Climate Change and Children's Health:

What Health Professionals Need to Know and What We Can Do About It

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It's difficult to pick up a paper or turn on the news these days without bumping into a story about climate change. Reports from eminent scientific panels, universities, government and environmental organizations, and Vice President Al Gore's film, An Inconvenient Truth, have thrust this issue into everyday consciousness. Most informed citizens worry about what kind of planet we'll leave for our children and grandchildren. Like many, we may not believe we can have an effect on a phenomenon of such great magnitude – but many scientists agree that action NOW can mitigate the pace of the changes we're witnessing, and avert the most disastrous consequences of climate change. As health care professionals, we can – and should – take steps to help our planet remain habitable for future generations.

Children will bear a disproportionate adverse health burden resulting from climate change. In this article, we summarize the latest conclusions on climate change and discuss its main health effects with a primary focus on children's health. We tell you why scientists say that stopping the pace of climate change is such an urgent issue. We then discuss what you can do in your community to prepare for climate change, educating the families in your care, and helping the situation through choices in the office, hospital and your personal and public life.

Climate Change is real and indisputable

Climate change refers to any significant change in measures of climate (such as temperature, precipitation or wind) lasting for an extended period (decades or longer). (See Glossary for a list of terms including the difference between climate change and global warming). In February of this year, the Intergovernmental Panel on Climate Change (IPCC), a group of hundreds of independent, international scientists established in 1988 by the United Nations and considered to be the world's most authoritative voice on climate change, began releasing its 4th Assessment Reports (http://www.ipcc.ch). Their message is strong and unified – warming of the Earth's climate is "unequivocal," and human activity, particularly the burning of fossil fuels, is a major cause (See Sidebar - the Greenhouse Effect.) Improved, tested and validated computer models can reliably reproduce past and present climate conditions at the global level. Direct observations from around the world, on land and in the sea, from the upper atmosphere, and from satellites combined with paleoclimatologic data from nearly a thousand millennia paint a coherent picture of what constitutes normal climate variation. These data also indicate that warming over the past few decades is well outside of that norm in both rate and scale. That part of the scientific debate is settled. The uncertainty now centers on other questions: how hot will it get, how fast, how widely will climate variables fluctuate, what will be the consequences, and – most importantly – what can we do about it ?[1]

Using reliable computer models, climatologists can approach answers to some of these questions, but incomplete understanding of major influences (such as melting of glaciers and response of ocean currents) remains, possibly leading to overly conservative predictions. At the very least, warming will continue throughout the 21st century due to the long residence time of already emitted atmospheric greenhouse gases (GHG) and the slow response time of oceans. Climate effects will vary by region and be most dramatic in higher latitudes and coastal areas. Rainfall and freshwater availability, average temperatures, agricultural growth zones and sea level all will change. Ecological and human health consequences can be anticipated and some are already being measured, particularly at the poles.[2, 3] Children are likely to suffer disproportionately from the direct and indirect health consequences of a rapidly warming world.[4]

Health effects of climate change

The World Health Organization recently estimated that 34% of all childhood illness in the world (compared to 24% of all age illness) and 36% of deaths in children under age 14 are due to modifiable environmental factors.[5] Because of physical, physiologic and cognitive immaturity, children are more sensitive than adults to harm from environmental hazards. Climate change increases these hazards by worsening air quality, stimulating more extreme weather events, creating conditions that favor increases in food-, water- and vector-borne infections, and enhancing heat stress conditions.

Air quality is threatened via at least three mechanisms: heat-driven increases in ground-level ozone, energy production-driven increases in particulates and other fossil fuel-related air pollutants, and changes in aeroallergens. Ground level ozone is formed by the action of sunlight on nitrogen oxides and volatile organic compounds emitted from motor vehicles and other sources. Ozone production is favored at high temperatures even without additional precursor pollutants. Ozone exposure increases the rate and severity of asthma attacks and may play a causal role in asthma onset when exposures are high and prolonged.[6, 7] This represents a large health threat to the 6.5 million US children with asthma and to those at risk of developing asthma as the number of "code orange" and "code red" ozone days increases. Both population growth and warmer climate will create increased energy demands. If society meets this demand by burning more fossil fuels to create the electricity needed to power air conditioners, all major air pollutants – including ozone – will increase. Studies clearly show that childhood exposure to specific air pollutants is related to decreased lung growth and permanent decrements in pulmonary function as well as increases in respiratory infection, asthma, infant mortality and all age mortality, miscarriages, preterm delivery and low birth weight.[6] Mercury from the burning of coal also ends up in the food chain and threatens the neurological development of fetuses and young children. Finally, we expect that climate change will result in changes in the quantity, quality and distribution of pollens and other aeroallergens.[8] For example, poison ivy grown at high concentrations of CO_2 is more allergenic than poison ivy grown at current outdoor levels.[9] Ragweed pollen production increases with increased CO_2 concentrations, and a rise in ambient ragweed pollen as temperature increases is already being measured.[8] Thus, asthma and allergies are likely to be worsened regionally in a warmer world. To the degree that allergy plays a role in the causation of asthma, we can expect that more asthma will result from increases in aeroallergen exposure.

