

The Science of Climate Change

Duke Energy's position in the climate change debate reflects our acceptance of the synthesis of the peer-reviewed scientific literature provided by the United Nations' Intergovernmental Panel on Climate Change. More than 3,000 scientists participated in the latest IPCC review, which was published last year, and is available on the web at: <http://www.ipcc.ch>.

The IPCC is a scientific review body created by the World Meteorological Organization and the United Nations Environment Program, assigned to report the state of scientific knowledge on climate change in regular intervals. The IPCC defines climate change as:

“...a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.”

The IPCC's Fourth Assessment Report contains several key findings that have been peer reviewed and published, concerning both the effects and potential causes of climate change. The panel concluded that:

- Eleven of the last twelve years (1995-2006) rank among the twelve warmest years since 1850, when regular scientific measurement of global surface temperatures began. “Warming of the climate system,” the report says, “is unequivocal.”
- Satellite data since 1978 show that annual average Arctic sea ice extent has shrunk by 2.7 percent per decade.
- Global average sea level has risen since 1961 at an average of 1.8 mm/yr. and, since 1993, at an average of 3.1 mm/yr. with contributions from thermal expansion, melting glaciers and ice caps and the polar ice sheets.
- Global GHG emissions due to human activities have grown since pre-industrial times, with an increase of 70 percent between 1970 and 2004.
- The increases in these GHG concentrations are due primarily to fossil fuel use, with land use change providing another significant, but smaller, contribution.
- Continued GHG emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st Century that would very likely be larger than those observed during the 20th Century.

Based on its evaluation of the science since its Third Assessment Report in 2001, the IPCC was more certain that human activities were influencing the Earth's climate. Using a standard of measurement to express that likelihood, the IPCC review found:

- It was very likely (greater than a 90 percent probability) that sea level rise during the latter half of the 20th Century was attributed to global warming and human activities contributed to that warming.
- It was likely (greater than a 66 percent probability) that human influences have contributed to changes in wind patterns, affecting extra-tropical storm tracks and temperature patterns.
- It is likely they have caused increased temperatures of extreme hot nights, cold nights and cold days.
- More likely than not (greater than a 50 percent probability) that the increased risk of heat waves, regional drought and extreme regional heavy precipitation since the 1970s is caused by human-contributed climate change.

The IPCC Report does say there are still scientific uncertainties that remain to be explored and better understood. Among them are questions relating to impact of cloud cover, how climate change may be expressed regionally, a more complete picture of the observed natural response to anthropogenic warming, and the apparent variability of the ocean carbon feedback ability.

The IPCC is not alone in its view of the science.

The National Science and Technology Council's Committee on Environment and Natural Resources published its own report and among its many findings found:

Global averaged concentration of carbon dioxide in the atmosphere has increased from about 280 parts per million in the 18th Century to 383 parts per million in 2007. Current atmospheric concentration of carbon dioxide greatly exceeds the natural range of the last 650,000 years (180 to 300 parts per million) as determined from ice cores.²

And, in a report published by the U.S. Department of Agriculture (USDA), the government finds that increased temperatures from climate change are already having an impact. In the report entitled "The Effects of Climate Change on Agriculture, Land Resources, Water Resources and Biodiversity," USDA says:

As temperature rises, crops will increasingly experience temperatures above the optimum for their reproductive development, and animal production of meat or dairy products will be impacted by temperature extremes. Management of Western reservoir systems is very likely to become more challenging as runoff patterns continue to change.³

Finally, the contention that human emissions of GHGs are contributing to climate change is supported by the National Academies of Science (or their equivalent) of the following countries⁴: Brazil, Canada, China, France, Germany, India, Italy, Japan, Russia, United Kingdom, and the United States.

Certainly, there remains some controversy regarding climate change. However, among those scientists actively working and publishing in the legitimate scientific journals, there is very little debate around the basic points that the earth is warming and that increasing concentrations of GHGs are largely (not exclusively) responsible. One of the oft-repeated frustrations by the most prominent scientific experts in this field is opponents' use of non-peer reviewed scientific material to bolster their arguments. The science community has expressed dismay that, often, these claims are afforded the same treatment by the mainstream media, which is intent on reporting all sides of a story.

