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Washington Greenhouse Gas Emission Reduction Limits

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Washington State Department of Ecology
Olympia, Washington

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- Amy Snover, PhD, Assistant Dean, Director, Climate Impacts Group, College of the Environment University of Washington

Executive Summary

In 2008, the Washington Legislature recognized that climate changes posed serious threats to the economic wellbeing, public health, natural resources, and the environment of the state. To limit the impacts of climate change, the Legislature required that the state reduce its greenhouse gas emissions by setting limits on those emissions. The Legislature also required the limits be reviewed and recommendations be made by the Department of Ecology (Ecology) using the most current global, national and regional climate science.

Climate change is affecting Washington

Climate science has continued to advance since Washington set its first greenhouse gas limits. As required by law, Ecology requested the University of Washington Climate Impacts Group prepare an updated report on the impacts of climate change on Washington.

The UW report shows that Washington is experiencing long-term impacts consistent with what is expected as a result of climate change. The sea level is rising on most of Washington's coast, ocean acidification has increased, and there's long-term warming. Glaciers and spring snowpack have declined and the timing of stream flows has changed for many rivers. And, climate extremes like floods, droughts, fires and landslides are already affecting Washington's economy and environment.

The effects of climate change on water supplies, public health, coastal and storm damage, wildfires, and other impacts will be costly unless additional actions are taken to reduce greenhouse gases.

Greenhouse gas reduction requirements

When Washington set its greenhouse gas limits in 2008, the Legislature enacted the state's commitment to do its part to stabilize the global climate by reducing its greenhouse gases, and emission limits were set to be achieved by 2020, 2035 and 2050.

The limits recognized that Washington State is unique when compared to other states. Washington relies heavily on hydropower, and hydropower creates fewer greenhouse gases than other sources of electricity, like coal or natural gas. The limits adopted were lower than levels committed by several nations and states. A year after Washington State set their greenhouse gas levels, the United States committed to even lower emission levels.

Current greenhouse gas emissions trends show that globally greenhouse gases have continued to increase since 1990, and have reached levels not seen in the last 800,000 years. To have a reasonable chance to avoid unprecedented risks to peoples' lives and wellbeing, the Intergovernmental Panel on Climate Change has concluded that emissions reductions in excess of what have been pledged or committed by nations are required.

Recommendations

Climate change is not a far-off risk. It is happening now globally and the impacts are worse than previously predicted, and are forecast to worsen. Since Washington's adoption of the limits in 2008, the global, national and regional climate science is increasingly clear. Annual global emissions from human activities continue to increase. If we delay action by even a few years, the rate of reduction needed to stabilize the global climate would be beyond anything achieved historically and would be more costly.

Washington State's existing statutory limits should be adjusted to better reflect the current science. The limits need to be more aggressive in order for Washington to do its part to address climate risks and to align our limits with other jurisdictions that are taking responsibility to address these risks. Several United Nations member countries - including the United States government, several states, and local jurisdictions - are actively addressing climate change, and have adopted or pledged more stringent greenhouse gas emissions targets than Washington State.

However, Ecology recommends that no changes be made to the state's statutory emission limits at this time. International negotiations are under way regarding new emissions reductions targets, in preparation for the UN climate conference in December 2015, to be held in Paris. Ecology recommends waiting until the negotiations are concluded, as the result could better inform how Washington's limits should be adjusted.

Introduction and Purpose of the Report

In 2007, Former Governor Gregoire issued Executive Order 07-02 establishing goals for greenhouse gas emissions limits for Washington State. The statewide goals were adopted into law in 2007 with passage of Engrossed Substitute Senate Bill 6001 (Chapter 80.80 RCW). When enacting the statewide goals, the Legislature stated in section 1(b) that: "Washington's greenhouse gases emissions are continuing to increase, despite international scientific consensus that worldwide emissions must be reduced significantly below current levels to avert catastrophic climate change."