The IPCC report states with increased confidence that climate change will result in more frequent and stronger hurricanes, typhoons, tornadoes and floods. Children, particularly very small ones, are at increased risk for death and injury from these extreme events in part because they depend totally on adults for protection. Hurricanes Katrina and Rita taught us how completely a natural disaster can displace a population and destroy important infrastructure including health care and schools. Psychological sequelae such as post-traumatic stress disorder, behavior and sleep problems are documented, and there is some evidence, although it is mixed, that children may be more susceptible to these sequelae.[10, 11] In western parts of the country, we expect longer and more severe drought with subsequent increases in wildfires.

Changes in precipitation and more extreme precipitation events are also very likely. Heavy rain is highly correlated with outbreaks of waterborne illness as surface and ground water become contaminated by run-off and overwhelmed water treatment systems. Sixty-eight percent of outbreaks of waterborne illness in the US over the past 45 years were associated with rainfall above the 80th percentile.[12] Infants and small children are at higher risk for complications and hospitalizations from such infections. Food-borne infections are likely to increase due in part to changes in eating behaviour (including more outdoor food preparation and dining), and in part because food-borne pathogens grow faster in warmer weather. We can expect to see more diarrhoea and more hospitalizations for dehydration. In a 6-year study from Peru, researchers found an 8% increase in hospitalizations for diarrhoea with every degree centigrade increase above the normal average temperature.[13] Work from Canada shows a correlation between peak temperatures and peaks in cases of campylobacter, E coli and salmonella infections.[14]

Patterns of vector-borne illness are expected to change. Insects and rodents respond quickly to changes in temperature and moisture by migrating and, during favorable conditions, by reproducing more rapidly, often resulting in localized "plagues". Temperature increases accelerate the vector's life cycle and shorten the incubation time of parasites living in the vector. Warmer weather and failure of winter kills will prolong the transmission season and change the range of vectors in latitude and altitude, resulting in more illness. Amplification of West Nile Virus, for example, is associated with warmer winters and spring drought.

Some of these illnesses are particularly devastating to children. Malaria, for example, causes 350-500 million illnesses per year and more than one million deaths, mostly in young children. "Home grown" malaria clusters over the past few years remind us that global warming-related vector-borne illness is a reality for the highly industrialized world as well as for the developing world.[15]

Although we can expect that cold-related deaths will decline, heat-related deaths are likely to increase. This is a concern primarily for the elderly; infants and small children are at greater risk than the average adult from heat stroke and death under extreme temperature conditions. Very small children are vulnerable because they do not have fully developed temperature regulation mechanisms and are unable to change their environments without help from adults. Older children and adolescents spend more time in vigorous activity outdoors and thus have higher exposures. The incidence of heat-related mortality may be declining in the US, despite increasing temperatures, however, probably because of the widespread availability of air conditioning.[16] This adaptive technology requires higher energy use and comes at a cost when the energy derives from more fossil fuel combustion – resulting in more air pollution, more air pollution-related illness, greater GHG emissions, and more global warming – a vicious cycle.
Table 1 summarizes the major health effects of climate change.

What the future holds

Children inherit the societies that adults build. Our children and grandchildren will inherit a warmer world and a world with more extreme weather events. Even if we abruptly reduced GHG emissions to zero, enough excess energy is stored in the climate system to guarantee *at least* another 0.6° C temperature increase in this century.[17] Depending on how rapidly we react, the world of the future could be radically different from the world we know now. Initially, poor children in developing countries (and poor children in our country) will suffer disproportionately because of their limited capacity to adapt to climate change. Ultimately, however, climate change is a global problem with global consequences. If business continues as usual – with industrialized and rapidly developing countries using traditional fossil fuels – we are likely to witness crises in food and water supply, large scale species extinctions, forced migrations of populations because of dramatic sea level rise, drought, and loss of natural resources. These stresses will have major global economic impacts. [18]

While this doomsday scenario is not inevitable, we need to act quickly if we are to prevent it. James Hansen of NASA's Goddard Space Institute argues that two metrics, dramatic sea level rise and massive species extinction, can be used to determine how much climate change and warming we can tolerate with reasonable expectations of surviving and thriving at current global population levels.[19] For example, Dr. Hansen estimates that if we can limit warming in the 21st century to 1 degree centigrade, we can expect an eventual (in a few centuries) sea level rise of less than 6 meters and climate-related extinction of around 10% of species. If we continue to increase emissions at the current rate, temperatures will rise by at least 3 degrees centigrade by 2100 with an eventual sea level rise of 25 meters and a loss of 50% of species. Many scientists believe that there may be a "tipping point" temperature that, if exceeded, could trigger catastrophic change over a relatively short period of time (perhaps a few decades) unless action is taken to change current trends.[20]

Anthropogenic GHG emissions are the major cause of climate change. The most important GHG is carbon dioxide (CO_2), responsible for more than 60% of cumulative anthropogenic warming globally, and more than 90% of the warming over the last 10 years.[21] Historically, annually and per capita, the US produces more GHGs than any other country in the world.[19] (See Figure 1) In 2005, almost 39% of US CO_2 emissions came from residential and commercial buildings (of these 74% were from electricity generation and the rest from natural gas and fuel oil used for cooking and heating). Transportation generated 33% of CO2 emissions (60% of these are from personal vehicle use). (Figure

2) Industry was responsible for the balance of around 28%.[22] Since 1990, US CO_2 emissions from transportation, residential and commercial sources *increased* by 25%, 31.5% and 34.6% respectively, while they have *decreased* by 3.1% from industrial sources. Thus choices we make on a daily basis are, in aggregate, major components of the US emissions story. How and what we drive, how we light and heat our offices, and how we build our houses all make a difference.