We do not claim to be experts on the science of climate change but we take our cue from the peer-reviewed science as synthesized and reported by the IPCC. We acknowledge that climate change is occurring and that human interaction with the environment is responsible for much of it. We also acknowledge a responsibility to engage our policymakers in a solution-oriented approach as quickly as possible.

The shareholders who asked us to produce this report have asked us why we cannot precisely calculate the impact Duke Energy's actions are having on global temperatures, and in turn what impact those changes might cause. A ton of carbon dioxide emitted from any source, whether one of our power plants in Indiana or from a burning forest, has an almost immeasurable impact on global CO₂ concentrations. Therefore, the actions of any single emitter acting alone will have zero impact. It is only with enactment of regulations in the largest emitting countries to reduce **total** CO₂ emissions that we will avoid a future with even higher GHG concentrations than today. Climate change is a global problem that requires a global answer.

² See <http://www.ostp.gov>

³ See http://www.usda.gov/oce/global_change/files/SAP4_3/ExecSummary.pdf

⁴ See <http://www.nationalacademies.org/onpi/06072005.pdf>

Alternative Climate Views

Skepticism is an important part of the scientific process. In challenging conventional thinking, it tests both hypothesis and theory, giving energy and credibility to the consensus that emerges.

Although we noted little, if any, debate on the Senate floor this past June on the science of climate change, there remains, certainly, an active and vocal skeptics community, whose views can be readily found on the Internet and, sometimes, in the mainstream press. Duke Energy has followed their arguments closely and will continue to do so. But, our policy positions are driven by the IPCC peer-reviewed science and by our judgment that this science is not only credible, but that it is accepted by the vast majority of public policymakers who will shape U.S. climate legislation in the years to come.

We view our engagement in the climate debate as a pragmatic response to both scientific and political reality. Our approach is predicated on the responsibility we feel to contribute positively to the public discourse and reduce the risks to our customers, shareholders and communities.

The Free Enterprise Action Fund asked us to specifically address the scientific arguments put forward by those who dispute climate change theory. As they did not specify which of the many arguments one can find on the internet, we have relied on the following BBC article by Richard Black.

BBC NEWS

Climate scepticism: The top 10

What are some of the reasons why "climate sceptics" dispute the evidence that human activities such as industrial emissions of greenhouse gases and deforestation are bringing potentially dangerous changes to the Earth's climate?

As the Intergovernmental Panel on Climate Change (IPCC) finalises its landmark report for 2007, we look at 10 of the arguments most often made against the IPCC consensus, and some of the counter-arguments made by scientists who agree with the IPCC.

1. EVIDENCE THAT THE EARTH'S TEMPERATURE IS GETTING WARMER IS UNCLEAR

Sceptic

Instruments show there has been some warming of the Earth's surface since 1979, but the actual value is subject to large errors. Most long-term data comes from surface weather stations. Many of these are in urban centres which have expanded in both size and energy use. When these stations observe a temperature rise, they are simply measuring the "urban heat island effect". In addition, coverage is patchy, with some regions of the world almost devoid of instruments. Data going back further than a century or two is derived from "proxy" indicators such as tree-rings and stalactites which, again, are subject to large errors.