In 2008, with the enactment of the Limiting Greenhouse Gas Emissions Act (Chapter 70.235 RCW), the goals were adopted as *limits*, that the Legislature expected Washington to achieve statewide by 2020, 2035 and 2050. The intent of the Legislature, in 2008, was to:

> "(a) limit and reduce emissions of greenhouse gases; (b) minimize the potential to export pollution, jobs, and economic opportunities; and (c) reduce emissions at the lowest cost to Washington's economy, consumers, and businesses" (RCW 70.235.005(3)).

The greenhouse gas emissions limits established in RCW 70.235.020 are the same as those adopted in Executive Order 07-02 and RCW 80.80.020 (2007):

"The State shall limit emissions of greenhouse gases to achieve the following limits for Washington State:

- By 2020, reduce overall emissions of greenhouse gases in the State to 1990 levels;
- By 2035, reduce overall emissions of greenhouse gases in the State to 25 percent below 1990 levels;
- By 2050, the state will do its part to reach global climate stabilization levels by reducing overall emissions to 50 percent below 1990 levels, or 70 percent below the State's expected emissions that year."

Recognizing that scientific understanding of the causes and consequences of climate change was rapidly expanding, the 2008 legislation required the Washington Department of Ecology (Ecology) to periodically report to the Legislature to summarize climate science and make recommendations regarding the statutory greenhouse gas emissions limits. Specifically, RCW 70.235.040 states that:

> "Within eighteen months of the next and each successive global or national assessment of climate change science, the department shall consult with the climate impacts group at the University of Washington regarding the science on human-caused climate change and provide a report to the legislature summarizing that science and make recommendations regarding whether the greenhouse gas emissions reductions required under RCW 70.235.020 need to be updated."

This report was prepared in response to the legislative requirement. The report summarizes the rationale for Washington's existing statutory emissions limits for 2020, 2035, and 2050; documents key implications of recent advances in global, national and regional climate science; and provides recommendations regarding the statutory greenhouse gas emission limits established in RCW 70.235.020.

Summary of the Rationale for the Existing Reduction Limits

Scientific Basis for the Existing Reduction Limits

Washington State existing greenhouse gas emissions limits were based on global, national, and regional climate change scientific information available in the 1990s and early 2000, including: the United Nations Intergovernmental Panel on Climate Change (IPCC) Third and Fourth Assessment Reports, 2001 and 2007 respectively[1]; the First and Second U.S. National Climate Assessment, 2000, and 2008 respectively[2]; and University of Washington Climate Impacts Group Interim Report, (2007)[3].

When the existing limits were established, there was (and remains) strong scientific consensus that increasing emissions of greenhouse gases were causing global temperatures to rise at rates that have the potential to cause economic disruption, environmental damage, and a public health crisis. Specifically the consensus expressed by the United Nations Intergovernmental Panel on Climate Change (IPCC) in its Third and Fourth Assessment Reports, 2001 and 2007 respectively[4] was that:

- "Global warming is 'unequivocal' and that human activity is the main driver, very likely (meaning a 90% or greater probability) causing most of the rise in temperatures since 1950."
- "Continued greenhouse gas 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."
- "Anthropogenic (i.e., human caused) warming could lead to some impacts that are abrupt or irreversible, depending upon the rate and magnitude of the climate change."
- "Anthropogenic warming and sea level rise will continue for centuries, even if greenhouse gas concentrations were to be stabilized."
- "Impacts of climate change will vary regionally. Aggregated and discounted to the present, they are *very likely* to impose net annual costs, which will increase over time as global temperature rises."

[1] http://ipcc.ch/publications_and_data/publications_and_data_reports.shtml#1
[2] http://ncanet.usgcrp.gov/
[3] http://cses.washington.edu/db/pdf/cighb1303interim580.pdf
[4] http://ipcc.ch/publications_and_data/publications_and_data_reports.shtml#1

- "Many impacts can be avoided, reduced or delayed by greenhouse gas reduction (mitigation) actions."