There is reason for hope. Using current technologies that can be deployed rapidly, scientists and policy analysts have developed approaches to stabilizing and reducing GHG emissions over the next decades. For example, the Carbon Mitigation Initiative at Princeton University has proposed a plan based on the "stabilization triangle," the difference between zero growth of GHG emissions and projected "business as usual" growth over the next 50 years.(See Figure 3.) Their initial goal is to prevent doubling of CO_2 from pre-industrial levels – the doubling is a level above which it is believed that dangerous climate change is highly likely – buying time to develop additional clean energy and carbon sequestration technologies for future reductions. To achieve this, they have divided the stabilization triangle into 7 equal wedges and proposed solutions based on available energy efficiency and other technologies.[23] Another analysis suggests that deployment of aggressive energy efficiency programs for buildings and vehicles would be sufficient to offset energy emissions growth for the next 30 years.[24] California and the Northeast states are committed to aggressively developing renewable energy sources such as wind and solar power. Other approaches and technologies are proposed and more will be developed – but to avoid accelerating toward the "tipping point", action must begin now on known, straightforward GHG reduction strategies.

What the Healthcare Community Can Do

The United States has committed to strategies that will "prevent dangerous anthropogenic interference with the climate system" through the ratification in 1992 of the UN Framework Convention on Climate Change. Many of the changes needed to substantially alter the pace of climate change must come from governmental action, but, as health care professionals, we have a particular responsibility as well as opportunities to mitigate human influences on climate change. We can: 1) anticipate climate change-related health impacts on our local communities; 2) devise and implement adaptive strategies that will minimize illness, and 3) in our personal, professional and public lives, engage in actions to reduce GHG emissions, and encourage others –including government – to do the same.

In anticipation of more extreme weather events, we can work with local authorities to strengthen the public health infrastructure including early warning systems, and disaster preparedness and response plans. In areas where vector-borne illness is likely to increase, we can work to implement preventive strategies such as eliminating breeding grounds for rodents or mosquitoes, thus minimizing the need for the widespread use of toxic pesticides. In large cities subject to heat waves and concentrated air pollution, we can participate in programs to educate parents, teachers, child care providers and children, about using the heat index and air quality index. Each region faces different challenges; professionals who understand the vulnerabilities of children are needed everywhere.

The voice of health care professionals is powerful. We can work to become role models and champions of GHG reduction. Table 2 has a preliminary list of actions to be taken at home, in the office, at the hospital and in the community to help create a culture of conservation and energy efficiency. Educating the families in our care is part of the process (see Sidebar – Steps families can take). Educating the next generation of health care professionals is also part of the process.. Those of us involved in resident and medical student education can develop and implement ways to teach this new "non-traditional" but crucial part of health care. Table 3 lists some resources for additional information.

Responding to climate change on a personal level will often require changes in long-established practices – these changes may be difficult for some. Many of the actions that mitigate GHG do, however, have benefits. Energy efficiency saves money on energy bills. Reducing auto dependence promotes physical activity and helps fight obesity. GHG reductions will improve air quality and save lives, hospital visits and money. In many ways, actions to respond to the challenges of climate change are win-win activities. We hope that this article persuades readers to join the campaign to reduce GHG pollution – and that we can prevent climate change from permanently degrading the future for children we will never meet. The responsibilities and opportunities are ours.

Table 1

Major Health Effects of Climate Change[4, 25]

Phenomenon	Human Health Impact	Additional Child Specific Risks
Fewer cold days and nights	Fewer cold-related deaths	Children will benefit
Increased frequency of warm spells and heat waves	Increased heat-related deaths and illness	Very young at higher risk of death; older children will have more heat stress due to time spent in exercise outside
Increased heavy precipitation events	Increased risk of injury, death, infectious, respiratory, GI and skin diseases	Very young vulnerable to hospitalization and complications from infection
Increased areas of drought, wildfires	Increased risk of food and water shortage, malnutrition and infection, concentration of toxic water pollutants, injury and death	Growth retardation, developmental delay
Increased tropical storms and cyclones	Increased risk of injury, death, water-, food-, and vector-borne illness	Children may be more susceptible to injury, post-traumatic stress, certain infections
Increased air pollution	Exacerbation of respiratory illness, premature mortality	Children's small airways more susceptible to asthma, infection
Changes in distribution and potency of allergens, mycotoxins	More severe and more prevalent allergies	Allergies, cancer, birth defects
Increased sea level, saltwater intrusion into fresh water	Abrupt coastline change, forced migration, injury, drowning	Disruption of family and school infrastructure, other social disruption

Table 2-

Responding to Climate Change -- A **"Starter List"** of What Health Professionals Can Do

Adapting to Climate Change

In your practice
- Maximize immunizations
- Educate your families on use of heat, air quality and UV indices

Working with local public health officials
- Engage in disaster preparedness & response planning
- Develop low toxicity approaches to vector-borne disease threats
- Augment surveillance of climate-related infectious diseases

In your community/region
- Protect local drinking water sources
- Support local, organic agriculture
- Advocate for greener energy power sources