Counter

Warming is unequivocal. Weather stations, ocean measurements, decreases in snow cover, reductions in Arctic sea ice, longer growing seasons, balloon measurements, boreholes and satellites all show results consistent with the surface record of warming. The urban heat island effect is real but small; and it has been studied and corrected for. Analyses by NASA for example use only rural stations to calculate trends. Recently, work has shown that if you analyse long-term global temperature rise for windy days and calm days separately, there is no difference. If the urban heat island effect were large, you would expect to see a bigger trend for calm days when more of the heat stays in the city. Furthermore, the pattern of warming globally doesn't resemble the pattern of urbanisation, with the greatest warming seen in the Arctic and northern high latitudes. Globally, there is a warming trend of about 0.8C since 1900, more than half of which has occurred since 1979.⁵

⁵ See http://ipcc-wg1.ucar.edu/wg1/FAQ/wg1_faq-3.1.html

2. IF THE AVERAGE TEMPERATURE WAS RISING, IT HAS NOW STOPPED

Sceptic

Since 1998 - almost a decade - the record, as determined by observations from satellites and balloon radiosondes, shows no warming.

Counter

1998 was an exceptionally warm year because of the strong El Niño event. Variability from year to year is expected, and picking a specific warm year to start an analysis is "cherry-picking"; if you picked 1997 or 1999 you would see a sharper rise. Even so, the linear trends since 1998 are still positive.⁶

3. THE EARTH HAS BEEN WARMER IN THE RECENT PAST

Sceptic

The beginning of the last Millennium saw a "Mediaeval Warm Period" when temperatures, certainly in Europe, were higher than they are now. Grapes grew in northern England. Ice-bound mountain passes opened in the Alps. The Arctic was warmer in the 1930s than it is today.

Counter

There have been many periods in Earth history that were warmer than today - if not the MWP, then maybe the last interglacial (125,000 years ago) or the Pliocene (three million years ago). Whether those variations were caused by solar forcing, the Earth's orbital wobbles or continental configurations, none of those causes apply today. Evidence for a Mediaeval Warm Period outside Europe is patchy at best, and is often not contemporary with the warmth in Europe. As the US National Oceanographic and Atmospheric Administration (NOAA) puts it: "The idea of a global or hemispheric Mediaeval Warm Period that was warmer than today has turned out to be incorrect". Additionally, although the Arctic was warmer in the 1930s than in the following few decades, it is now warmer still.⁷

4. COMPUTER MODELS ARE NOT RELIABLE

Sceptic

Computer models are the main way of forecasting future climate change. But despite decades of development they are unable to model all the processes involved; for example, the influence of clouds, the distribution of water vapour, the impact of warm seawater on ice-shelves and the response of plants to changes in water supply. Climate models follow the old maxim of "garbage in, garbage out".

Counter

Models are simply ways to quantify understanding of climate. They will never be perfect and they will never be able to forecast the future exactly. However, models are tested and validated against all sorts of data. Over the last 20 years they have become able to simulate more physical, chemical and biological processes, and work on smaller spatial scales. The 2007 IPCC report produced regional climate projections in detail that would have been impossible in its 2001 assessment. All of the robust results from modeling have both theoretical and observational support.⁸

5. THE ATMOSPHERE IS NOT BEHAVING AS MODELS WOULD PREDICT

Sceptic

Computer models predict that the lower levels of the atmosphere, the troposphere, should be warming faster than the Earth's surface. Measurements show the opposite. So either this is another failing of the models, or one set of measurements is flawed, or there are holes in our understanding of the science.

Counter

Lower levels of the troposphere are warming; but measuring the exact rate has been an uncertain process, particularly in the satellite era (since 1979). Readings from different satellites need to be tied together, and each has its own problems with orbital decay and sensor drift. Two separate analyses show consistent warming, one faster than the surface and one slightly less. Within the uncertainties of the data, there is no discrepancy that needs to be dealt with. Information from balloons has its own problems but the IPCC concluded this year: "For the period since 1958, overall global and tropical tropospheric warming estimated from radiosondes has slightly exceeded surface warming".⁹

⁶ See http://ipcc-wg1.ucar.edu/wg1/FAQ/wg1_faq-3.1.html and http://ipcc-wg1.ucar.edu/wg1/FAQ/wg1_faq-9.1.html

⁷ See http://ipcc-wg1.ucar.edu/wg1/FAQ/wg1_faq-6.2.html and http://ipcc-wg1.ucar.edu/wg1/FAQ/wg1_faq-6.1.html

⁸ See http://ipcc-wg1.ucar.edu/wg1/FAQ/wg1_faq-8.1.html

⁹ See http://ipcc-wg1.ucar.edu/wg1/FAQ/wg1_faq-3.1.html and Thorne, P. W., D. E. Parker, B. D. Santer, M. P. McCarthy, D. M. H. Sexton, M. J. Webb, J. M. Murphy, M. Collins, H. A. Titchner, and G. S. Jones (2007), Tropical vertical temperature trends: A real discrepancy?, *Geophys. Res. Lett.*, 34, L16702, doi:10.1029/2007GL029875.

