CLIMATE

Climate Change and Midwest Power Plants

CLEAN AIR TASK FORCE

77 Summer Street, Boston, MA 02110

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Power plant on the Ohio River.

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Front Cover: Photograph of the five Great Lakes, USA and Canada, with Lake Michigan and Chicago in the foreground. Photo taken by astronaut from space shuttle at 156 nautical miles above Earth, June 1991. Source: NASA Earth from Space photo # STS040-077-044.

Back Cover: Satellite image of the Great Lakes, OrbView-2, August 15,1999. Provided by the SeaWiFS Project, NASA/Goddard Space Flight Center, and ORBIMAGE.

Introduction

Our climate is an ever-changing natural system of complexly linked relationships between the atmosphere, the land and the oceans. But as population has spiraled upward in the past century, our use of energy and other resources has disrupted the delicate balance in the Earth's systems. We must begin to right this imbalance.

While our climate has always been dynamic and characterized by change, the dramatic alterations occurring in the atmosphere and oceans are now clearly outside of the realm of natural variations. In particular, human use of fossil fuels has begun to change the fundamental composition of the atmosphere in many ways, causing it to more effectively trap solar radiation, leading to the one degree Fahrenheit increase in global mean temperature measured in the past century. Manmade carbon dioxide that has already accumulated in the atmosphere will continue to warm our planet for many decades – if not centuries – to come. Even the most aggressive emissions reductions scenarios examined by researchers may be unable to stem a further warming of the next few degrees– *but we can begin today to reverse this trend.* In the United States, warming may manifest in climate changes that some argue could be accommodated by adaptation. Indeed in some regions, including the Midwest, there may even be some benefits (for example, increased yields in some crops). However, if we do not begin to reverse this trend by taking aggressive action to reduce future carbon emissions, scientists predict future increases in temperature of 5 to10 °F. This magnitude of warming is predicted to result in more severe consequences in our region and around the country. Moreover, while developed nations such as the United States may have the ability to partially adapt to the smaller changes in climate, the outlook for the poorest developing countries is dire in all plausible future carbon emissions scenarios.

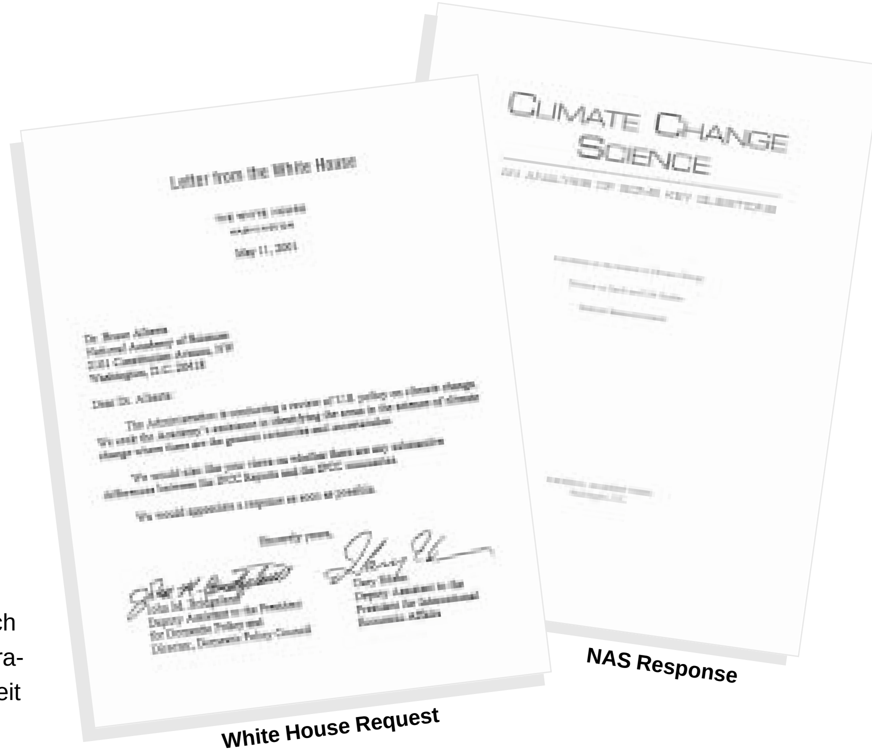
We Are at the Heart of the Problem…and the Solution

The United States emits the most greenhouse gases per capita, over six times the rest of the World.[1] As compared to the rest of the World, we use over seven times the electricity per capita, yet we represent less than five percent of the World's population.[2] The six Midwest states of Minnesota, Wisconsin, Michigan, Illinois, Indiana and Ohio, described in this report, bear a special responsibility. **These six states are home to 140 CO_2 producing power plants that annually release about two percent of the planet's total man-made CO_2, eight percent of the nation's total man-made CO_2, and 25 percent of the CO_2 released by power plants in the U.S.**[3,4] Two major Midwest power companies – American Electric Power and Cinergy – *each* contribute two and one percent of the nation's total manmade CO_2 emissions respectively.[5] If the Midwest leads the U.S. in curbing its substantial electricity-related CO_2 emissions, we can begin to steer our country's course towards a solution that will benefit the Midwest and people around the world.

It is important that we think beyond our own back yards as stewards of our planet and as major contributors to the problem. Unlike smog, solutions to climate change are not region-specific, and therefore the abatement of greenhouse gases from the Midwest region's concentrated coal fired electric utilities should be both Midwest and national priorities. This report outlines how the Earth's climate has changed, and how the World's top scientists believe it could change in the future with a focus on six Midwest states. Federal policy is currently being proposed to limit growth of carbon dioxide emissions and other climate pollutants from U.S. power plants. If the substance of this important policy is made law, the United States will have contributed an important step towards limiting the risk of major changes to our climate, while at the same time providing cleaner air to breathe and helping to ensure a healthy future for our children and for generations to come.

Is Climate Change Real?

Over the past few decades, a debate has raged over climate change. But the World's top climate scientists are no longer asking if climate change is real; instead they are investigating how our climate is changing. According to a 2001 National Academy of Sciences (NAS) report requested by President Bush, ***Climate Change Science: An Analysis of Some Key Questions***, the NAS concurs with the Intergovernmental Panel on Climate Change (IPCC) scientific report[6] which concludes that global average surface temperatures may increase by 3-10 degrees Fahrenheit (°F) by the end of this century as a result of human activities.[7] IPCC also documents how climate change has already begun to take its toll. Scientists have determined that the 1990s were the warmest decade of the millennium, and 1998 the warmest year.[8] At the same time, according to the Energy Information Administration (EIA), greenhouse gases emissions increased by 3.1 percent in 2000, the second largest increase in the decade.[9]



"The committee generally agrees with the assessment of human-caused climate change presented in the IPCC Working Group I scientific report... The predicted warming of 3 °Celsius (= 5.4 °F) by the end of the 21st century is consistent with the assumptions about how clouds and atmospheric humidity will react to global warming."