Minimizing Future Climate Change through Reducing GHG emissions

In your practice
- "Green" your office and hospital; if building, use the Green Guide for Health Care (GGHC) and consider LEED certification
- Institute policies to reward coworkers who bike/walk/carpool/use public transport (e.g. more flexible work hours to accommodate public transportation schedules)
- Develop educational materials and signage about reducing GHG for your patients.
- Educate patients and families about actions to reduce climate change (see sidebar)
- Educate medical students and residents on climate-related health problems
- Explore ways to do more by phone and electronically (CME, video cam consultations)

In your home
- Switch to compact fluorescent bulbs
- Turn it OFF when not in use
- Adjust your thermostat
- Do an Energy Audit
- Set computers to use existing features to automatically shift to lower power states or to turn off after extended periods of inactivity

In your travels
- Walk and bike more
- Change to a more fuel-efficient car
- Carpool
- Consider public transport
- Minimize and consolidate long distance travel

In your Community

- Speak locally about health reasons to reduce GHG emissions
- Ask your mayor to sign the "mayor's pledge"; become a Sierra Club "cool city"
- Offer expert testimony, Op-Eds, letters to the editor on health threats from climate change
- Engage medical students and residents in advocacy for the planet
- Participate fully as a citizen - vote, educate elected officials, volunteer, run for public office

Table 3

Resources with an Emphasis on Climate Change Solutions

Environmental Defense. "Fight Global Warming; what you can do"
http://www.fightglobalwarming.com/page.cfm?tagID=135

Green Guide for Health Care. http://www.gghc.org

National Resources Defense Council. "Solving Global Warming; it can be done."
http://www.nrdc.org/globalWarming/solutions/default.asp

Sierra Club. "10 things you can do to fight global warming."
http://www.sierraclub.org/globalwarming/tenthings

Stop Global Warming. "Take Action." http://www.stopglobalwarming.org/sgw_takeaction.asp

Union of Concerned Scientists. "Global Warming. What you can do. Ten personal solutions"
http://www.ucsusa.org/global_warming/solutions/ten-personal-solutions.html

US EPA. "Energy Star; Protect our Environment for Future Generations."
http://www.energystar.gov/

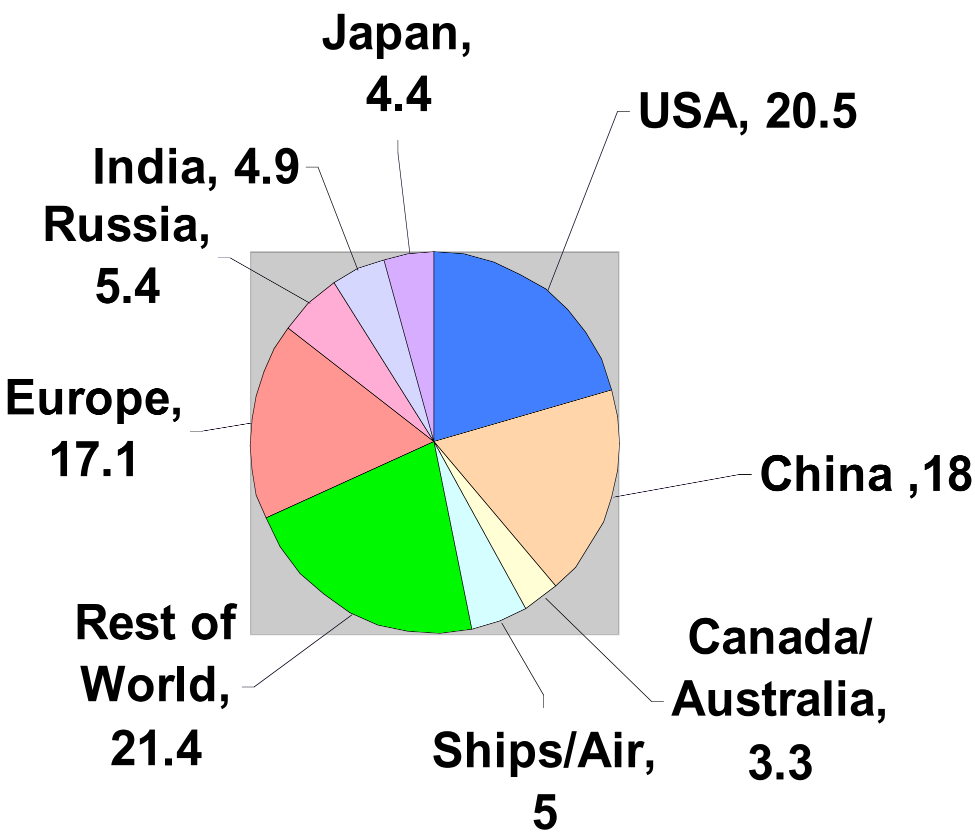
US Green Building Society "Leadership in Energy and Environmental Design"
http://www.usgbc.org/DisplayPage.aspx?CategoryID=19

World Wildlife Federation. "What you can do to switch off global warming"
http://www.panda.org/about_wwf/what_we_do/climate_change/what_you_can_do/index.cfm

Figure 1.