For Washington State, the University of Washington's Climate Impacts Group concluded, in its 2007 Interim Report, that the effects of climate change are already being felt in the state. Research on observed changes that document, for example, that mountain glaciers in the North Cascades had seen a long term decline on the order of 25 percent, and peak spring river runoff was occurring 0 to 30 days earlier depending on river type and location.

These changes impact the State's dependence on snowpack for fresh water, its reliance on hydropower for energy, and its extensive shoreline. A 2006 economic analysis[5] of current and likely future effects of global climate change on Washington's economy concluded:

- "Climate change impacts are visible in Washington State and their economic effects are becoming apparent."
- "The economic effects of climate change in Washington will grow over time as temperatures and sea levels rise."
- "Although climate change will mean increasing economic effects, it also opens the door to new economic opportunities. "

Rationale for Selecting 1990 as the Base Year for the Emissions Reductions Limits

The year 1990 was established as the "base year" for benchmarking emissions reductions under the international agreement referred to as the Kyoto Protocol[6] for the United Nations Framework Convention on Climate Change (UNFCCC). One of the first tasks set by the UNFCCC was for signatory nations to establish national inventories of greenhouse gas emissions, which were used to create the 1990 benchmark levels for the commitment of the Kyoto parties to emissions reductions.

Though the United States has not ratified the Kyoto agreement, many states and cities followed the international community by using the year 1990 as the common benchmark for tracking progress on emission reductions[7]. This includes ten states[8] out of 20 with greenhouse gas emissions reduction targets, and many of the 1,060 cities that have to date joined the U.S. Mayors Climate Protection Agreement, created in 2005 by Seattle Mayor Greg Nickels.

[5] https://fortress.wa.gov/ecy/publications/publications/0701010.pdf
[6] The Kyoto Protocol, adopted in Dec. 1997, is an international agreement linked to the United Nations Framework Convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets. The Kyoto Protocol is seen as an important first step towards a truly global emission reduction regime that will stabilize GHG emissions,
[7] 'A Look at Emissions Targets' published by Center for Climate and Energy Solutions at http://www.c2es.org/what_s_being_done/targets).
[8] http://www.c2es.org/print/us-states-regions/policy-maps/emissions-targets

Businesses undertaking voluntary actions to reduce emissions are also using 1990 as the benchmark year. The Climate Group, which represents a coalition of international business and government organizations, tracks actions taken by many companies to reduce greenhouse gas emissions from 1990 levels[9]. Similarly, the 1990 level is used by companies when reporting to the Carbon Disclosure Project (CDP)[10], a forum used by institutional investors to request information on greenhouse gas emissions from some of the world's largest companies.

In 2007, the Legislature directed the Washington Departments of Ecology and Commerce (then Community Trade and Economic Development - CTED) to estimate Washington State's 1990 total greenhouse gas emissions and total emissions in each major sector and to report the findings by December 2007. Washington State's 1990 baseline was estimated at about 88.4 million metric tons of total carbon dioxide equivalent ($MMtCO_2e$) [11].

Rationale for Selecting the Statutory Emissions Reductions Limits

In RCW 70.235.020 (1)(a)(iii) the Legislature required that:

> "By 2050, the state will *do its part to reach global climate stabilization levels* by reducing overall emissions to fifty percent below 1990 levels, or seventy percent below the state's expected emissions that year."*(emphasis added)*

Stabilization refers to the intent to reach a stable global *temperature* by keeping the global *carbon dioxide concentrations* in the atmosphere below certain values. In 2002, the United Nations Framework Convention on Climate Change (UNFCCC) incorporated the concept of climate stabilization[12] as a key objective of its formal Framework Convention Policy.

> "Article 2. Objective. The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."