How Our Climate is Already Changing

The Earth has an energy imbalance: more energy enters the Earth's atmosphere than leaves it, resulting in a net increase in heat in the Earth's system and increasing temperatures. As confirmed by the recent NAS Report, global mean temperature has already increased about 1°F since 1900 (Figure 1) largely as a result of man-made air pollution emissions.[10] During the same period, North America has warmed about 1.25 °F. Although temperatures are warming globally, there is regional variability. For example, based on recent estimates of North American data, mean temperatures have fluctuated up and down in North America over the past century. Temperatures hit their highest recorded levels in the 1990s although temperatures had peaked previously in the 1930s to similar levels (Figure 2).[11] The same study suggests

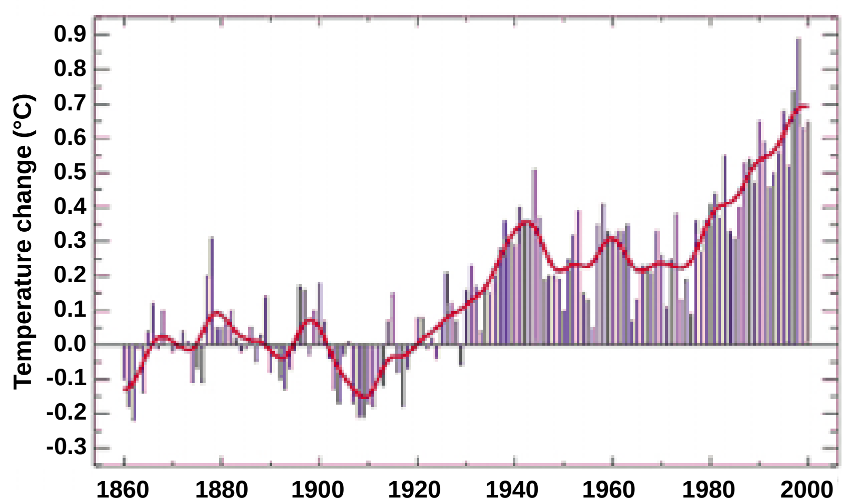


FIGURE 1 —

Over the past century, mean global temperature has increased by about 1 °F (0.6 °C).

that the Midwest region has become warmer over the past century. Despite regional variations in temperature in the U.S. and around the world over the past century, the 1990s were the hottest years on record globally.

> *"In light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the past 50 years is likely to have been due to the increase in greenhouse gas concentrations."*
>
> — *Intergovernmental Panel on Climate Change, Geneva, March 2001*

A second NAS report released in late 2001, *Abrupt Climate Change: Inevitable Surprises* suggests that recent widespread changes in climate have occurred with "startling speed" and that, "greenhouse warming and other human alterations of the earth system may increase the possibility of large, abrupt, and unwelcome regional or global climatic events."[12]

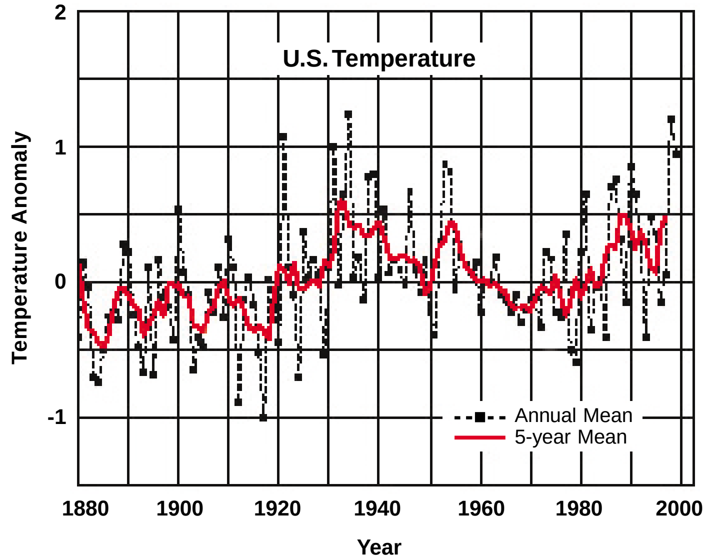
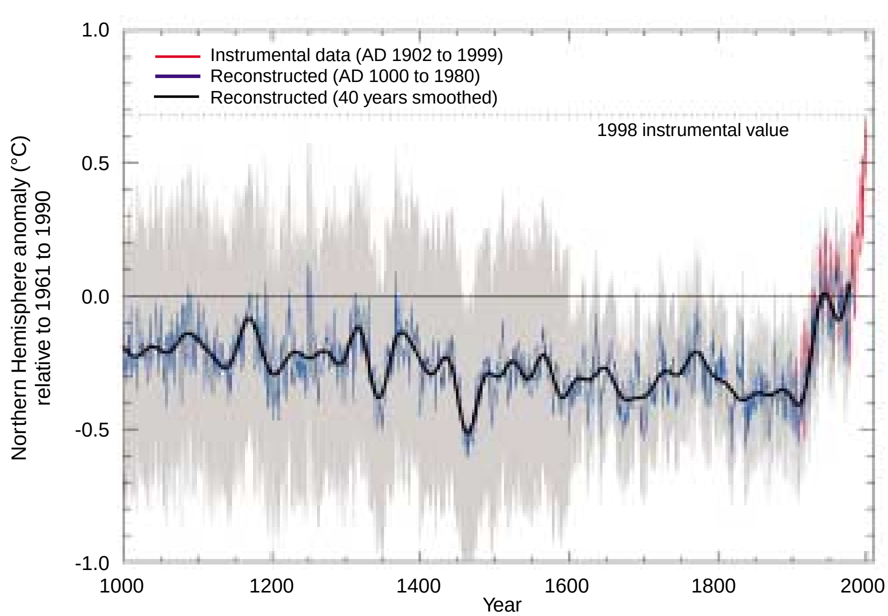


FIGURE 2 —

Corrected temperature trends at U.S. meteorological stations (Hansen et al 2001) demonstrate regional variability in climate while global mean temperatures have steadily risen. In the U.S. temperatures recently met and exceeded their previously highest levels – levels seen in the 1930s. The same measurements show that Midwest temperatures have risen over the past century.

The Earth's Changing Climate

In the past one hundred years, global surface temperatures have increased by over 1 °F. About half of this change has come since 1970. Moreover, 17 of 20 years since 1980 were the warmest of the century, with 1998 topping the list. These temperature changes for the twentieth century are higher than for the previous 1,000 years. Corroborating measured changes in our global atmosphere, a recent report also documents a buildup of heat in the oceans – a more robust measure of our changing environment.[13] At the same time, global sea levels have risen an average of 4-8 inches, glaciers continue to melt at both poles, and mountain glaciers recede in Glacier National Park and other locations around the world.