Percent Total Carbon Dioxide Emissions for 2005

Adapted from Hansen[19]

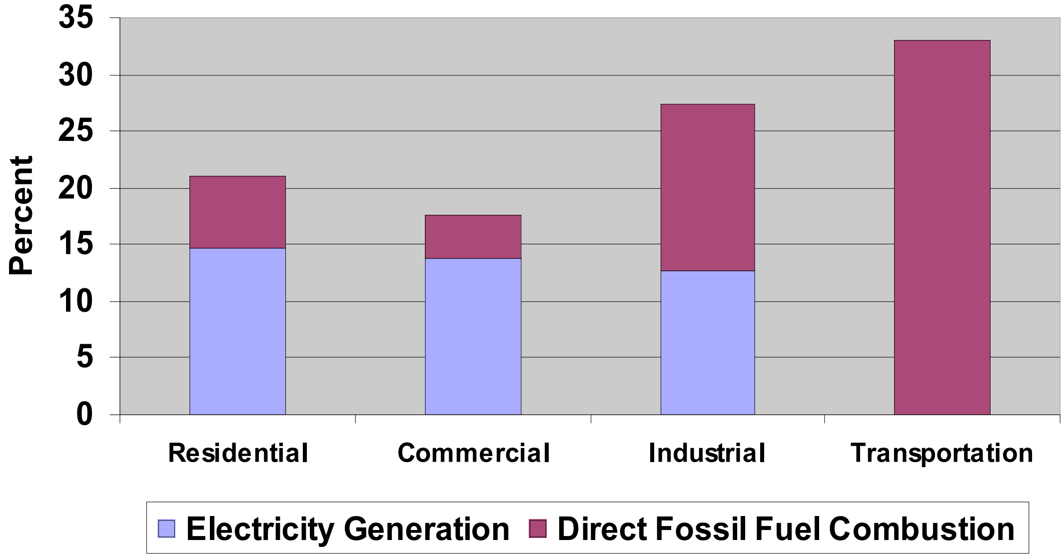


Caption for Figure 1:

The US, the leading GHG emitter in the world, was responsible for 27.8% of the cumulative emissions from 1750-2005. *Per capita* emissions in the US in 2004 were 20.18 metric tonnes/person compared to 3.62 in China, 1.04 in India, and 4.24 averaged globally (http://www.eia.doe.gov/environment.html).

Figure 2:

US CO_2 Emissions from Fossil Fuel Combustion Percent by End-Use Sector[22]



(percentages do not add to 100 because US territories have been omitted for simplicity)

Caption for Figure 2:
Sources of CO_2 emissions can be presented by "end-use sector"- residential, commercial, industrial, transportation – or by fuel source. Electricity, which is used for lighting, heating, air conditioning and running appliances, is separated out because it represents a very large portion of emissions. Emissions related to electrical generation vary by fuel type from very low emission (hydroelectric) to very high emission (coal). More than one-half of the electricity generated in the US comes from burning coal. Direct fossil fuel combustion refers to natural gas and heating oil used in buildings and by industry, and from petroleum (gasoline and diesel) used mostly in transportation.

Taken together, residential and commercial buildings are responsible for 39% of CO_2 emissions, three quarters of which are from electricity use. Industry produces 28% of annual emissions split evenly between direct combustion and electricity use. Transportation is responsible for 33 % of CO_2 emissions, the majority (60%) of which result from personal vehicle use.

Figure 3: The Stabilization Wedges (COPYRIGHT PERMISSION PENDING)

