so important now...haven't we always throughout history had periods of global warming and cooling?

Now there are six billion people dependent upon complex natural systems for survival. As we have studied past periods of global warming and cooling, we have recognized the difficulties which species have in adapting and surviving due to both the absolute change in temperature and the rate of change. Although the global observed temperature increase during the industrial age to date *seems* to be a relatively modest 1° F., there are already considerable impacts being observed, ranging from loss of coral reefs to desertification to loss of polar icecaps to a pine beetle epidemic here in the high country. Global climate models, based upon different assumptions and projections, suggest an average global temperature increase of 2-5° C. (4-9° F.) during the remainder of the 21st century unless strong preventive actions are taken. To make matters worse, based upon CO₂ emissions data from 2008, trends indicate that recent emissions are near the top end of (previously projected) emissions scenarios (www.realclimate.org/index.php/archives/2010/06/recent-trends-in-co2-emissions/)

In what ways do human activities affect greenhouse gases in the atmosphere?

Human activities affect the production and release of greenhouse gases in many ways. In the United States most attention is focused upon the burning of fossil fuels, which are widely used by households, manufacturing processes, transportation activities, commercial and institutional buildings and in the generation of electricity. Other human activities, such as construction (e.g. production of brick and cement) and agriculture indirectly cause greenhouse gas emissions. Garbage disposal, through organic matter that winds up in landfills, produces methane, a highly potent greenhouse gas. Other materials, including plastics, metals and glass, when they are recycled will reduce the energy input and greenhouse gases resulting from their production. For all of these reasons, the consumer recycling and composting programs operated by Summit County and HC3 are important means to reduce greenhouse gas emissions.

Other important human activities which contribute to global warming have not received as much attention. Land use conversion, including deforestation and agriculture, are estimated to cause 20-25% of the greenhouse gas increase, both through the release of gases into the atmosphere and from the destruction of "sinks" which remove carbon dioxide from the atmosphere. Some specific examples include the conversion of forest land (a "sink") to agricultural land (which may release nitrogen gases), the conversion of forest land to suburban land uses, the raising of livestock (which release methane gases) and the cultivation of rice (which releases methane).

Are there other benefits from taking actions to combat global warming?

One intelligent and environmentally-concerned person we know is unsure about the complicated climate change science and whether it has been conclusively demonstrated whether humans are responsible for global warming and climate change. Nevertheless, he has chosen to act as an energy and environmental steward in his personal conduct. Not only is he exercising the "precautionary principle" which states that in the event of uncertainty that humans should act to minimize potential catastrophic damage, but he is also helping both himself and our society to realize many other benefits from his actions.

The first and most obvious benefit to most people is saving money. For typical households it is feasible to reduce residential fuel use, electricity consumption and gasoline use by 25%..or more. In some cases a significant investment is required, which is then regained by the consumer over time. After conserving energy, additional reductions in fossil fuel consumption are possible by substituting renewable forms of energy, such as wind, solar, biomass and geothermal. (See HC3 website Energy section for further information about energy conservation, renewable, and available grants and financing). In addition, energy conservation and the substitution of renewable energy offer many other “cobenefits” for society.

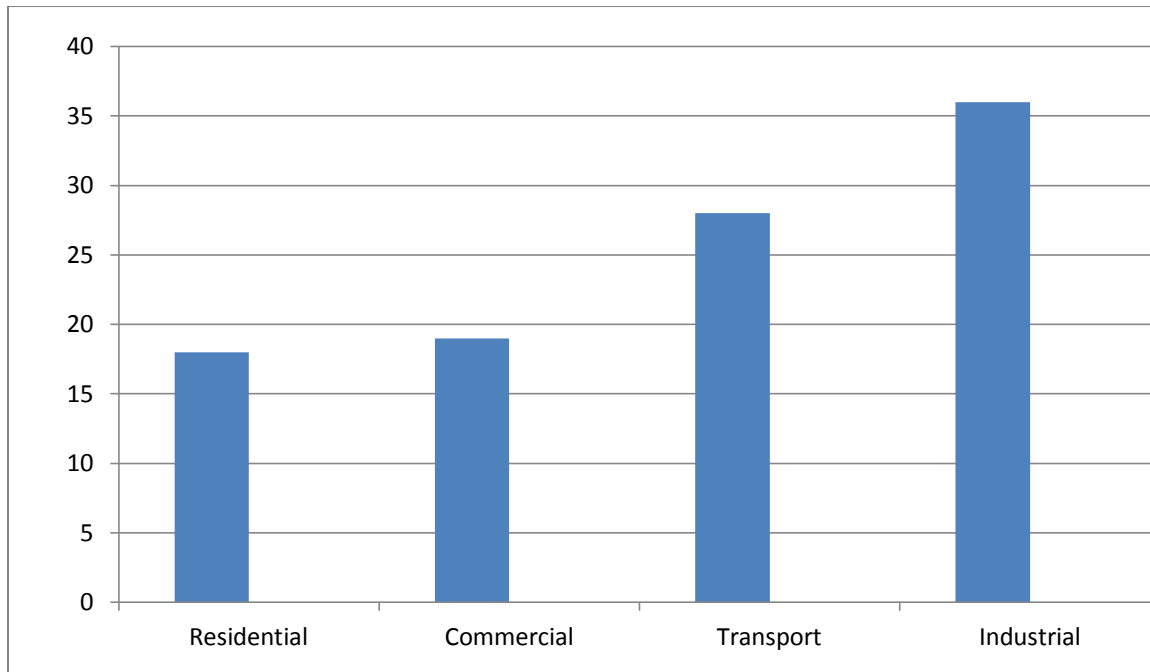
Many federal and state and local programs have been established to solve a variety of “air pollution” problems, such as airborne pollutants affecting human health, automobile smog, acid precipitation and even indoor air quality. However, these are mostly “energy problems”, which are caused by the way we use fossil fuel energy. Hence several air pollution problems could be mostly solved through reliance upon energy conservation and renewable energy.