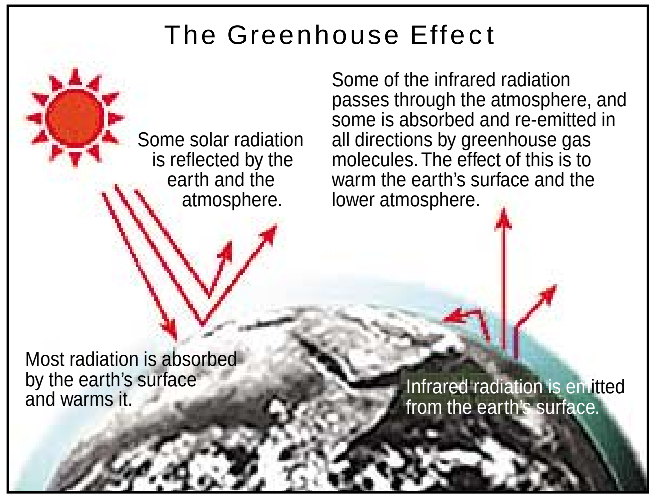


The Role of Pollutants in Climate Change

The greenhouse effect occurs when ultraviolet light transmitted from the sun into the atmosphere becomes heat and is absorbed by atmospheric gases, much as light is converted to heat (infrared) and is trapped inside a greenhouse or sunroom (Figure 3). The “greenhouse gas” that is associated with the strongest positive climate forcing effect (warming) over the past century is carbon dioxide (CO_2). Ground level ozone pollution, methane and chlorofluorocarbons (CFCs) are also important greenhouse gases. CO_2 can stay in the atmosphere for centuries. Power plants are key contributors to the buildup of both CO_2 and ground-level ozone. All of these gases have increased substantially over the past century. For example:

- Atmospheric concentrations of CO_2 increased from 280 parts per million in 1750 to 367 ppm in 1999, a 31 percent increase;[14]
- Today’s CO_2 levels have not likely been exceeded in the past 20 million years and have not been surpassed in the past 20,000 years;
- Ground level ozone – an atmospheric pollutant that the Clean Air Act is aimed at reducing – is the third most important greenhouse gas;
- Black carbon soot, although not a greenhouse gas, is a light and heat-absorbing warming agent and contributes to unhealthy fine particulate matter air pollution.

While the impacts of black carbon and ozone are more short term, carbon dioxide may linger in the atmosphere for a century or more in part due to the length of time it takes for the oceans to absorb it. Although mitigating black carbon emissions and ground-level ozone from a variety of sources should be adopted as an effective additional short-term strategy, reducing CO_2 emissions globally now will have lasting benefits because of long atmospheric residence time.



Source: U.S. Department of State (1992)

FIGURE 3 —

The greenhouse effect. *Global warming is similar to a greenhouse where light transmitted through the glass roof is trapped as heat. In the atmosphere, ultraviolet light passes through the atmosphere and is transformed into infrared light (which is heat). Like the glass in a greenhouse, greenhouse gases such as carbon dioxide in the atmosphere trap the infrared heat so it cannot be radiated back out into space. As a result an energy imbalance causes the planet to warm. The greater the abundance of greenhouse gases, the more heat that is trapped.*

Paralysis by Analysis or Meaningful Solutions?

Many of the future changes in our climate have been predicted based on a forecasted doubling of CO_2 under “business as usual” scenarios over the course of this century, leading to projected increases in global mean temperatures of 2.5 to 10.4 °F (Figure 4).[15] Even under the most aggressive remedial actions modeled by IPCC, global mean temperature increases of between 2.7 to 3.6 °F will likely occur by 2100. In North America, temperatures are predicted to warm from 2-5 °F in a low emissions case to as much as 6 to 13°F in the high emissions case, meaning we could see about two to four times the warming that occurred in the last century by 2100 if little action is taken now.

Some argue that model uncertainty warrants further investigation before commitment to action. Indeed, researchers around the world are developing more sophisticated techniques to estimate what changes may lay in store for the future. But while there are uncertainties in the climate models, they universally spell out significant potential risks associated with extreme temperature and precipitation change. **Importantly, we now know what needs to be done, and we have the ability to implement solutions. The time to take action is now.**

There are also significant co-benefits associated with reducing greenhouse gases. The World Health Organization estimates that 8 million premature deaths are associated with fossil fuel energy consumption,[16] many of which may be avoided in the process of reducing carbon dioxide and ground-level ozone-forming nitrogen oxides from power plants.[17]

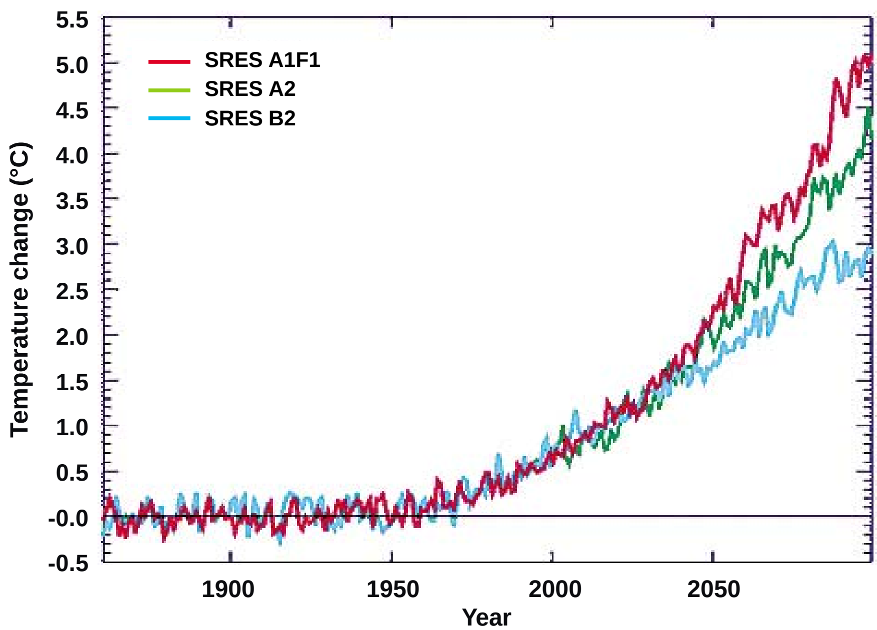
Observed biological and physiological changes cited by IPCC include glacial shrinkage, thawing of permafrost, early thawing and late freezing of lakes and rivers, lengthening of the growing season in mid-latitudes, shift of plant and animal ranges, earlier flowering of trees and emergence of insects and egg laying birds.

With the abundance of coal-based electric energy sources in the Midwest, our region is instrumental to achieving meaningful greenhouse gas emissions reductions in the United States. This report provides a summary of our current understanding of how climate change could impact the Midwest and how reducing power plant emissions in the region is needed to do our part to mitigate climate change for the sake of generations to come.

> *"…there is high confidence, recent regional changes in temperature have had discernable impacts in many physiological and biological systems."* [18]
>
> — *Intergovernmental Panel on Climate Change (IPCC), 2001*

FIGURE 4 —

Predicted global warming for three different scenarios were generated by IPCC. A1F1: assumes a future world with rapid economic growth depending on fossil fuels, A2: assumes a future world with continuous rise in global population but lower income growth, and slower technological improvement. In B2, population increases throughout the 21st century but less than A2 and levels of economic and technological growth are the least of the 3 scenarios (Source: Hadley Centre, UK).[58]



The Midwest's Climate is Already Changing

Like the rest of the World, the Midwest's climate has undergone measurable changes over the 20th century:[19]

- The region is warmer and wetter than it has been over most of the past 12,000 years;[20]
- Observed precipitation has increased by about two percent per decade since 1911, and precipitation has risen by about 10-20 percent in the Midwest in the past 100 years;
- In the 20th century, the upper Midwest states of Minnesota, Wisconsin and Michigan warmed by about 4 °F, and ice-thaw data suggests a late winter warming of 4.5 °F since the 1850s;
- Along the Ohio River Valley, slight cooling has been observed, possibly due to the reflective effects of sulfate aerosol pollution in the air (a by-product of SO_2 emissions). As such, sulfates may be masking the true potential for warming in the region, which could lead to

future increases in temperature as sulfur is reduced from the concentrated smokestack sources in the Ohio River Valley; and

- Climate change over the past century may be in part responsible for increasing extreme weather events such as heat waves, flooding and severe storms.