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[9] The Climate Group's *Carbon Down, Profits Up* report, third edition http://www.c2es.org/docUploads/Climate%20Group%203rd%20ed.pdf

[10] http://www.pwc.com/gx/en/sustainability/publications/carbon-disclosure-project/index.jhtml

[11] http://www.ecy.wa.gov/climatechange/ghg_inventory.htm.

[12] The concept was first introduced in Rio de Janeiro, June, 1992, with the international environmental treaty, referred to as Kyoto protocol. The treaty was aimed at stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system – commonly believed to be around 2°C above the pre-industrial global average temperature.

The United States, in mid-1990s, agreed in principle to work with more than 140 other nations under the UNFCCC to achieve the objective of the Framework Convention Policy - stabilization of greenhouse gas concentrations in the atmosphere. However, the U.S. did not carry the agreement forward.

In 1996 and again in 2005, the European Union pronounced that policies to mitigate anthropogenic climate change should restrict the global mean temperature rise to 2^{o} Celsius, or 3.6^{o} Fahrenheit, a threshold aimed at limiting dangerously disruptive climate change[13]. This threshold was formalized politically in 2009 when world leaders, including the United States, signed the Copenhagen Accord. The Accord included a commitment to keeping increases in global average temperature from rising.

In 2007, the Intergovernmental Panel on Climate Change (IPCC)[14], examined the relationships between several levels of atmospheric carbon dioxide concentrations (i.e., 350, 450, 750 and 1000 part per million) and corresponding ranges of global mean temperature increases in 2100. The purpose of the analysis was to estimate the levels of emissions reductions needed to stabilize CO_2 concentration[15] and limit climate change below what is considered "dangerous".

The IPCC concluded that a concentration level of 450 parts per million (ppm) is required to have at least a 50% chance of stabilizing the climate and avoiding the worst impacts of climate change. Under this scenario greenhouse gases from developed countries would need to be reduced substantially during this century. Developed countries as a group would need to reduce their emissions to below 1990 levels in 2020 (on the order of 10 to 40 % below 1990 levels for most of the considered stabilization regimes) and to still lower levels by 2050 (40 to 95 percent below 1990 levels), even if developing countries make substantial reductions.

As a result, many developed countries pledged to reduce their emissions from 12 to 20 percent below 1990 levels by 2020, and 2 to 3 % per year afterword, varying due to assumptions made in the pledges. The European Union committed to reducing its domestic greenhouse gas emissions from 1990 levels by at least 20% by 2020, 40% by 2030, and 80% by 2050.

The U.S. pledged[16] a reduction of 17 % from 2005 levels by 2020 and more than 80 % below 2005 levels by 2050 in 2009. The pledge for 2020 was officially announced at the 15th session of the Conference of the Parties to the United Nations Framework Convention on Climate Change, in Copenhagen, Denmark.

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[13] History of the 2^{o} C climate target, 2010 John Wiley & Sons, Ltd. Volume 1, July/August 2010.

[14] Technical Summary for the IPCC Fourth Assessment Report, 2007 - the analysis builds on a prior IPCC report on Stabilization of Atmospheric Greenhouse Gases, February 1997.

[15] Concentrations of some greenhouse gases decrease almost immediately in response to emission reduction, while others can actually continue to increase for centuries even with reduced emissions.

[16] Emissions reduction levels were debated by Congress under several proposals from the House and Senate. For example under the American Clean Energy and Security Act (Waxman- Markey) the proposed reductions were 17% by 2020, 42% by 2030, and 83% by 2050 (benchmark is 2005 emissions).

Regionally, the New England states and East Canadian Provinces adopted targets for reducing their total greenhouse gas emissions. Similarly, New York, New Jersey, California, and Oregon adopted executive and legislative reduction targets.[17]

For Washington State's commitment to "do its part to reach global climate stabilization levels" – the State's greenhouse gas emissions are relatively lower than other states and economies of a similar size, in part due to its heavy reliance on electricity derived from the state's hydropower system. Taking this into account, the 2050 limit was set at 50 % below 1990 levels, or 70 % below the State's expected emissions that year, which establishes a range for the 2050 emissions limit.