Moreover, there can be a number of other economic benefits to society. Energy conservation and renewable energy production are labor-intensive and can provide many new jobs in the manufacturing of insulation, metals, glass, and components, and in design, assembly and installation of energy applications; much of the economic impact is in state and local economies. To the extent that foreign oil consumption can be reduced, the pressure to conduct expensive and tragic foreign wars will be reduced and our national security will also be enhanced.

Personal Actions and Green Lifestyles to Reduce Greenhouse Gas Emissions

The climate change issue may seem to be so vast that it’s tempting to think that “the government” or “corporations” or a new “savior technology” will have to solve the problem of GHG emissions. When we examine the diverse sources of greenhouse gases, as noted in the accompanying bar chart, it is unlikely that a single actor or technology will solve the problem. Of course, each economic sector has to become more efficient and “green” in the way energy is used; but this will taken time based upon how investment capital is allocated and new technology is developed.

U.S. Greenhouse Gas Emissions by Economic Sector, 2008 (%)



Source: U.S. Energy Information Administration, *Emissions of Greenhouse Gases in the U.S., 2008*

However, there *is* one common link across all economic sectors –manufacturing, residential, transportation, electrical generation - you, I, the consumer - that can take immediate actions to reduce GHG emissions . From the next chart we can get a global perspective as to why our “carbon footprint” as consumers is so important. The current per capita GHG emissions in the United States simply cannot be sustained throughout the world without greatly magnifying the climate problem. Fortunately, there is much we can do to reduce our personal carbon footprint, while we await transformational changes to the global fossil fuel era. Let us consider how to reduce our carbon footprint through our household energy management, household waste management, transportation, and general consumerism

CO₂ Emissions Per Capita, 2008 (metric tons)

United States -	19.2
China -	4.9
Europe -	7.8
World Average -	4.5

Household Energy Management

The above bar chart indicates that the GHG emissions from the household sector are about 18% of all GHG emissions . It should be noted that the majority of these emissions results from household

consumption of electricity (and that all electrical generation accounts for about 35% of total GHG emissions). When we stop to consider how we use energy in our own households, there seem to be virtually limitless opportunities for reducing energy use through household energy management, as well as selected opportunities to use renewable energy in way that are unique to Colorado. Energy experts have tended to classify the many opportunities for reducing energy consumption into one of two approaches: improve the efficiency at which the energy conversion takes *or* find ways to accomplish the same task by using less energy input. Let's examine opportunities in the typical U.S. household to do both.

More energy-efficient appliances are now available, including furnaces, boilers, air conditioning units, televisions, freezers, washers and dryers, computer monitors and lighting fixtures. Thanks to the federally-mandated EPA Energy Star labels, it is now relatively easy when replacing an old appliance to compare and choose an energy-efficient model. There are also "calculators" available for consumers to use to help determine the most cost-effective appliance purchase based upon how long it will take to "pay back" the costs of energy-efficient models from energy savings (<http://www1.eere.energy.gov/calculators/homes.html>).