Our Climate Could Change Substantially in this Century

Even more disturbing is the magnitude of predicted changes in the Midwest during the 21st century:

- A possible 5-10 °F temperature increase for the Midwest in the 21st century; [21,22]
- Night time temperatures are expected to warm more than daytime (an additional 1-2 °F);
- In Des Moines Iowa, less than 20 days per year are currently above 90 °F, but the number of days with temperatures above 90 °F would double with a 3.6 °F average increase in temperature; [23]
- One model[24] predicts that the climate of Illinois may be similar to Oklahoma's by 2090, with summer average temperatures of over 80 °F; and
- An increase in precipitation by 10-30 percent compared to the previous century. With this, extreme precipitation events are predicted to increase, with the Upper Midwest states potentially hit the hardest.

Predicted Temperature and Precipitation Changes in the Midwest

Scientists use a variety of complex models to estimate the magnitude of future changes in climate. Typically these estimates assume we do little to change our emissions of CO_2 and other climate pollutants. However, we can and must reduce these pollutants to lower the risk of future climate changes. One of the most widely accepted climate models (Hadley, UK) was utilized to estimate changes in each of the six Midwest states as summarized in Table 1. (The Hadley Model has typically yielded more conservative estimates than the other most widely used Canadian model. For example, over this century, the predicted mean global temperature increase under the Hadley model is 5 °F whereas under the Canadian Model, the estimated increase is 10 °F. Therefore the temperature changes highlighted in Table 1 are conservative.)

TABLE 1 —

Climate Change Over the Past Century and Predicted Changes in this Century for the Six Midwest States Under the U.K. Hadley Model.[26]

State	Temperature Change Past 100 yrs Measured	Temperature Change Next 100 yrs Predicted	Precipitation Past 100 yrs Measured	Precipitation Next 100 yrs Predicted
Michigan	+ 1.1 °F	+ 4 °F	+20%	+ 5-20%
Indiana	+ 1.8 °F	2 to 4 °F	+10%	+ 5-30%
Ohio	+ 0.3 °F	3 to 4 °F	-10(S) to+10%(N)	+ 15-25%
Wisconsin	no change	+ 4 °F	+ 5 - 10 %	+ 15-20%
Minnasota	+ 1 °F	+ 4 °F	20% in S	+ 15%
Illinois	+ 0.2 °F (Decatur)	+ 2 to 3 °F	+ 20%	+10-70%

In general, the Hadley model predicts temperature increases of up to 4 °F in the six states, along with increased precipitation and extreme weather events.[25] The speed of the change is also important: **the predicted changes in this century range from approximately two to four times the rate of the increase measured over the past century.**

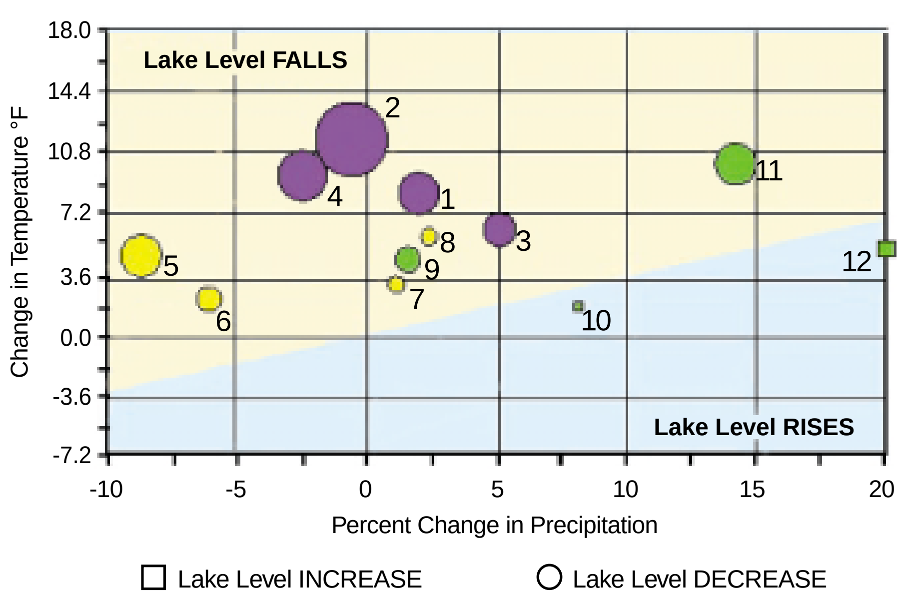
Lake Levels and Waterways of the Midwest are Susceptible to Climate Change

The Midwest is home to some of the greatest water treasures in the world: the Great Lakes and the Mississippi River. Midwesterners take great pride in the natural beauty, recreation and shipping opportunities these waters afford. But higher temperatures mean higher rates of evaporation, which has the greatest influence on a lake's water levels. The Canadian and Hadley models suggest an increase in water surface temperatures by 4° to 9 °F. Despite an increase in precipitation in much of the Upper Midwest, current climate models predict changes in Great Lake water levels ranging from a slight increase to an 8-foot due to climate change over the 21st century (Figure 5).[27] The Canadian model predicts lake level drops of up to 2.4 feet by 2030, and 2-5 feet on Lakes Huron and Michigan by 2090,[28] suggesting that action now may avoid more drastic drops in the future under this scenario. Potential lake impacts include:

- Reduced flows and possible adverse impacts to a backbone of the Midwest economy, the Great Lakes shipping industry;
- Lower hydropower generation and potentially impeded travel on Midwest waterways, including the Missouri River and upper Mississippi River system, resulting in a need for expensive dredging;
- Redistribution of current wetland areas;
- Higher frequency of extreme weather events such as higher precipitation and related flash flooding, similar to the 1993 floods that paralyzed the Mississippi River system and put several communities under water;
- Ice cover decreases of one to two months for Lakes Superior and Erie;
- Impacts to bird populations. Waterfowl are adversely affected by changing numbers of ponds. During 2000 drought conditions, the numbers of ponds in the Great Lakes region dropped by 40 percent from 1999 leading to a decline in populations of breeding ducks.[29]

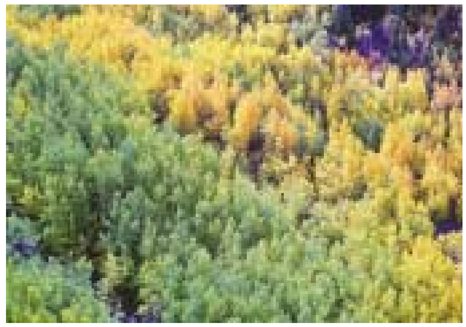
FIGURE 5 —

Lake level changes predicted in a variety of models, with a preponderance of models suggest lake levels dropping. Lake level changes from the two most sophisticated models and incorporating aerosols range from a modest increase in lake levels (#12 Hadley model) to a major drop (#11 Canadian model) (After Figure 4.3, Lofgren et al (2001) USGCRP Assessement, Great Lakes Water Resources).



