

# Climate Change: Our Future

**Carbon dioxide (CO<sub>2</sub>) emissions are warming the planet and must be substantially lowered soon to prevent harm**



## **Preface**

All environmental issues are, and will be, affected by global warming and the attendant changes in climate. This RACC module is a survey of current thinking of the large majority of climatologists and environmental organizations about the many issues of climate change. Each segment contains hypertext to direct the inquisitive reader to deeper levels or interesting asides. The module is not meant to be a course in climate change. It is meant to be helpful to those who wish to be themselves helpful.

And, by the way, all errors you might find are mine.

—Fred Fevrier

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## **Climate Change Module - Sections**

EVIDENCE OF WARMING

CAUSE OF WARMING

NEED TO LOWER CO<sub>2</sub> EMISSIONS

HARM OF UNCHECKED WARMING

LONG TIMESCALES TO CONSIDER

HURDLES

THE PLAN: RENEWABLES

THE MITIGATION OF CO<sub>2</sub>

NEEDED INNOVATION

WHAT WE CAN DO

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## Evidence of Warming is Strong

- Winters are warmer, summers are [hotter](#). See [here](#) also.
- [Plants](#) are budding earlier in spring, losing leaves later in fall.
- Almost [all glaciers](#) are melting, and many will disappear soon. See [video](#)
- Sea level is [rising](#) from glacier [melt-water addition](#) and heat expansion of water. See [video](#) , another [video](#), [Scientific American](#), yet another [video](#)
- Ocean water is [warming](#) at an increasing rate.
- The Arctic [sea ice is shrinking](#) and the [West Antarctic ice](#) is melting. [video](#)
- The [Greenland ice cap](#) is melting at an increasing rate.
- Weather is getting [more extreme](#): heavy rainfall events and regional droughts are more intense, as predicted by climate models.
- Forest fires are larger and more destructive, fueled by regional droughts
- [Measured heat](#) coming down from the sky is increasing in step with CO<sub>2</sub> increase.
- Hurricanes are [more powerful](#) on average as predicted by climate models.
- Record high temperatures are far [more common](#) than record lows.
- Globally, the two years (2014 +2015) are the [hottest on record](#) since 1880.
- The [range](#) of plants and animals is moving northward in our hemisphere or up in elevation.
- Hot, more acidic ocean water is [killing large areas of coral](#) worldwide.
- Wide areas of [forest](#) destruction are related to drought and warmer winters. See [video](#)

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## CO<sub>2</sub> Is the Main Cause of Global Warming

- Warming, to be explained by science and common sense, requires a new or increasing heat source.
- The [level of CO<sub>2</sub>](#) in the atmosphere is increasing as warming increases. CO<sub>2</sub> has [long been thought a greenhouse gas](#), or an atmospheric gas that reflects heat from the sky back to Earth.
- No warming mechanism other than the increasing of atmospheric CO<sub>2</sub> fits the timing and strength of warming. This [excludes](#) other heat sources, like increasing [sunlight](#), cosmic rays, volcanic activity, increase in Earth's core temperature, plate tectonic heat release, etc. Other [greenhouse gases](#) add fractionally to warming except water vapor, which is a greenhouse gas whose increase depends on temperature only.
- Scientists ([Feldman 2015](#)) made daily [measurements](#) of infrared heat radiated down to Earth from the overhead clear sky at two locations over 10 years. They [measured only heat coming from CO<sub>2</sub>](#) in the air that was heated by sunlight and heat reflected from the Earth. At the same time, they estimated [daily atmospheric concentration of CO<sub>2</sub> overhead](#). They found that measured heat on the ground from the sky increases when the overhead CO<sub>2</sub> concentration increases. They also found that the amount of heat radiated down decreases when CO<sub>2</sub> in the sky above decreases in concentration. Thus, increasing atmospheric CO<sub>2</sub> is increasing the warming of the Earth's surface.
- Scientists (Feldman) found something else, of even greater importance. They determined that the total amount of increased heat coming down to the ground from CO<sub>2</sub> radiation increase alone [explained most of Earth's increased warming during that 10 year period](#). **Now we are sure that increasing atmospheric CO<sub>2</sub> is the major cause of global warming and climate change.**
- Scientists were not surprised by Feldman's results. Scientists measured physical properties of CO<sub>2</sub> and long ago surmised that CO<sub>2</sub> trapped heat in the atmosphere (called the [Greenhouse Effect](#)) had kept Earth warmer than expected. Weather balloon and airplane measurements of CO<sub>2</sub> and local atmospheric temperatures strongly suggested CO<sub>2</sub> as the cause of global warming. Feldman proved it.
- Measurements made by satellites (outside of Earth's atmosphere) of [heat radiated out to space](#) show a decrease over time as Earth's surface warming increases, consistent with the notion that CO<sub>2</sub> is preventing heat from escaping the atmosphere.
- A great [majority](#) of published climate scientists and US science organizations support the fact of global warming caused primarily by rising manmade CO<sub>2</sub>. Also [see](#) and [see](#).