The easiest way to reduce energy use, aside from turning out lights and unplugging appliances when not in use, is to replace incandescent light bulbs with compact fluorescent lights, which use appropriately 75% less electricity and generally last a few years. (Although the initial purchase may cost a few dollars per bulb, look for special promotions offered through electric utility companies for as little as one dollar per bulb.) In warmer climates, where air conditioning is frequently used, these CFL bulbs also reduce the summertime room temperature compared to incandescent lights.

When it comes to the second category of household energy management, using less energy to accomplish a task, there are many opportunities, some based upon common sense and others based upon personal creativity.

Object: To Stay Warm

Seal leaks around windows, doors and electrical outlets; add attic insulation to reduce building heat loss. Fully open south-facing window shades and drapes during the day on sunny days (almost every day in Colorado!) to maximize free solar energy. Use zone thermostats or close heat vents to reduce heating of unused areas of home. Be sure that heating registers or baseboards are not blocked from good airflow. Why not turn the thermostat down several degrees and wear a (stylish) sweater by day and a warm blanket at night. Plant bushes outside house as "wind breaks".

Object: To Stay Cool

When and where practical, don't continuously run the central AC, but instead open windows at night and use a fan to pull in cooler air. Consider installing energy-efficient window AC units (or fans) in specific locations rather than retrofitting central AC. Wear cooler clothes. Plant deciduous trees around house for shade in summer (and sun in winter).

Object: To Cook Efficiently

When practical, utilize microwave as opposed to stove or oven. Try to use oven only on cooler days. Cover pots on stove to reduce cooking time; lower stove setting after boiling occurs. Where feasible, cook multiple meals and save.

Object: Wash and dry dishes efficiently

Run dishwasher with full load and use natural air drying instead of electric heating element

Object: Wash and dry clothes efficiently

Use appropriate timing cycles. Use a cold wash and use a drying rack and/or hanger to air dry very wet clothes (well-suited to Colorado's dry climate!)

With respect to many household appliances, lower energy consumption is also achieved through proper maintenance (heating and air conditioning units) and cleaning (furnace filters, refrigerator coils, vacuum cleaners). These and other ideas for reducing energy consumption through household energy management are further discussed in *Low Carbon Diet* by David Gershon, which also includes quantitative estimates of carbon dioxide emissions reductions which consumers can achieve .

Finally, once measures to achieve lower household energy consumption have been taken, some consumers may wish to then utilize renewable energy sources to provide some or all of their remaining household energy needs. In Colorado an abundance of sunshine, wind, and land availability provide opportunities for solar, wind and geothermal (heat pump); and federal and state government and electric utilities provide economic incentives for homeowners and businesses. Also, some electric utilities will make the purchase of wind energy available to customers for a nominal additional charge. Finally, (and sadly) an abundance of beetle-kill wood also provides a renewable wood-pellet fuel source for woodstoves with no net GHG emissions (because normal wood decay processes would have returned CO₂ to the atmosphere anyway).

Household Solid Waste Management

Here in the high country waste management is a significant environmental issue; wastes have the potential to cause significant pollution of local bodies of water and to consume large amounts of precious land. Household solid waste management has a significant impact in *two* ways upon the GHG emissions from the household sector and from the manufacturing and transportation sectors as well.

First, organic materials – like paper, food wastes, yard wastes and wood wastes - which are buried in landfills will decompose without oxygen (anaerobic) and produce *methane*. Methane is a GHG which is many times more potent than the more common CO₂ towards causing global warming, notwithstanding that there is some common confusion as to “how much”. Because methane is a relatively short-lived greenhouse gas in the atmosphere (average residence time of 12 years) , the Intergovernmental Panel on Climate Change in their Fourth Assessment Report (2007) noted its relative potency (compared to CO₂) as 72 for a 20-yr. period, but “only” 25 for the 100-yr. period normally considered in climate change assessments. As a result of these consideration, a special form of recycling – composting –

has become an important part means to reduce landfill organic wastes and the GHG they emit while at the same time producing a useful soil enrichment.

The second important way in which household waste management affects GHG emissions is through recycling. When processed materials, such as glass, metals, plastics, and cardboard, are discarded into a landfill, the energy content used to manufacture these products is *wasted*; and new raw materials must be mined, refined, and smelted before new products are made. Instead of discarding processed materials to the landfill, their recycling will reduce energy consumption and related GHG in manufacturing new products - for example, an approximately 95% reduction for aluminum, 50% for glass and 60% for paper. (<http://www.Earth911.com/reduce/energy-costs-and-conservation-facts/>)

The complete waste management ethic consists of the environmental “three R’s” - reduce, reuse and recycle. “Reducing” wastes is mainly a function of purchasing methods and lifestyle choices towards reducing consumption (see below regarding “Consumerism”). “Reusing” means finding another use for something which would otherwise be recycled or thrown away. There are many ways to reuse items. Female friends have been known to loan each other clothes. Siblings have been known to “hand me down” clothes, but if you’re not into that you might certainly donate them, and many other items, to a goodwill store. Another creative way is to find other, different uses for items – who needs Tupperware when you have some many empty plastic food containers and glass jars to use? Practicing the three “Rs” will reduce consumption, wastes *and* the production of greenhouse gases.