Environmental Stress May Affect the Ecology of the Midwest's Forested Areas

According to some models, in regions characterized by continued warming, the transition zone between the temperate (mixed hardwood) and boreal (softwoods) forest could migrate northward effectively expanding the range of the temperate forests, and therefore pushing our beloved "north shore" forests into Canada. For example, according to Rizzo and Wilken (1992), much of the boreal forest in upper Minnesota, Wisconsin and Michigan would be replaced by grasslands and cool temperate forests.[31] Increased CO_2 may also increase the productivity and growth rates of trees. While increased production may seem beneficial, increased environmental stress on trees from potential insect and pest migration may make them more susceptible to disease.



Climate Change could Adversely Affect Crop Yields in the Midwest

Warming may have an initial positive impact on many crop yields in the Midwest that could ultimately reduce a need for irrigation.[33] But there are clearly a wide range of modeled responses of crop yields to climate change, ranging from failure to doubled harvests in North America and the Midwest.[34] Crop yields may also be temperature threshold-dependent; increases in yields may be limited to temperature increases of 3.6 °F, but temperature increases exceeding 7.2 °F may result in reductions in yield.[35,36] Ultimately, how U.S. agriculture fares with future changes in climate is a function of both climate changes and the industry's ability to adapt. For example, modeling suggests that U.S. cereal production decreases by a quarter or more without adaptation, but production impacts are not as great if farmers are able to adapt.[37]

Climate change may result in greater variability in temperature and precipitation resulting in more heat waves and precipitation extremes.[38] According to a report by the Center for Health and the Global Environment at Harvard Medical School,[39] climate change in the U.S. may mean less stable weather patterns, more extreme weather events, and therefore increased uncertainty for agriculture. The report documents how extreme weather events over the past two decades have resulted in severe crop damage and increased pesticide use, exacting significant economic cost to U.S. farmers. Similarly, in the future, shifts in ideal geographic ranges for crops may occur, extreme weather may make it more difficult for farmers to determine when to plant crops, and climate change may also

As an example of how pest damage can impact the Midwest, the southern corn leaf blight in 1970-71, spreading north from Mississippi during a tropical storm, resulted in a reduction of national crop yields by 15 percent and an estimated loss of over $1 billion. Some regions of the Midwest reported 50-100 percent losses.

enhance the spread of agricultural pests and disease. Climate change could also increase the use of pesticides, which are costly and ultimately harmful to the environment.

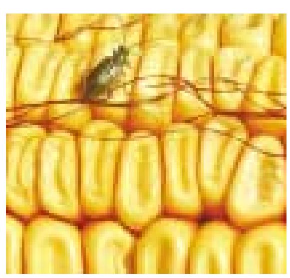
Despite predicted general precipitation increases, soil in the lower Midwest states of Illinois, Indiana and Ohio could be subject to more frequent drought and therefore reduced soil moisture conditions. Models suggest this outcome due to higher temperatures and attendant increased evaporation, coupled with greater temperature and precipitation extremes. Higher temperatures speed maturation of plants, reducing yields, and hastening the breakdown of organic soils. This, in turn, results in poor soil water retention. Cooler and damper conditions may result in insect infestations as well. According to EPA, corn yields in the Midwest, depending on the climate scenario, could either stay relatively stable or drop by 30-42 percent.[40] The risks are similar for soybeans. In the upper Midwest, crop yields could increase due primarily to an extended growing season.

Flooded soybean field

The Midwest is one of the country's largest and most important agricultural regions. Over the past decade in the United States, changes in agricultural productivity have been closely linked to changes in climate. For example, the drought of 1988 was accompanied by estimated losses of $56 billion.[32] The floods of 1993 in the Mississippi River Basin caused over $23 billion in agricultural losses.

Although yield increases in some crops are projected in some models, pest infiltration from other regions of the country coupled with an increase in frequency of flooding events may have the potential to counteract yield increases. Indeed, pest damage has increased since the 1970s. In the 1990s, pests were estimated to have destroyed about one third of U.S. crops in spite of advances in pest control technologies.[41] The ranges of soybean and corn pests have expanded since the early 1970s possibly in part due to climate trends. Reductions in rainfall also promote the formation of certain forms of fungi. An increase in the prevalence of the fungus wheat scab over the past decade could be due to progressively warmer temperatures. In addition, runoff of nitrogen and phosphorus fertilizers during extreme precipitation events could increase water pollution, increase algal blooms in lakes and reduce oxygen needed for fish and other living organisms. Climate change may also shift agricultural regions, straining an already stressed farming community due to the need for crop switching away from traditional crops.

Finally, ground level ozone is a greenhouse gas with significant direct impacts on crops and human health. Thus, reducing ozone will provide simultaneous benefits inreducing greenhouse warming, health impacts and crop losses.



Climate Change Could Impact Human Health in the Midwest

Climate change is widely expected to increase climate extremes, such as increasing the frequency of flooding and extreme temperatures. Flooding can increase the runoff of hazardous pollutants into reservoirs and ground water. Extreme temperatures can be deadly; in 1995, a heat wave in Chicago killed over 700 people. The air pollutants ground-level ozone and black carbon particulate matter also contribute to warming. Ground-level ozone smog formation typically increases during hot weather and with this come increases in cardiovascular and respiratory illness, especially in susceptible populations such as the millions suffering from asthma, the elderly and children. Black carbon is a component of $PM_{2.5}$ (fine particulate matter) in the Midwest, a pollutant that has been linked to premature death and a host of other respiratory and cardiovascular diseases. Reductions in these two pollutants would simultaneously result in both climate and health benefits. Moreover, strategies to reduce CO_2 would likely result in reduced air pollution emissions.

Recreation Could be Impacted by Changes in Climate in the Midwest

Changes in climate could affect both winter and summer recreation opportunities in the Midwest:

- Winter recreation opportunities, including skiing, snowmobiling, ice-skating and ice fishing could suffer as winters get shorter due to warmer temperatures. Some changes are already apparent. Lake ice cover in Madison, Wisconsin declined from about 120 days per year in 1850 to 90 days per year today.
- Summer recreation may also be affected by climate change. For example, boating on the Great Lakes is a much-loved activity in the Midwest: more than 4 million recreational boats are owned within the Great Lakes states. Potentially lower water levels may increase the chance of damage to boats entering or leaving the water, pose a greater risk of running aground in harbors and marinas, and result in the need for dredging, which releases buried toxins in the lake water and imposes a huge financial burden on marina owners.
- Fishing could be impacted by changes in fish habitats that result from changing temperatures in lakes and other water bodies. In the Great Lakes region, habitat for warm water fish would increase while habitat for coldwater fish would decrease, effectively driving the coldwater fish north. By some estimates, the geographic boundaries for fish species could move north by 500-600 km (300-350 miles), while at the same time, the overall number of species could increase.[42] In the southern part of the Midwest, one study suggests that 70 percent of the sites would be unsuitable for sucker or rainbow trout while the number of sites suitable for large mouth bass would double.[43] In some scenarios, however, simulated lake surface temperatures in some Wisconsin lakes could exceed lethal levels for fish.

Solutions

The United States emits approximately 6.6 tons of greenhouse gases for every man, woman and child every year,[44] and emissions per capita increased about 3.4 percent between 1990 and 1997. Of these emissions, about 82 percent come from burning fossil fuels to generate electricity and power our cars. Electric utilities alone release 38 percent of CO_2 released from fossil fuels – over one-third of the national problem.