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## **We Must Lower CO<sub>2</sub> Emissions Soon to Slow Warming**

- [Inter-national agreements \(IPCC 2015\)](#) have set 3.6°F as an obtainable global average temperature rise above preindustrial (1750) levels. A higher temperature increase will have greater [consequences](#).
- Scientists have [estimated](#) that to have a 60% chance of keeping the temperature increase below 3.6°F, we must release not more than 1000 gigatons (Gt) of CO<sub>2</sub> to the atmosphere ( one gigaton = one billion tons) over the next 25 years.
- The [global CO<sub>2</sub> release](#) rate is currently about 35 Gt/year and increasing. See [here](#).
- The greater the amount of CO<sub>2</sub> emitted by burning fossil fuels, the higher Earth's temperature will rise and the worse the impacts will be. So, the sooner, the better applies.

The amount of CO<sub>2</sub> that would be released by burning all fossil fuel reserves [far exceeds the safe limits on emissions](#). Scientists estimate that 80% of coal, 50% of gas, and 30% of oil reserves must [be unburned](#) (left in the ground) to limit the temperature increase to 3.6°F, avoiding the extreme scenario.

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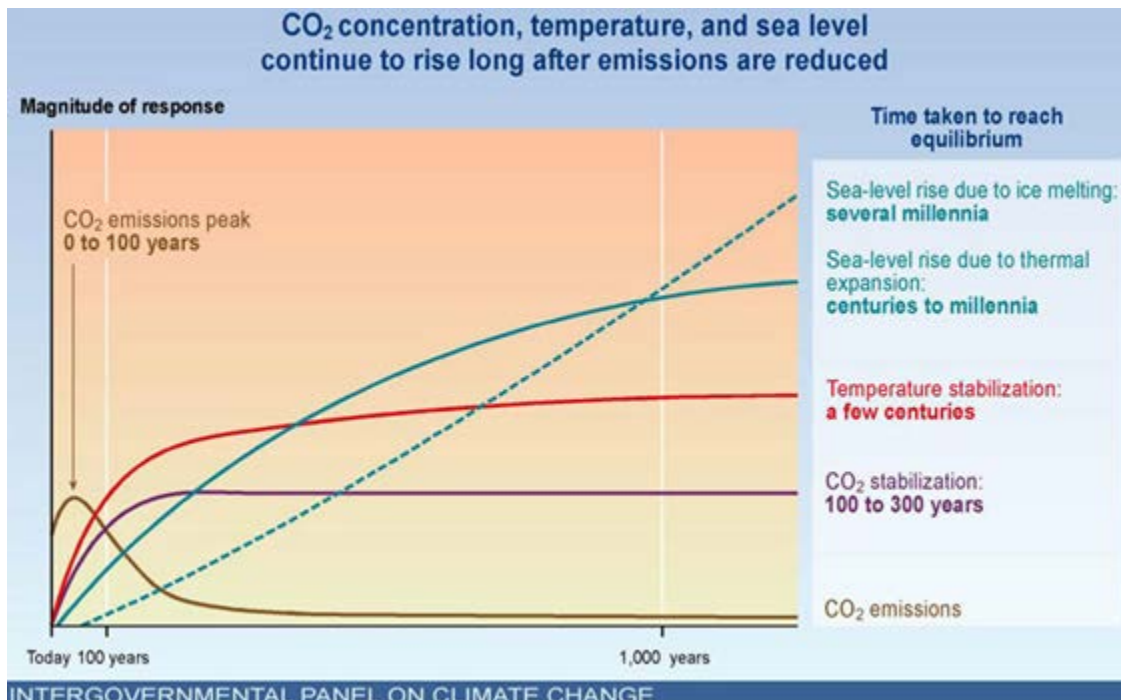
## Delaying Lowering CO<sub>2</sub> Emissions Means Increasing Warming and Climate Change Harm