To determine the range of the 2050 limit, an estimate of the expected emissions in 2050 is needed. This estimate is based on a "business-as-usual" set of conditions, assuming no additional actions are taken to reduce emissions. In 2007, a business-as-usual forecast was estimated for 2020[18] but not for 2050. A BAU estimate for 2050 was not prepared until 2013, when the Climate Legislative Executive Workgroup, through their consultant LEIDOS, estimated the business-as-usual emissions for 2020, 2035 and 2050[19].

A mid-level 2035 limit was set to drive continued progress toward meeting the 2050 reduction. The 2035 target also provides the State time to make any necessary adjustments to policies and programs, if needed.

The selected greenhouse gas reductions limits for 2020 and 2050 are less stringent than reduction levels pledged one year later by the United States. Table 1 below shows how the US pledged targets compare to Washington's statutory limits for 2020 and 2050 respectively.

Table 1- Comparing WA Statutory Limits to the US Pledged Targets, in MMTCO2e

	WA Limits	**US Pledged Targets Applied to WA**
2020	88.4(1990 levels)	81.5 *(17% below 2005 levels)*
2050	44.2-41.5 (50% below 1990 levels, or 70% below expected emission in 2050[20])	17.7 *(80% below 2005 levels)*

[17] http://www.c2es.org/print/us-states-regions/policy-maps/emissions-targets

[18] The Center for Climate Strategies, at the request of the Departments of Ecology and Commerce (then CTED) prepared the Greenhouse Gas Inventory and reference case Projections, 1990-2020.

[19],[19] Climate Legislative Executive Workgroup: Leidos Final Report on Evaluation of Approaches to Reduce Greenhouse Gas Emissions in Washington State, Oct. 2013; page 11

[20] This is based on using projected GHG emissions without federal and state actions, referred to as Business-As-Usual (BAU). See Leidos Final report.

Summary of Recent Advances in Climate Science

Scientific advances in understanding the causes and consequences of climate change have continued since enactment of the greenhouse gas emissions limits in 2008. These advances have been documented in a range of sources, including international, national, regional, and statewide reports and papers.

Current Trends in Greenhouse Gas Emissions

Globally and nationally, economic and population growth continue to be the most important drivers of increasing greenhouse gas emissions. Global annual carbon dioxide emissions have continued to grow since 1990 (the Kyoto Protocol reference year), primarily from fossil fuel emissions and secondarily from net land use change emissions**.** The rate of increase slowed briefly in 2012 (increasing 1.1 percent), then it increased by 2.3% in 2013, with a total of 36 $GtCO_2$[21] emitted to the atmosphere in 2013 (61% above 1990 emissions). Emissions are projected to increase 2.5% in 2014.

Atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years. The rates of atmospheric carbon dioxide accumulation are influenced by the rate of anthropogenic (i.e., human caused) emissions versus the rate of net uptake by natural sinks (ocean and land). The atmospheric concentrations of carbon dioxide have increased 40% since pre-industrial times (270 part per million[22], prior to 1750). The ocean has absorbed about 30% of the emitted anthropogenic carbon dioxide, causing ocean acidification (IPCC Summary 2013). About half of cumulative anthropogenic carbon dioxide emissions between 1750 and 2010 have occurred in the last 40 years and the *observed* average *rate of increase* over the last century is higher than any observed rate of change in the last 20,000 years. The total atmospheric concentration (measured by NOAA in Mauna Loa, Hawaii) in 1958 was 316 parts per million (ppm). In November 2013, the measured concentration was substantially higher at 395 ppm. From April to June 2014 the CO_2 concentration averaged above 400 ppm.