Electric power generation in the Midwest (Table 2, Figure 6) accounts for 22 percent of the nation's total – a disproportionate share of the nation's power plant related carbon dioxide (CO_2). **Therefore, reducing CO_2 and other climate pollutants from the Midwest is critical to the United States doing its part to reduce the pollutants that are responsible for climate change.**

Midwest Power Plants

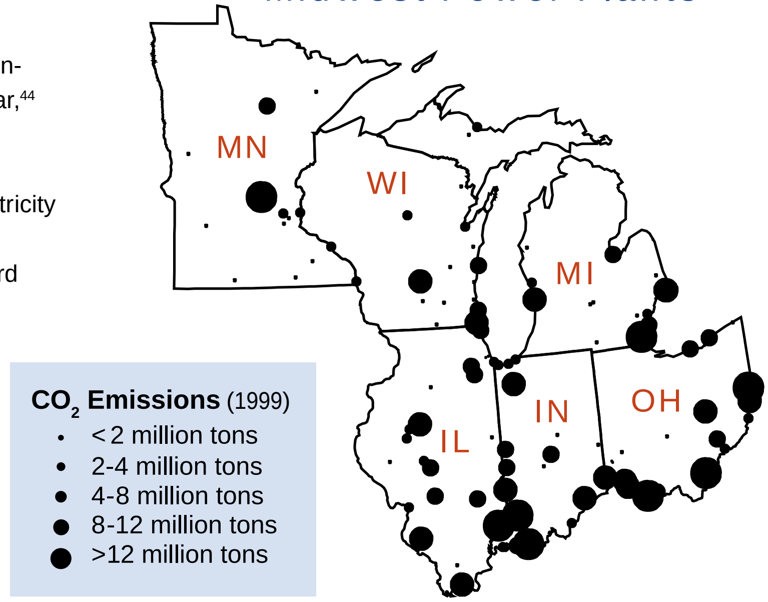


FIGURE 6 —

Power Plant CO_2 Emissions in the Six-State Midwest region. The Midwest is home to some of the largest combustion-related carbon dioxide sources in the U.S.

(Source: MSB Energy Associates)

TABLE 2 —

How CO_2 Emissions from Midwest Power Plants Stack Up

(For this report, Midwest is defined as: MN, WI, MI, IL, IN, OH)

Midwest Plants as a Percent of World CO_2	**2%**
Midwest Plants as a Percent of Total U.S. CO_2	**8%**
Midwest Plants as a Percent of Power Plant CO_2 Emissions	**22%**
Electric Utility Share of CO_2 in U.S.	**29%**
Electric Utility Share of CO_2 in U.S. from Fossil Fuels	**38%**
Range of Power Plant Share of Total CO_2 in Each State	**37-64%**
Cinergy Share of U.S. CO_2	**1.0%**
AEP Share of U.S. Power Plant CO_2	**2.1%**
CO_2 Share of Greenhouse Gas Emissions in U.S.	**80%**

Number of CO_2 Producing Power Plants in 6 State Region	**140**
Output of Power Plants in 6 State Region (MW)	**89,000**
Number of U.S. CO_2 Producing Plants	**737**
Output of U.S. Power Plants (MW)	**462,000**
Total U.S. Man-made CO_2 *(millions of tons)*	**6,386**
Total U.S. Non-Combustion CO_2 *(millions of tons)*	**98**
Total Utility CO_2 *(millions of tons)*	**2,453**
Total Worldwide CO_2 *(millions of tons)*	**24,774**
Total Power Plant CO_2 Emissions for the 6 States *(millions of tons)*	**538**

Getting the Earth's Atmosphere Back on Course: Avoiding High Risks

We can, and should, begin to take aggressive measures to reduce climate pollutants. Without emissions reductions, the rate of temperature change will double or quadruple, as predicted under the more conservative Hadley model. To slow the pace of our rapidly changing climate, steps to curb the release of CO_2 must be taken expeditiously. Immediate reductions below today's levels will not serve to turn back the climate clock but can slow the accelerating, and potentially more damaging, pace of change predicted over the coming decade (Figure 7).

Climate models agree that climate risks will escalate with the projected increasing global temperatures in the 21st century. Figure 8 conceptually demonstrates that greater risks are more probable around the globe under a business as usual scenario (higher temperature changes) than with an aggressive emissions reductions scenario (lower temperature changes). We cannot avoid all of the impacts of climate change already underway. On a global scale, changes of two to three times the temperature increase seen in the past century may be unavoidable despite our best efforts to reduce greenhouse gases. In fact, some may find the predicted changes in the Midwest beneficial initially (e.g. enhanced crop yields, reduced lake-effect snow). However, the worst projected impacts – those projected for later in the century under a scenario where little is done to reduce greenhouse gases and further doubling warming to five or more times the rate of the last century – may be avoidable if action is taken now.[46]

In the Midwest region, large and potentially avoidable temperature changes in the future could mean changes in crop yields, lake levels, extreme weather, ice seasons, and snow cover:

- Changes in lake levels under the Canadian model suggest declines in 2030 and even greater declines in 2050.[47] Lake level drops would result in a much greater need for dredging and water management. In fact, one study suggests that lake and river conditions would be unacceptable for all commercial and recreational users by 2090, compared to the partly acceptable intermediate conditions in 2030 and 2050 in Lake Ontario and the St Lawrence River;[48]
- One assessment suggests that under both the Canadian and Hadley models, increased CO_2 may result in increased crop yields through 2050 but then decreased yields from 2050 through 2100, especially in southern and western locations of the region;[49]
- In the Canadian model, the probability of extremely hot weather in the Midwest states radically increases with climate changes later in the century. Extreme heat