- Once emitted, a substantial amount of [CO<sub>2</sub> remains in circulation](#) for “centuries”. So the warming effect of CO<sub>2</sub> released today lasts a long time. Not producing CO<sub>2</sub> is far preferable to trying to remove the gas from smokestacks or the air. [Removal of CO<sub>2</sub> from air](#) is slow and expensive, and storage is problematic.
- [Climate models](#) predict that [higher CO<sub>2</sub> levels will cause](#) hotter summers, more intense and longer-lasting heat waves, stronger storm systems, more intense flooding events, and intensified periods of drought. See MIT [video](#)
- Even moderated warming (lowered CO<sub>2</sub> emissions) will affect [food production](#). Unchecked warming (continued increasing CO<sub>2</sub> emissions, sometimes called “business as usual”) could seriously [disrupt global food output](#) due to heat, local extremes of drought and flood, and increased soil water evaporation.
- If [all the Earth’s ice melts](#), the oceans could rise up to 240 feet, flooding hundreds of millions of homes and hundreds of major cities worldwide. We could expect wide social displacement, albeit over many centuries, with major risk of [political instabilities](#) on all scales. See [here](#).
- Sea level rise of 6 feet is predicted by 2100 [in Virginia](#) and the world. Storm events will destroy homes, [businesses](#), and civil infrastructure, with the [need to rebuild](#) or “retreat.” (Important: websites constructed before March 2016 use the old prediction of 3’ of sea level rise by 2100; [new science](#) and insurers now says 6 feet).
- Rising sea level will likely continue until CO<sub>2</sub> greenhouse heat from the sky decreases. Scientists have called for future lowering of [CO<sub>2</sub> level below 350 ppm](#), thus hopefully slowing the melting of ice that causes sea level rise.
- More intense [ocean acidification](#) from increased atmospheric CO<sub>2</sub> beyond IPCC targets may [prevent calcification of the shells of sea creatures](#) that remove enormous amounts of carbon from the sea (and thus the air), resulting in still more warming.

Climate change will [adversely](#) affect health and mortality. [Heat stress](#), augmented [infectious disease](#) patterns, falling air quality, homelessness, flooding will each take a toll. See [here](#). WHO [here](#).

## Long Timescale Considerations are Ominous

### Stabilizing Earth's temperature will require a long time after CO<sub>2</sub> emissions are controlled



IPCC climate projections, 2014, of lowered CO<sub>2</sub> scenario: Even though emissions are lowered “today”, actual CO<sub>2</sub> levels rise for some time, but temperature takes longer to plateau, while melting of ice and rising sea level continue for possibly thousands of years, to a maximum 240 feet.

- The longer we wait to lower CO<sub>2</sub> emission rates, the longer it will take for Earth's climate to stabilize and the higher will be the stabilized temperature.
- Global CO<sub>2</sub> emissions are currently increasing. The recent [2016 Paris Conference of Parties \(COP 21\)](#) accords signed by 195 countries stated "that much greater emission reduction efforts will be required in order to hold the increase in the global average temperature to below 2 °C" by 2050.
- Many factors known to affect climate are included in models that calculate future conditions. Some of these factors have poorly understood strengths. Examples of these are: atmospheric aerosol reflection of heat, other greenhouse gas emission rates, change in ocean CO<sub>2</sub> uptake affected by acidification, emission rate of soil CO<sub>2</sub> caused by soil warming and water loss, methane emission by thawing tundra, tree and plant CO<sub>2</sub> uptake rate change as warming increases, ocean emission of methane from hydrates, and others. See [Climate Forcing](#) or [more advanced Climate Forcing](#).
- Presently unknown effects that are not now foreseen may well come into play at higher average temperatures. This possibility is unsettling. See [here](#)

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## Hurdles to Reducing CO<sub>2</sub> Emissions