Transportation

Dependent upon our own unique consumer needs and wants, transportation is an intensively personal choice – particularly here in the high country where recreational lifestyles and a harsh environment effect a variety of vehicles including RVs, pick-up trucks, SUVs, small station wagons, jeeps, small cars and hybrids. With respect to reducing GHG emissions, clearly the miles per gallon is the critical factor, and the weight of the vehicle is a key factor in the MPG. But it’s not the only factor – vehicle design (such as aerodynamics, engine and tires) and operational factors are important. So even if you don’t believe that “small is beautiful” when it comes to vehicles, there is still a number of things which a driver can do to maximize the fuel-efficiency for a particular vehicle type:

- Keep vehicle well-tuned
 - Keep tires properly inflated
 - Minimize idling times
 - Drive at optimal speeds (generally 55 to 60 mph)
 - Eliminate rapid acceleration and deceleration
- (see *Low Carbon Diet* for additional information about quantitative reductions in CO₂ emissions)

Some consumers also wish to consider alternative vehicles, such as hybrid cars or electric cars. Whereas there is universal agreement that hybrids are a superior alternative to the conventional gasoline internal combustion engine for improving mileage and reducing GHG emissions, there is considerable controversy with respect to electric cars, which are currently being touted as a cornerstone of national energy policy.

One group, the Auto Alliance, which represents several auto manufacturers, has funded independent research which concluded that whether electric cars are better than conventional gasoline engines in reducing GHG emissions is wholly dependent upon the source of electricity for the car and its battery. If the electricity is generated by coal (the major source of electricity in the U.S.), the electric car is responsible for considerably greater GHG emissions than the gasoline engine. However, if the source of electricity is nuclear or renewable energy, then the electric vehicle is substantially better. On the other hand, the Electrification Coalition, which includes a consortium of electric utilities, has studied the issue and concluded that electric cars reduce GHG emissions regardless of the source of electricity. For additional information see a recent article in the magazine *Inside Science* (http://www.insidescience.org/policy/sparks_fly_over_electric_car_funding)

One certain conclusion is that if a consumer purchases renewable energy from an electric utility *and* uses an electric battery vehicle, he will greatly reduce GHG emissions compared to a conventional auto.

Consumerism

How we act as consumers cuts across manufacturing and transportation and related energy use and GHG emissions in our economy. In addition to reducing GHG emissions, our actions can contribute towards a more generally sustainable lifestyle. Let's consider (1) how our consumer and purchasing choices generally affect GHG emissions and (2) how our diet and food purchase affect GHG emissions.

There are some general guidelines for purchasing household items which will tend to reduce GHG emissions. The first question is whether we truly *need* the item. It is desirable to purchase items which are durable, well-made and designed to last, such as your energy-efficient automobile; also look for items which are made from recycled materials. In addition, wood-crafted items, such as furniture are preferable to metal or plastic. Wood has two advantages. First, it will require less processing and energy input than other materials. Second, wood products provide long-term storage (sequestration) of carbon dioxide removed from the atmosphere and therefore help to reduce the concentration of CO₂ in the atmosphere. (With respect to home construction the choice of materials is a bit more complicated dependent upon the climate; here in the cold but sunny high country brick could have advantages similar to the adobe style). Finally, we might also look to purchase used items in good condition, rather than new items.

The U.S. food system is highly energy-intensive through the various stages of cultivation, harvesting, processing, packaging, transportation and distribution, refrigeration, and cooking. A well-known "rule of thumb" is that it requires 10 calories of fossil fuel energy for each calorie of food energy! Therefore there are many measures which we as consumers can take to reduce our food dependency on fossil fuels. We might try to "eat lower on the food chain," which would include occasional meatless meals, less corn-fed beef and more poultry, pork or fish. We could look for locally-produced food, including fresh, seasonal, locally-produced produce and fewer refrigerated items. By preparing and cooking multiple meals at the same time we can save energy (and store the extra meals in re-usable food containers).