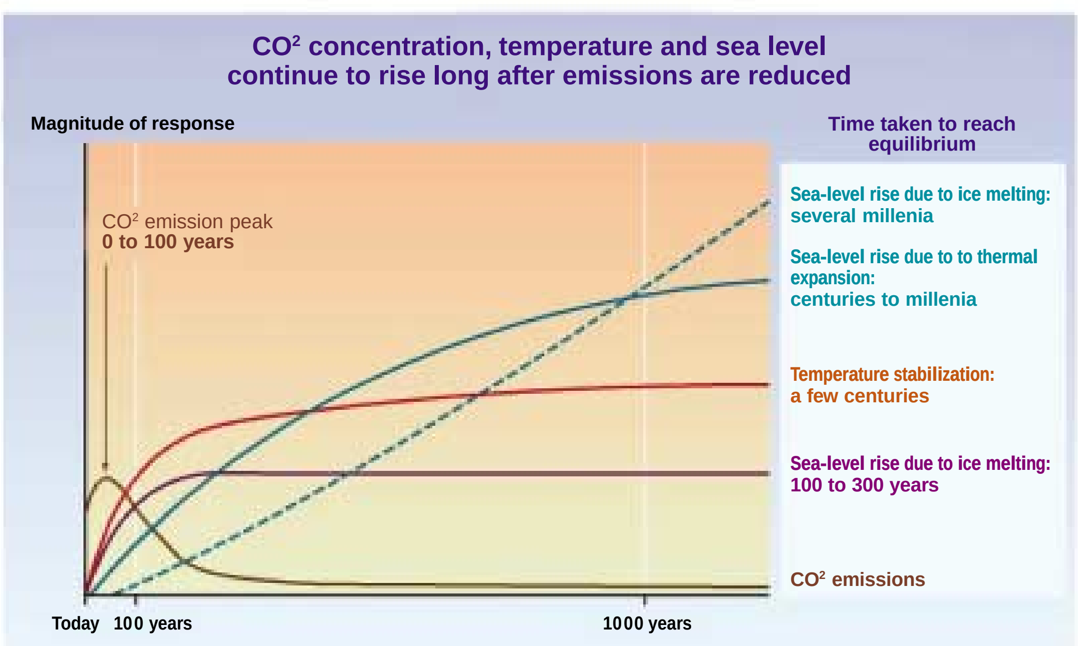
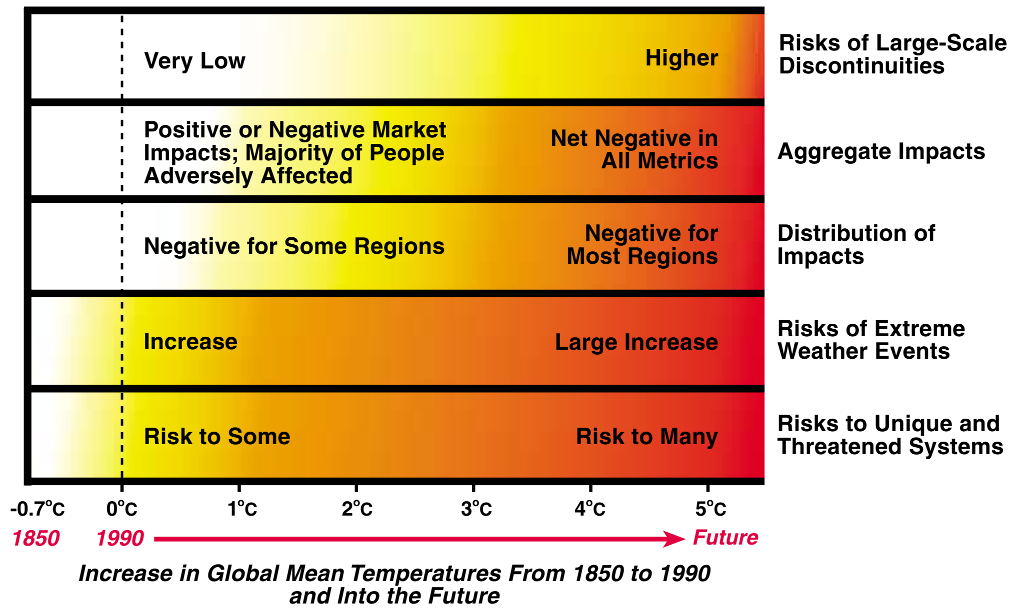


FIGURE 7 —

Despite emissions reductions, CO_2 impacts continue for a long time.[1]

FIGURE 8 —

(After IPCC, 2001). Impacts of or risks from climate change, by reason for concern. Each row corresponds to a reason for concern, and shades correspond to severity of impact or risk. White means no or virtually neutral impact or risk, yellow means somewhat negative impacts or low risks, and red means more negative impacts or higher risks. These temperatures should be taken as approximate indications of impacts, not as absolute thresholds.



waves characterized by three consecutive days above 100 °F are predicted to increase from one event in 50 years to one event in 10 years by the 2030s. More importantly, extreme heat waves increase dramatically to every other year by 2090. While the initial increase in these heat waves in the next few decades may be largely inevitable, the more extreme impacts later in the century may be avoidable by taking aggressive action now;

- The number of winter nights above freezing could increase from five nights per year to 15 by the end of the century, reducing ice cover by half. In the latter part of the century, sustained snow cover (>30 continuous days) could disappear from the southern part of the region. These changes would adversely impact winter sports and recreation and the economies that depend on them; and
- In the latter part of the century, a large temperature increase could result in a major change in forest cover, with colder climate tree species migrating progressively north. White pine and yellow birch could disappear from the southern Midwest, while jack pine and red pine may all but disappear from the entire region.

Power Plants, Greenhouse Gases and Climate

Scientists have linked the accelerated release of greenhouse gases over the past century (resulting from burning fossil fuels) to the increases in global temperature. This blanket of greenhouse gases (GHGs) absorbs ultraviolet light, turns it to heat, and traps it in the Earth's atmosphere, much like a greenhouse. The most potent greenhouse gases include carbon dioxide, methane, nitrous oxide (N_2O – not to be confused with NO_x), water vapor, ozone smog and chlorofluorocarbons (Figure 9). Black carbon – fine aerosol particles, byproducts of inefficient combustion – also absorb light and heat. Of all these human-formed pollutants, scientists have determined that carbon dioxide caused the most heating between 1850 and 2000.[50]

Source: NASA

Carbon dioxide accounts for the largest share of GHG emissions in the U.S., and power plants make up nearly one third of the CO_2 emissions from fossil fuel combustion. Carbon dioxide accounted for 80 percent of greenhouse gas emissions in 1998, growing 13 percent between 1990 and 1999.[51] Coal is of greatest concern as it contains the highest amount of carbon per unit of energy, while natural gas has about 45 percent less.[52] Electric utilities accounted for 29 percent of the carbon dioxide emissions in the U.S. between 1990 and 1998.[53] In 1998, power plants in the six Midwest states accounted for 37 to 64 percent of the CO_2 emissions in those states (Table 3). As shown in Figure 10, if unabated, "business as usual" scenarios suggest continued growth of CO_2 emissions well through the next two decades.

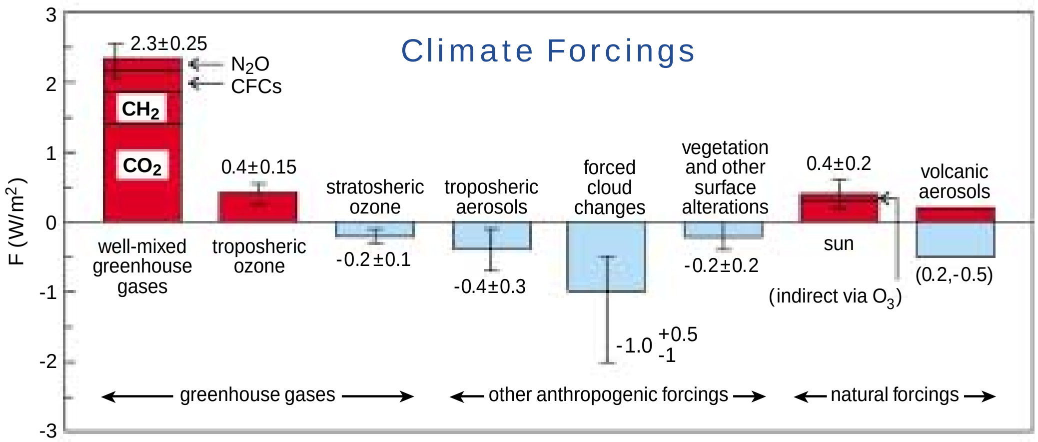


FIGURE 9 —

Pollutants and their impacts on climate.

Chart showing climate forcings (shown in Watts per square meter; warming above line, cooling below) between 1850 and 2000 (Hansen, after IPCC). Carbon dioxide has had strongest positive climate forcing (heating) over this period. Ozone smog (tropospheric ozone) is also associated with a significant warming effect.