- Background: a substantial amount of emitted [CO<sub>2</sub> remains](#) in the air for a very long time (centuries). Newly emitted CO<sub>2</sub> rapidly redistributes worldwide to affect the entire globe.
- [Fossil fuel reserves are currently worth about \\$28 trillion](#). The reserves have no immediate economic value if left in the ground. Fossil fuel companies and their investors are reluctant to accept the move to carbon-free energy sources. See [here](#).
- The world's transportation, heating, cooling, and electrical generation systems are based largely on oil, gas, and coal. Lowering [CO<sub>2</sub> emissions](#) enough to help Climate Change is impossible without converting to wind and solar energy (renewable energy) and/or nuclear fission or fusion (if developed). But any conversion will require massive investment, innovation, and public willingness to change and adapt.
- Developing countries are reluctant to give up current systems and practices based on fossil fuels and forest burning they cannot afford to replace. They see the large [carbon footprint](#) of persons living in developed countries and point out that it is many times that of their citizens, and that the developed world should partly finance developing world changes toward CO<sub>2</sub> mitigation.
- Developed countries do not want to disadvantage their economies with massive investments and new taxes unless other developed countries are committed likewise. **So mutual agreement is a delicate but critical element in reducing CO<sub>2</sub> emissions worldwide.**
- The world population, 7.4 billion, is [still growing](#), mainly in the developing world. Since every person has a [carbon footprint](#), world CO<sub>2</sub> emissions will tend to increase on the basis of population growth alone.
- Public understanding of the reliability of climate science and its projections has been undermined by [disinformation](#) disseminated by the fossil fuel interests. See also [here](#) and [here](#) and [here](#) and even [here](#).
- We each are different in our degree of willingness to accept some [responsibility](#) for a share of climate change. The [carbon footprint](#) exercise shows that we all make CO<sub>2</sub> and we all have opportunities to reduce our CO<sub>2</sub> footprint.
- The willingness to act to diminish one's carbon footprint varies widely, in part because "action" implies for some a denial of pleasures many of us expect: meat at every meal, vacations by air travel, pleasure drives in the family car, long hot showers, food grown on other continents.
- Current US political funding methods include the unlimited influence of vested interests on regulation and public policy, coupled with the infusions of public misinformation about Climate Change and intimidation of outspoken scientists, have resulted in a Climate Change policy gridlock in the US. [See Video](#)

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## The Plan to Lower Our CO<sub>2</sub> Emissions

- We need to reduce our carbon footprint, as a country and as individuals. All countries of the Earth must be encouraged to do likewise.
- We must slow way down or stop our use of coal, oil, gas, and forest destruction. We must make electricity with energy sources that don't need burning. [Germany](#) has already converted most of their electric power generation to wind and solar (called **renewables**). Why can't the United States do this?
- To limit temperature rise to 3.6°F, we must replace gasoline motors with electric motors and insulate homes and buildings more efficiently. See: [US CO<sub>2</sub> emissions](#).
- Our electricity can easily be generated by "renewables": solar, hydroelectric, and wind (and nuclear, possibly) to power the electric grid. If only solar panels were used, the land area required to power the whole of USA today would be 3 Texas counties. See [Elon Musk](#).
- Other areas of needed change: [air travel](#), [cement use](#), [forest burning](#).
- We need to negotiate and cooperate with the other 194 countries that signed on to the IPCC Paris December 2015 accords.



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## Toward Climate Mitigation

### Moderating Climate Change Requires Coordinated Action by Citizens, Governments and Corporations Worldwide

- The origin and volume of CO<sub>2</sub> being emitted by all countries globally clearly points to the idea that any solution must arise from negotiation, mutual agreement, and cooperation. The IPCC is the venue for this to occur. Governments of the world must continue to cooperate on Climate Change agreements.
- [Satellites](#) in orbit now can detect and measure the real time sources of CO<sub>2</sub> emission. Verifiability is in place.
- The United States needs to further incentivize the people, corporations, utilities, and state and local governments to install effective wind and solar electrical generation while de-incentivizing coal and oil-based electrical generation that increases CO<sub>2</sub>. See [here](#)
- The United States needs to consider a [Carbon credit](#) and/or [carbon fee/tax](#) or other disincentive scheme that as fairly and evenly as possible directs societal behavior toward lower net carbon emissions. Tax policy needs to point corporate behavior toward lower CO<sub>2</sub> emissions and needed innovation investment. The aggregate fees might be directed to CO<sub>2</sub> capture, and fees themselves might be tied to CO<sub>2</sub> capture cost (estimated currently at \$25-50/ton when scaled up).
- Utility companies should envision a new role. They must be encouraged to [support](#) home-owner solar installation grid connections.
- Informed citizens **must** be the driving force for these changes if Government lags. Voting can drive change.
- Selling fossil fuels to non-complying nations should be prohibited.
- Sweden's decarbonizing [success](#). Germany's [progress](#). California's [doing it](#). Canada [electrifying but still pumping oil](#).
- [Fossil fuel recovery tax incentives](#) must be stopped.
- [Methane leaks](#) need an aggressive legal framework to plug.