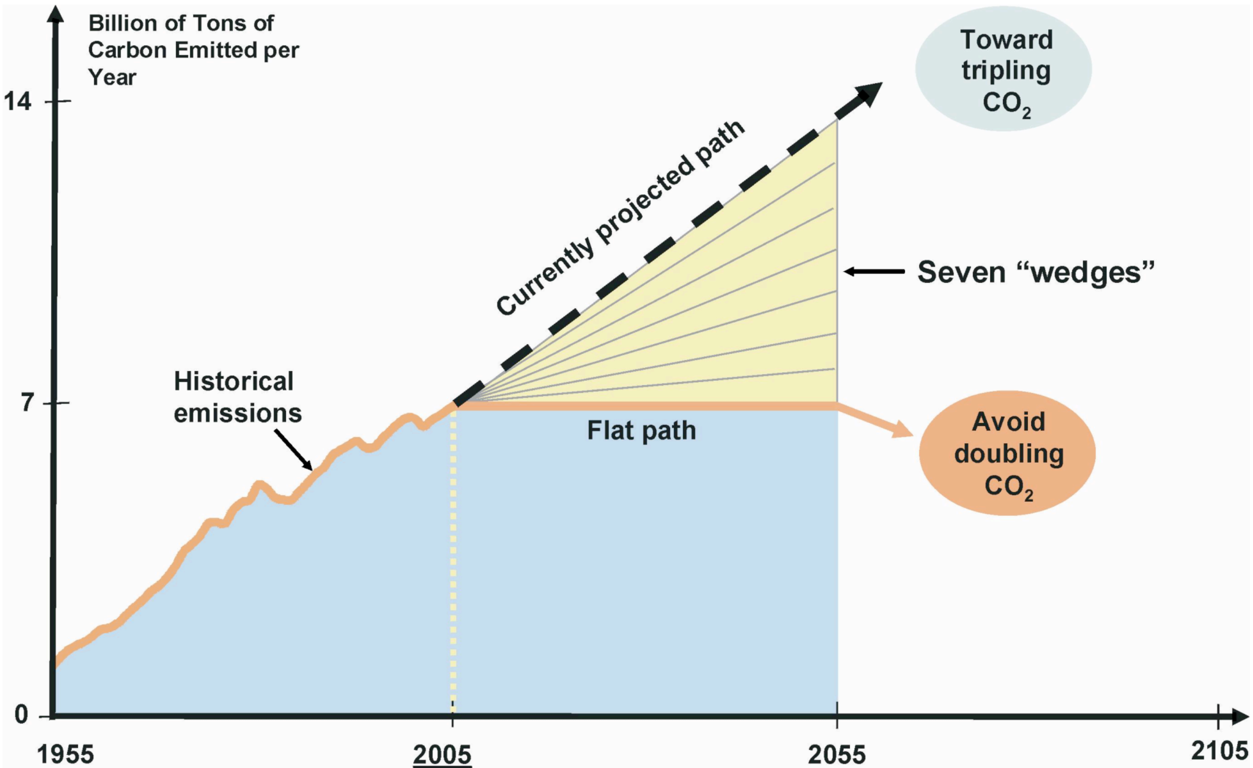
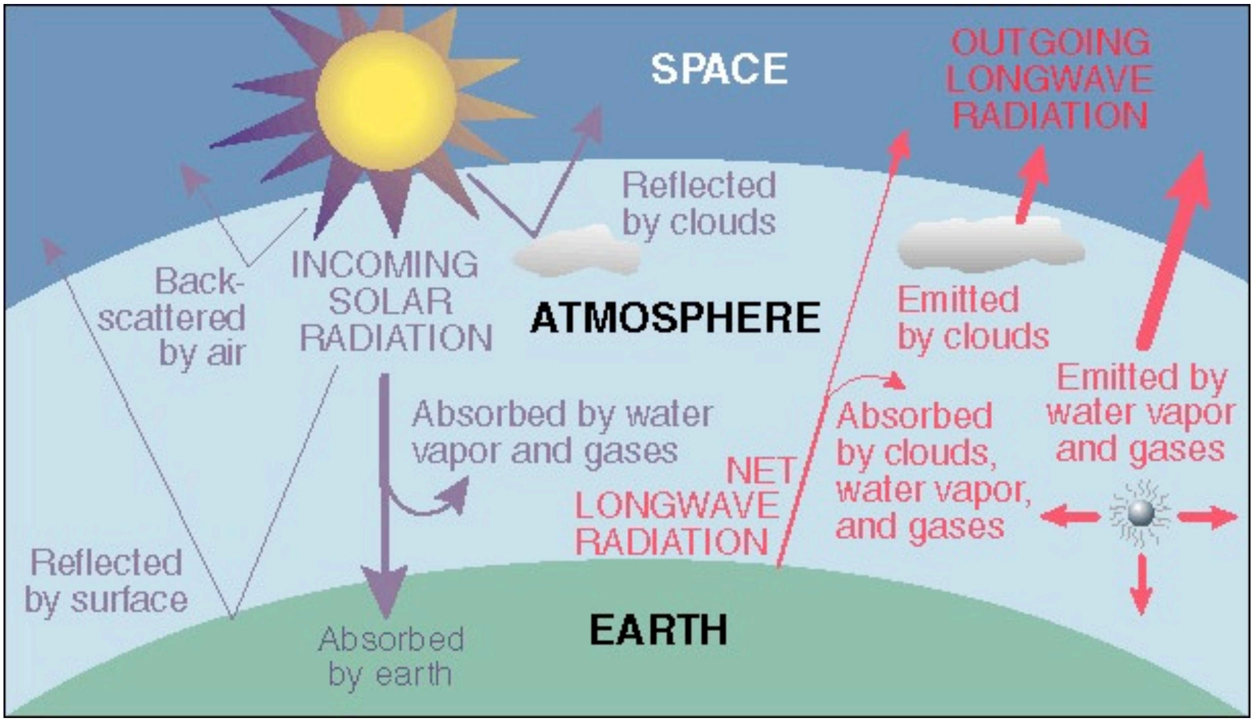


Image courtesy of Carbon Mitigation Initiative, Princeton University.

Caption to Figure 3:

In order to avoid doubling of current CO_2 emissions, the Carbon Mitigation Initiative (CMI) developed the concept of stabilization wedges. Current global emissions are ~7 billion tons of carbon/year. Assuming "business as usual" emissions growth rate that number will double in 50 years. Each "wedge" represents $1/7^{th}$ of the emissions that are needed to avoid carbon doubling in the next 50 years. The CMI proposes interventions using current technologies to achieve stabilization of carbon emissions at current levels. (http://www.princeton.edu/~cmi/resources/stabwedge.htm, accessed June 29, 2007).

SIDEBAR – Greenhouse Effect



The Greenhouse Effect is a crucial part of the Earth's climate system that maintains temperatures much warmer than would be expected from direct solar heating. Without the greenhouse effect, the Earth would be a frozen planet unable to sustain life. Incoming short wavelength, solar radiation (shown in purple) is absorbed and converted to long wavelength radiation (shown in red), at or near the Earth's surface. Heat results from the absorption of some long wavelength radiation by atmospheric gases including water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The greenhouse effect refers to retention of this heat in the atmosphere. Some human activities, particularly the burning of fossil fuels, increase the amount of greenhouse gases, primarily CO_2, resulting in more heat retained in the atmosphere.