Finally, we can look for food and beverages with less packaging waste. For example, drink concentrates require less packaging and weigh less to ship than drinks in bottles or cartons. One easy way to reduce packaging, which also generally saves money, is to purchase larger sizes of cans, jars and bottles (which have a larger surface-to-volume ratio). In general, the purchase of individual plastic water bottles is of dubious value (certainly here with the mountain-fed water supply); the bottles require large energy inputs for manufacturing and shipping and produce vast amounts of waste. Why not refill a re-usable water bottle?

Offsetting Greenhouse Gas Emissions

Okay, you've tried to do the right things to be a good steward of the environment. All of the measures you have taken, including those suggested above, should result in a direct and measurable reduction in your monthly electric consumption and home fuel consumption and in improved gasoline mileage, as well as indirect impacts in other economic sectors. But unless you decided to turn off the heat and lights, stop eating, and leave the car in the garage – it's likely that your activities will still result in some amount of GHG emissions. As noted previously, you may be able to purchase renewable energy from your electric utility (Xcel Energy has such a program). Then, you may want to "offset" the remainder of your GHG emissions.

This simply means making a nominal payment to another party who will (1) develop a project that will reduce an equivalent amount of your GHG emissions or (2) plant trees or other vegetation which will remove (sequester) an equivalent amount of CO₂ from the atmosphere or protect existing forests to retain CO₂. In general, to be most beneficial it is desirable to purchase an emissions reduction which would otherwise not likely to happen in the absence of the offset project. For example, some government entities and nonprofit organizations (e.g. school buildings, senior centers, service organizations) may not have the funds to invest in a rooftop solar photovoltaic project or upgraded building energy management system. However, if many individuals purchase "offsets", such a project may be funded. Many organizations are now providing opportunities to purchase "emissions reductions offsets," including the Colorado Carbon Fund. (<http://www.coloradocarbonfund.org>) (More information about the Colorado Carbon Fund is presented on this website)

The second method of offsetting emissions through carbon sequestration is also an attractive alternative for a number of reasons. First, at this point in time, it is considerably less expensive to offset a given amount of GHG emissions by either planting new trees or protecting existing forests. Second, it is also possible to promote other environmental objectives at the same time – such as the conservation of tropical rain forests and animal habitats, sustainable use of forests to provide livelihoods for indigenous people, the restoration of wetlands and habitats, and the reforestation of decimated pine-beetle forests. Organizations which provide opportunities to purchase these kinds of offsets include American Forests (<http://www.americanforests.org>) and Conservation International (<http://www.conservation.org>)

Of course, before purchasing emissions offsets, it is necessary to estimate what your remaining GHG emissions are, based upon some simple household and lifestyle characteristics. All three of the organizations listed above have GHG emissions "calculators" on their websites.

Climate Change Affects Colorado

Although climate change is a global phenomenon, with profound effects and implications for people and natural systems everywhere, Colorado is uniquely dependent upon its climate to sustain both its economy and population. Summer and winter outdoor recreation, resort communities, agriculture and ranching, urban populations, wildlife habitats and forest health are all critically dependent upon the interplay of temperature, precipitation, evaporation, snowmelt and runoff.

As temperatures continue to increase over time, these other climate variables will be affected in many important ways. Clearly the length of the snow season will contract, the depth of mountain snowpack will diminish, and the snowmelt will advance earlier into springtime. In turn, the peak river flow may diminish somewhat and occur earlier in the season. Warmer temperatures will also increase evaporation from streams and reservoirs and lower the oxygen content of streams.

These climatic changes will have important impacts and will require various adaptations for Colorado's economy and populations. Outdoor recreation, including the length of the winter resort season; fishing conditions in rivers, lakes and reservoirs; and river rafting and boating will face significant changes. Agricultural production will be affected by warmer temperatures, increased evaporation of soil moisture and changing waterflows for irrigation. Projected decreases in runoff will complicate water supply distributions for the Colorado and other rivers; and decreases in runoff coupled with increased evaporation will affect urban water supplies from reservoirs.

These concerns about climate change in Colorado have stimulated much scientific and policy interest among research institutions and government agencies in Colorado. As a result there is much detailed and quantitative information being published and made available to the public. The "Colorado Climate Report" is a good synthesis of climate change findings and implications published by the Colorado Water Conservation Board (http://www.colorado.edu/CO_Climate_Report/index.html). A few highlights from the Summary Report (pdf) include:

- an approximate 2.0 ° F. *observed* temperature increase in Colorado between 1977 and 2006 and a *projected* further increase to a total of 4.0 ° F. by 2050
-a projected 10-20% decline in Colorado high-altitude snowpack (above 8200ft.) by mid-century
-an observed two-week earlier shift in spring runoff between 1978 and 2004
-a projected decrease of runoff in the Upper Colorado River Basin of at least 6 to 20% by mid-century