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## We Need Innovation Now

- Improved renewable energy generation and storage systems are required to reduce CO<sub>2</sub> emissions.
- Higher efficiency, [very large batteries](#) and electrical storage systems are needed for all grid and large transportation applications of electrical motive power. Innovation need in this area is extreme.
- Safer, very long-term radioactive waste storage must be solved before nuclear energy may be acceptable to the public (if ever).
- [Perovskite-based solar cells](#) offer superior efficiencies but need further development.
- [Power grids](#) need upgrading and hacker protection
- Railroads should be [electrified](#) (here read the commentary by railroad engineers, as the article gives scant mention of CO<sub>2</sub> emissions), both passenger and freight. See [impediments](#).
- Fossil fuel burning coupled with efficient [smoke stack CO<sub>2</sub> capture](#) with long-term/permanent underground storage might prove helpful and acceptable; full scale demonstration projects have been unsuccessful.
- Large scale [carbon capture](#) and storage technologies are needed to lower atmospheric CO<sub>2</sub> and to price carbon credit schemes.
- [Uber driverless electric cars](#) with improved public transportation may satisfy the need for private vehicle ownership for many.
- [Video conferencing](#) is replacing much business travel. Improved, standardized video conferencing will further replace business travel.
- Next-gen video travelogues of high quality offer advantages over travel itself: security, comfort, and economy: they may dent airplane travel tourism someday.
- And many more.

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## What We Can Do

- Learn more about climate change and its many aspects; stay informed. Online course: [here](#). Another: [here](#). Text and climate model runs: [here](#).
- Learn about uninformed points of view. See [here](#) , Arguments and Resources; [Mis-informers](#).
- Take the time to estimate your Carbon Footprint. See [Carbon Calculator](#) ; take time with the Calculator and see how much you can learn from it.
- Receive Climate Change email news: regional [CAAV](#), [Climate Central](#), [UCSUSA](#), [NRDC](#)
- Talk about climate change to neighbors, friends, and family. Easy is good, scary is not.
- Think about what changes you believe need to come about to improve the outcome of climate change and talk to your state and national elected representatives involved in those decisions. See [EDF](#), [action](#) UCSUSA; these sites have petitions to sign and send to key lawmakers.
- Write a letter stating your point of view to newspapers or magazines. Enter the email addresses of your elected State and US representatives in your computer and let them know what you think is important.
- Join a local or national group that parallels your point of view and furthers your knowledge base. List of 47 US [organizations](#)
- Be aware that effort to reduce your carbon footprint cannot replace the need for necessary national carbon policy change. If you must choose to direct effort toward only one, choose policy change.
- Try to accept new landscapes that arise from needed new technologies like solar arrays. Challenge yourself to see necessary changes in a positive light. No mitigation will be the greater burden.
- Sign up for a custom Google search engine for Climate Change News, Desmog [here](#)

continued on the next page

### **What We Can Do** (continued)

You can help Climate Change and saving money at the same time. . (The next 9 suggestions will definitely save you money)

- **Reduce, reuse, and recycle if you don't already.**
- **Change the lightbulbs to [LED lights \(Energy Star\)](#), starting with the most-on, most used lights in your home. Environmental Protection Agency (EPA) estimates that you will save approx. \$200 for every 5 bulbs you replace, all while using up to 75% less energy.**
- **Seal leaky windows and doors with weather stripping. See [here](#).**
- **Buy Energy Star-rated high efficiency appliances, heating, and cooling equipment.**
- **Learn to fix leaky toilets and faucets; then fix them.**
- **Consider installing [solar panels](#). Currently, a 30% tax credit, dollar for dollar. (See[here](#)).**
- **Use a bike to get around. Or even walk.**
- **Buy a fuel-efficient (electric second car?) car when you do. And keep your [tires up](#).**
- **Take the train for intercity travel** – and join an organization that offers rail ticket discounts. [Amtrak](#) currently serves Staunton, Charlottesville, and Lynchburg, and is scheduled to serve Roanoke in the not-to-distant future – no security lines and wifi on board!
- OK, [here's](#) a 50 thing list. Wig out.
- [Plant trees](#) and capture from 3-8 tons of CO<sub>2</sub>/year per acre. Mature trees have been recently found more effective at CO<sub>2</sub> capture than was previously thought.
- [Stop junk](#) mail at this website.
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