Figure and caption adapted from http://pubs.usgs.gov/fs/fs137-97/fs137-97.html

Patient Handout

Things You and Your Family Can Do About Climate Change
(Adapted from Sierra Club and fightglobalwarming web sites[1])

The choices we all make in our daily lives affect the Earth. The coal used to generate electricity, the oil and natural gas that heat our homes, and the gasoline that runs our cars results in carbon dioxide (CO_2) being released into the air. Carbon dioxide increases the heat-trapping blanket that surrounds the planet, resulting in global warming.

Many things can be done to reduce our use of fossil fuels (fossil fuels are the oil, coal and natural gas that comes from decayed plants and animals). Here is a partial list of steps to take to protect the future of our planet.

At Home

Reduce! Reuse! Recycle!

Think about ways to reduce using unnecessary products – an example is bringing a cloth bag to the supermarket instead of having groceries bagged in paper or plastic. Reuse products whenever you can – pack your lunches in reusable containers instead of in paper and plastic bags, use a steel thermos for your homemade beverages or tap water. Use recycled paper – producing new paper, glass, and metal products from recycled materials saves 70 to 90 percent of the energy and pollution, including CO_2 that would result if the product came from virgin materials. Recycling a stack of newspapers only 4 feet high will save a good-sized tree.

Replace incandescent light bulbs with compact fluorescent bulbs.

Focus on the bulbs that burn the longest each day. Compact fluorescents produce the same amount of light as normal bulbs, but use about a quarter of the electricity and last ten times longer. In addition to making the air cleaner and curbing global warming, the step saves money on electricity bills and the cost of replacement bulbs. Look for the Energy Star label.

Save energy at home.

Turn off lights when you leave an empty room. Set computers to use existing features to automatically shift to lower power states or to turn off after extended periods of inactivity
Caulk and weather-strip doorways and windows. Adjust your thermostat – for each degree lower on your thermostat in the winter, energy bills are cut by 3 percent. Close windows when the heat or air conditioner is turned on. Ask your utility company to do a free energy audit of your home. Run your dishwasher only when it's full. These steps help the environment and save you money.

Save water.

Installing low-flow showerheads and faucets will save water without decreasing performance. Turning down the hot water heater to 120°F will result in hot water costs going down as much as 50%. This has the added benefit of being a safer temperature to prevent accidental hot water burns, especially in infants and young children.

[1] http://www.sierraclub.org/globalwarming/tenthings/

Buy energy-efficient electronics and appliances.
Replacing an old refrigerator or an air conditioner with an energy-efficient model will save you money on your electricity bill and cut global warming pollution. Look for the Energy Star label on new appliances or visit their website at www.energystar.gov to find the most energy-efficient products.

Outdoors

Smart driving
To burn less gasoline, make sure your car stays well-tuned car and has properly inflated tires. If you need a new car, consider buying an energy-efficient hybrid. Turn the engine off when waiting in line longer than 1 minute – for example, you can get out and talk to other parents waiting for school dismissal. Carpool or take the bus whenever you can.

Outside
Walk and bike more – these activities have health benefits too.
Plant greenery - planting trees and other greenery around the house will absorb CO_2, and decrease summer air-conditioning bills.

On vacation
Remember your energy saving habits when you travel by turning off lights and TV's when you leave the room. Many hotels offer the option of not having sheets and towels changed every day.

Get your kids involved
Our children are the ones who will inherit the planet. Teach your kids about global warming (and let them teach you!) and get the whole family involved. A checklist for kids can be found at http://www.fightglobalwarming.com/documents/5204_fgwdownloadkids.pdf

GLOSSARY – Selected Climate Change Terms[2]

Adaptation – adjusting natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Air quality index – a measure of daily air quality, the AQI focuses on health effects that may be experienced within a few hours or days after breathing polluted air. EPA calculates the AQI for five major air pollutants regulated by the Clean Air Act: ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. For each of these pollutants, EPA has established national air quality standards to protect public health. The index is color coded from Green (good) to Maroon (hazardous). (EPA, http://airnow.gov/index.cfm?action=static.aqi) The AQI may be included as part of local weather forecasts on TV and radio, or printed in the newspaper.

Biomass - all plant and animal matter on the Earth's surface. Fossil fuel is an example of biomass. Harvesting biomass and using it to generate energy such as heat, electricity or motion, is bioenergy. (http://www.aboutbioenergy.info/definition.html).

Carbon Sequestration - The uptake and storage of carbon. Trees and plants, for example, absorb carbon dioxide, release the oxygen and store the carbon. Fossil fuels, at one time living matter, continue to store the carbon until burned. (NOAA)

Climate - The average of weather over at least a 30-year period. The old saying is that climate is what we expect and weather is what we get. (NOAA)

Climate change – any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer). Climate change may result from natural factors, such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun; natural processes within the climate system (e.g. changes in ocean circulation); human activities that change the atmosphere's composition (e.g. through burning fossil fuels) and the land surface (e.g. deforestation, reforestation, urbanization, desertification, etc.) (EPA) Climate change is a broader concept than "global warming" which refers more specifically to temperature. See http://earthobservatory.nasa.gov/Library/GlobalWarmingUpdate/

Emission - the release of a substance (usually a gas) into the atmosphere.

Energy audit - the systematic analysis of energy consumption by and loss from a building or structure. Some utilities provide free energy audits for their customers.

Fossil fuel – oil, coal and natural gas that originates from decayed plants and animals.