6. CLIMATE IS MAINLY INFLUENCED BY THE SUN

Sceptic

Earth history shows climate has regularly responded to cyclical changes in the Sun's energy output. Any warming we see can be attributed mainly to variations in the Sun's magnetic field and solar wind.

Counter

Solar variations do affect climate, but they are not the only factor. As there has been no positive trend in any solar index since the 1960s (and possibly a small negative trend), solar forcing cannot be responsible for the recent temperature trends. The difference between the solar minimum and solar maximum over the 11-year solar cycle is 10 times smaller than the effect of greenhouse gases over the same interval.¹⁰

7. A CARBON DIOXIDE RISE HAS ALWAYS COME AFTER A TEMPERATURE INCREASE NOT BEFORE

Sceptic

Ice-cores dating back nearly one million years show a pattern of temperature and CO₂ rise at roughly 100,000-year intervals. But the CO₂ rise has always come after the temperature rise, not before, presumably as warmer temperatures have liberated the gas from oceans.

Counter

This is largely true, but largely irrelevant. Ancient ice-cores do show CO₂ rising after temperature by a few hundred years - a timescale associated with the ocean response to atmospheric changes mainly driven by wobbles in the Earth's orbit. However, the situation today is dramatically different. The extra CO₂ in the atmosphere (35% increase over pre-industrial levels) is from human emissions. Levels are higher than have been seen in 650,000 years of ice-core records, and are possibly higher than any time since three million years ago.¹¹

8. LONG-TERM DATA ON HURRICANES AND ARCTIC ICE IS TOO POOR TO ASSESS TRENDS

Sceptic

Before the era of satellite observation began in the 1970s, measurements were ad-hoc and haphazard. Hurricanes would be reported only if they hit land or shipping. Arctic ice extent was measured only during expeditions. The satellite record for these phenomena is too short to justify claims that hurricanes are becoming stronger or more frequent, or that there is anything exceptional about the apparent shrinkage in Arctic ice.

Counter

The Arctic Climate Impact Assessment project notes that systematic collection of data in parts of the Arctic began in the late 18th Century. The US National Hurricane Center notes that "organised reconnaissance" for Atlantic storms began in 1944. So although historical data is not as complete as one might like, conclusions can be drawn. And the IPCC does not claim that global warming will make hurricanes more frequent - its 2007 report says that if anything, they are likely to become less frequent, but more intense.¹²

9. WATER VAPOUR IS THE MAJOR GREENHOUSE GAS; CO₂ IS RELATIVELY UNIMPORTANT

Sceptic

The natural greenhouse effect keeps the Earth's surface about 33C warmer than it would otherwise be. Water vapour is the most important greenhouse gas, accounting for about 98% of all warming. So changes in carbon dioxide or methane concentrations would have a relatively small impact. Water vapour concentrations are rising, but this does not necessarily increase warming - it depends how the water vapour is distributed.