TABLE 3 —

Electric Utility CO_2 Emissions in the Six-State Midwest Region

	Illinois	Indiana	Michigan	Minnesota	Ohio	Wisconsin
Total CO_2	239,116,570	214,353,950	203,061,550	98,969,820	275,655,550	109,657,270
Utility CO_2 (tons)	92,596,000	137,368,000	81,041,000	36,914,000	138,782,000	51,654,000
Coal Plant CO_2 (tons)	88,698,000	135,863,000	78,289,000	36,336,000	138,406,000	50,594,000
CO_2 Utility Share	38.72%	64.08%	39.91%	37.30%	50.35%	47.10%

Taking Action

Because of the long lifetime of CO_2 and other climate pollutants in our atmosphere, reducing these emissions immediately is imperative. Stabilization of CO_2 and temperature could take a few hundred years (Figure 7). Thus, we must act soon to reduce these harmful emissions.

We Must Call on State and Federal Lawmakers to:

Target Pollutants that Impact Climate and Health.

Reducing CO_2 is clearly imperative in the effort to stem climate change in the U.S. and around the world. Because reducing CO_2 means cleaning up power plants and using cleaner energy sources, significant health benefits can be achieved in the process. Health and environmental benefits may also come from strategies aimed at reducing ground level ozone pollution. Power plants are the largest single source of CO_2, but are also a major source of nitrogen oxides that form ground-level ozone.

Clean up Coal Plants.

Electric power generation is responsible for 29 percent of the carbon dioxide emissions in the United States. Therefore, an important solution in reducing CO_2 and mitigating the impacts of climate change, lies in cleaning up old power plants, especially those that burn coal (about 99 percent of all power plant CO_2 in the Midwest comes from coal). For over thirty years the oldest, dirtiest coal-burning power plants have avoided meeting the stronger air emissions standards required of modern plants.

Requiring these coal plants to meet modern pollution control standards – combined with requiring reasonable reductions in power system carbon dioxide emissions – will facilitate investment in new generation technologies that either do not emit carbon dioxide or have relatively low carbon dioxide emissions. Such requirements will also facilitate installation of pollution controls on many existing plants.

Many cleaner, “low-carbon” or “no-carbon” power technologies are available today to begin replacing our older coal plants. These include highly efficient natural gas plants, renewable energy resources like solar and wind power, and emerging, highly efficient coal power technologies that can capture and geologically sequester most of their carbon. Several such advanced coal power plants have recently been proposed in Midwest states.

Support Development of Renewable Power.

Many practical opportunities exist in the Midwest to increase production of power from clean renewable power sources like wind and solar photovoltaics (“solar panels”). Expanding use of these resources will also help reduce Midwest CO_2 emissions.

You Can:

Use Less Energy and Cleaner Sources of Energy.

1. ***Using Less Energy.***

The United States uses more energy per capita than any other country, meaning we are responsible for much more CO_2 than our neighbors. Thus, as individuals, we have a responsibility to use our energy more carefully and efficiently because the choices we make about our energy consumption affect our climate.

- Using less energy means reducing the amount of carbon released into our air. About 19 pounds of CO_2 are released for every gallon of gasoline we burn[54] and therefore driving fuel-efficient cars will make a big difference. For example, if a SUV or pickup gets 15 miles per gallon but a car gets 30 miles per gallon, the car emits half the CO_2 of the SUV for every mile driven, whether the vehicles are rated low emissions or not. Carpooling is also a good way to reduce CO_2 and to save on gasoline bills. Cars are also a big source of ground-level ozone forming pollutants, and diesels form heat-absorbing black carbon particulate matter.
- Electric energy production is a major source of man-made carbon dioxide in our air. As we advocate cleaner sources of fuel, we can also do our part in conserving the electricity we use as individuals. For example, we can strive to reduce our usage of electricity and heating by using energy efficient appliances and lighting, shutting off lights when they are not needed and adjusting our heat or air conditioning a few degrees. Energy-saving activities have the added benefit of reducing our energy bills.

2. ***Cleaner Sources of Energy.***

Utilization of renewable and alternative forms of energy, such as wind and solar, will also avoid release of harmful climate pollutants into the atmosphere.

Midwest Historical and Projected CO_2 Trends

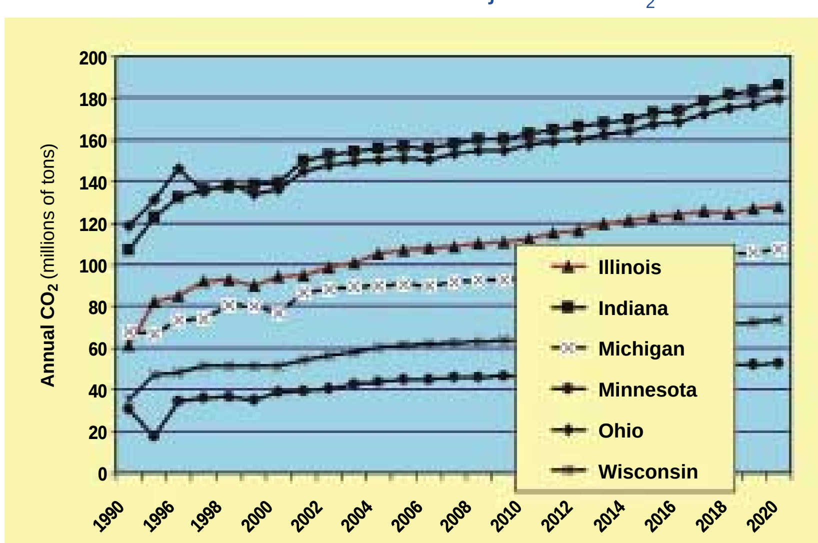


FIGURE 10 —

Carbon dioxide emissions progressively climb though 2020 under a business as usual scenario. These emissions will stay in the atmosphere and impact climate well into the next century.

(Source: MSB Energy Associates)

Endnotes

1 According to IPCC (2001), 1995 U.S. CO_2 emissions were 20.5 tons per capita while the mean for the rest of world was 3.2 tons per capita.

2 According to IPCC,(2001) electric consumption per capita is the U.S. is 12,660 kWhr and 1,689 kWhr for the rest of the world; U.S. is higher by a factor of 7.5. The world population is 6.2 billion and the US population is about 278 million; U.S. is 4.5% of world population.

3 Energy Information Administration (2000). U.S. CO_2 sources = 6386 million tons; worldwide sources = 25,408 million tons. Data provided by MSB Energy Associates.

4 The CO_2 emissions for the 6 state region are 538 million tons out of 2453 million tons from power plants nationally. Source: MSB Energy Associates; 2000 EPA CEMs database

5 American Electric Power annual CO_2 emissions = 131 million tons (5.3% of U.S. electric power sector emissions, 2.0 % of total U.S. CO_2 emissions); Cinergy = 69 million tons per year (2.8% of US electric power sector emissions, 1.1% of total US CO_2 emissions). Source: MSB Energy Associates.

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26 U.S. EPA 2001: State Impacts, EPA Global Warming , http://www.epa.gov/globalwarming/impacts/stateimp/index.html *NOTE: these are highly generalized results from U.K. Hadley model.*

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