Global warming – an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere, which can contribute to changes in global climate patterns. Global warming can occur from natural and manmade causes. In common usage, "global warming" often refers to the warming that can occur as a result of increased emissions of greenhouse gases from human activities.(EPA)

[2]For additional climate change terms see http://www.epa.gov/climatechange/glossary.html or http://www.climate.noaa.gov/index.jsp?pg=page_glossary.jsp&alpha=a from which many of these definitions were drawn

Global Warming Potential (GWP)- the cumulative radiative forcing effects of a gas over a specified time horizon resulting from the emission of a unit mass of gas relative to a reference gas. The GWP-weighted emissions of direct greenhouse gases in the U.S. Inventory are presented in terms of equivalent emissions of carbon dioxide (CO_2) For example, CO_2, responsible for about 62% of radiative forcing, has a GWP of 1. Methane, responsible for 20% of raidiative forcing, has a GWP between 20-24. N_2O, responsible for 6% of radiative forcing, has a GWP of around 300. (EPA)

Green Guide for Health Care (GGHC) – This is a best practices guide for healthy and sustainable building design, construction, and operations for the healthcare industry. www.gghc.org .

Greenhouse effect - trapping and build-up of heat in the atmosphere near the Earth's surface (troposphere). Some of the heat flowing back toward space from the Earth's surface is absorbed by water vapor, carbon dioxide, ozone, and several other atmospheric gases and then reradiated back toward the Earth's surface. If the atmospheric concentrations of these greenhouse gases rise, the average temperature of the lower atmosphere gradually increases. (EPA)

Greenhouse gases (**GHG**)- any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, but are not limited to, water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), ozone (O_3), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). The different gases have different global warming potentials and are often standardized to equivalents of carbon dioxide. (EPA)

Heat index - a measure of how hot it feels when relative humidity (RH) is added to the actual air temperature in degrees F. The heat index is sometimes referred to as the "apparent temperature (NWS http://www.crh.noaa.gov/jkl/?n=heat_index_calculator)

LEED (Leadership in Energy and Environmental Design) - the nationally accepted benchmark for the design, construction, and operation of high performance green buildings using the Green Building Rating System™ (http://www.usgbc.org/DisplayPage.aspx?CategoryID=19)

Mercury – atmospheric mercury enters bodies of water, is methylated by organisms and is taken up by fish that are eaten by other fish. The organic mercury thus biomagnifies, potentially reaching high levels by the time it is eaten by people including pregnant women. Organic mercury is a known neurotoxicant and can harm the fetus and young child.

Mitigation – actions to reduce GHG accumulation including decreasing emissions from burning of fossil fuels and increasing carbon storage in biomass such as forests.

Ozone – O_3, a gaseous atmospheric constituent. In the troposphere, it is created naturally and by activities resulting from fuel combustion. In high concentrations, tropospheric ozone can be harmful to living organisms. Tropospheric ozone acts as a greenhouse gas. In the stratosphere, ozone is created by the interaction between solar ultraviolet radiation and molecular oxygen (O_2). Stratospheric ozone plays a decisive role in the stratospheric radiative balance. Depletion of stratospheric ozone due to chemical reactions that may be enhanced by climate change results in an increase of ground-level ultraviolet (UV-) B radiation. (EPA)

Paleoclimatology – the study of ancient climate. One paleoclimatologic technique is to analyze the composition of trapped air bubbles in ice cores dating back hundreds of thousands of years; another is analysis of cores from ancient trees.

Radiative forcing - A change in the balance between incoming solar radiation and outgoing infrared radiation. Without any radiative forcing, solar radiation coming to the Earth would continue to be approximately equal to the infrared radiation emitted from the Earth. The addition of greenhouse gases traps an increased fraction of the infrared radiation, radiating it back toward the surface and creating a warming influence (i.e., positive radiative forcing because incoming solar radiation will exceed outgoing infrared radiation). (NOAA)

Sierra Club "Cool City" – a city that has made a commitment to stopping global warming by signing the US Mayor's Climate Protection Agreement. The Cool Cities campaign helps cities turn their commitments into action by promoting smart energy solutions. (Sierra Club http://www.coolcities.us/)

Stratosphere - the layer of atmosphere that lies about 15 to 50 kilometers above the Earth's surface. Ozone in the stratosphere protects the Earth from ultraviolet rays.

"Tipping point" – the concept that small changes will have little or no effect on a system until a critical mass is reached. Then a further small change "tips" the system and a large effect is observed

Troposphere - the lowest layer of the atmosphere that contains about 95 percent of the mass of air in the Earth's atmosphere. The troposphere extends from the Earth's surface up to about 10 to 15 kilometers. All weather processes take place in the troposphere. Ozone formed in the troposphere plays a significant role in the greenhouse gas effect and urban smog

Ultraviolet (UV) index - a measure to determine the strength of the sun's UV rays. The UV index helps people plan outdoor activities. Overexposure during days with high UV values can be harmful in the short term (e.g. sunburning) and over the long term (e.g. higher risk of skin cancer). The index scale runs from 1 (low danger) to 11+ (extreme danger). (NWS, http://www.crh.noaa.gov/ilx/?n=uv-index) The UV Index is available through TV and radio broadcasts and in newspapers in many cities in the US.

Vector-borne illness – a disease acquired when an organism (e.g. a mosquito or tick) transmits a pathogen (e.g. plasmodium or rickettsia) from one organism or source to another.

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