Counter

Water vapour is essentially in balance with the planet's temperature on annual timescales and longer, whereas trace greenhouse gases such as CO₂ stay in the atmosphere on a timescale of decades to centuries. The statement that water vapour is "98% of the greenhouse effect" is simply false. In fact, it does about 50% of the work; clouds add another 25%, with CO₂ and the other greenhouse gases contributing the remaining quarter. Water vapour concentrations are increasing in response to rising temperatures, and there is evidence that this is adding to warming, for example in Europe. The fact that water vapour is a feedback is included in all climate models.¹³

¹⁰ See http://ipcc-wg1.ucar.edu/wg1/FAQ/wg1_faq-9.2.html and http://ipcc-wg1.ucar.edu/wg1/FAQ/wg1_faq-2.1.html

¹¹ See http://ipcc-wg1.ucar.edu/wg1/FAQ/wg1_faq-7.1.html and http://ipcc-wg1.ucar.edu/wg1/FAQ/wg1_faq-2.1.html

¹² See http://ipcc-wg1.ucar.edu/wg1/FAQ/wg1_faq-3.3.html

¹³ See http://ipcc-wg1.ucar.edu/wg1/FAQ/wg1_faq-1.3.html

10. PROBLEMS SUCH AS HIV/AIDS AND POVERTY ARE MORE PRESSING THAN CLIMATE CHANGE

Sceptic

The Kyoto Protocol will not reduce emissions of greenhouse gases noticeably. The targets were too low, applied only to certain countries, and have been rendered meaningless by loopholes. Many governments that enthuse about the treaty are not going to meet the reduction targets that they signed up to. Even if it is real, man-made climate change is just one problem among many facing the world's rich and poor alike. Governments and societies should respond proportionately, not pretend that climate is a special case. And some economists believe that a warmer climate would, on balance, improve lives.

Counter

Arguments over the Kyoto Protocol are outside the realms of science, although it certainly will not reduce greenhouse gas emissions as far or as fast as the IPCC indicates is necessary. The latest IPCC Working Group 2 report suggests that the impact of man-made climate change will on balance be deleterious, particular to the poorer countries of the tropics, although colder regions may see benefits such as increased crop yields. Investment in energy efficiency, new energy technologies and renewables are likely to benefit the developing world.

Compiled with advice from Fred Singer and Gavin Schmidt

Story from BBC NEWS:

http://news.bbc.co.uk/go/pr/fr/-/2/hi/in_depth/629/629/7074601.stm

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Duke Energy is aware of the claim that the IPCC does not adequately represent the diversity of views of dissenting scientists. Opponents of the IPCC and climate science in general frequently cite the results of the Oregon Institute of Science and Medicine's (OISM) petition project¹⁴ to refute the "scientific consensus." The petition, disputing the theory of anthropogenic climate change and signed by over 31,000 scientists, was launched primarily in opposition to the Kyoto Protocol.

We note, however, that very few of the signatories are involved in climate research. The petition's conclusions are supported by a review article disputing the evidence of climate change that was published in the *Journal of American Physicians and Surgeons* (2007). This journal is a publication of the Association of American Physicians and Surgeons (AAPS). AAPS was formed in 1943 to oppose government funded healthcare and its executive director is one of the six staff members of OISM. Our research shows that the journal is not listed by MedLine/PubMed¹⁵ despite having been reviewed by them as recently as 2004.¹⁶ Of equal concern, the publication does not appear in searches of Journal Citation Reports¹⁷ using the ISI Web of Knowledge, in part because it is not listed in the ISI Index. Among the criteria for inclusion in the index (which covers over 9000 peer reviewed publications) is a determination "of the journal's citation history and or the citation history of its authors and editors" – this is a metric to gauge the influence of the publication within the scientific community.

The article has been very influential among many scientists not involved in climate research and undoubtedly encouraged many of them to sign the anti-Kyoto petition. However, it is not taken seriously by those conducting climate research who publish their findings in accepted peer reviewed journals. Therefore, neither the article nor the resulting petition can be taken as a valid refutation of the generally accepted scientific view of climate science as presented by the IPCC.

¹⁴ See <http://www.oism.org/pproject/>

¹⁵ See <http://www.nlm.nih.gov/pubs/factsheets/jsel.html>

¹⁶ See http://www.nlm.nih.gov/archive/20060816/istrccommittee/jun04/jun04_titles_scheduled.html

¹⁷ See <http://scientific.thomson.com/products/jcr/>