In 2013, global carbon dioxide emissions were dominated by emissions from China (28%), the USA (14%), the EU (28 member states; 10%) and India (7%). Growth rates of these countries from 2012 to 2013 were 4.2% for China, 2.9% for the USA, −1.8% for the EU28, and 5.1% for India (Figure 2). The per-capita CO_2 emissions in 2013 were 5.1 Mt of carbon per person/yr for the globe, 16.4 $MtCO_2$ for the USA, 7.2 $MtCO_2$ for China, 6.8 $MtCO_2$ for the EU28, and 1.9

[21] One gigaton is equal to one billion tons. 1 gigaton of carbon equals 3.67 gigatons of carbon dioxide.

[22] Atmospheric CO_2 levels are expressed in parts per million by volume (ppm). 1 part per million of atmospheric CO_2 is equivalent to 2.13 Gigatons or 7.81 Gigatons of Carbon Dioxide

$MtCO_2$ for India. Several countries are advocating for greenhouse gas emission reduction goals based on per capita allocations, as an equitable distribution of the responsibility.

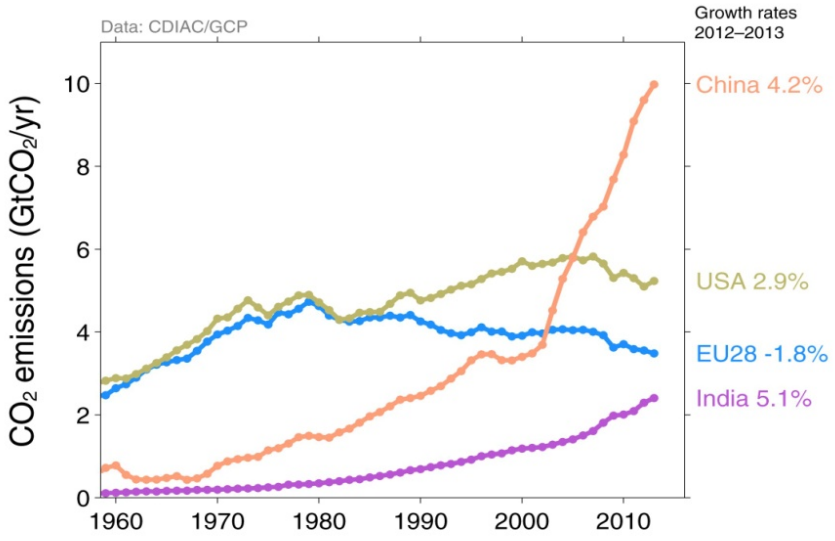

Figure 1 - Carbon Dioxide Emissions for the top four emitting countries

As illustrated in Figure 1, the total greenhouse gas emissions in the United States declined from 2007 to 2012. The decline was due to the recession, improved efficiency measures and the natural gas boom. However, after the 5-year decline greenhouse gas emissions in the U.S. are on the rise. According to the Energy Information Administration the U.S. total greenhouse gas emissions show an increase of roughly 2.9% in 2013 above the 2012 level. Emissions in 2013 are slightly more than 10% below 2005 levels (this is above the levels the US-pledged target of 17 % below 2005).

Washington State's emissions profile differs slightly from most states and the United States as a whole. The electricity sector is the largest source of emissions in the U.S. In Washington, the transportation sector is the largest source of emissions, accounting for over 44 % of total emissions in 2011. Emissions from Washington's electricity sector are generally lower than emissions from other states because of the state' extensive use of hydropower. However, energy sector emissions will fluctuate with changes in hydropower output. For example, in 2011 the total emissions dropped by 3.8 % relative to 2010. In 2010 the state experienced a drought, which required utilities to purchase more coal and natural gas power to replace lost hydropower capacity. Although the state made significant progress towards achieving the limits since 2005, the total emissions continue to grow. In 2011 the total emissions were about 5 % more than the 1990 level (Figure 2).

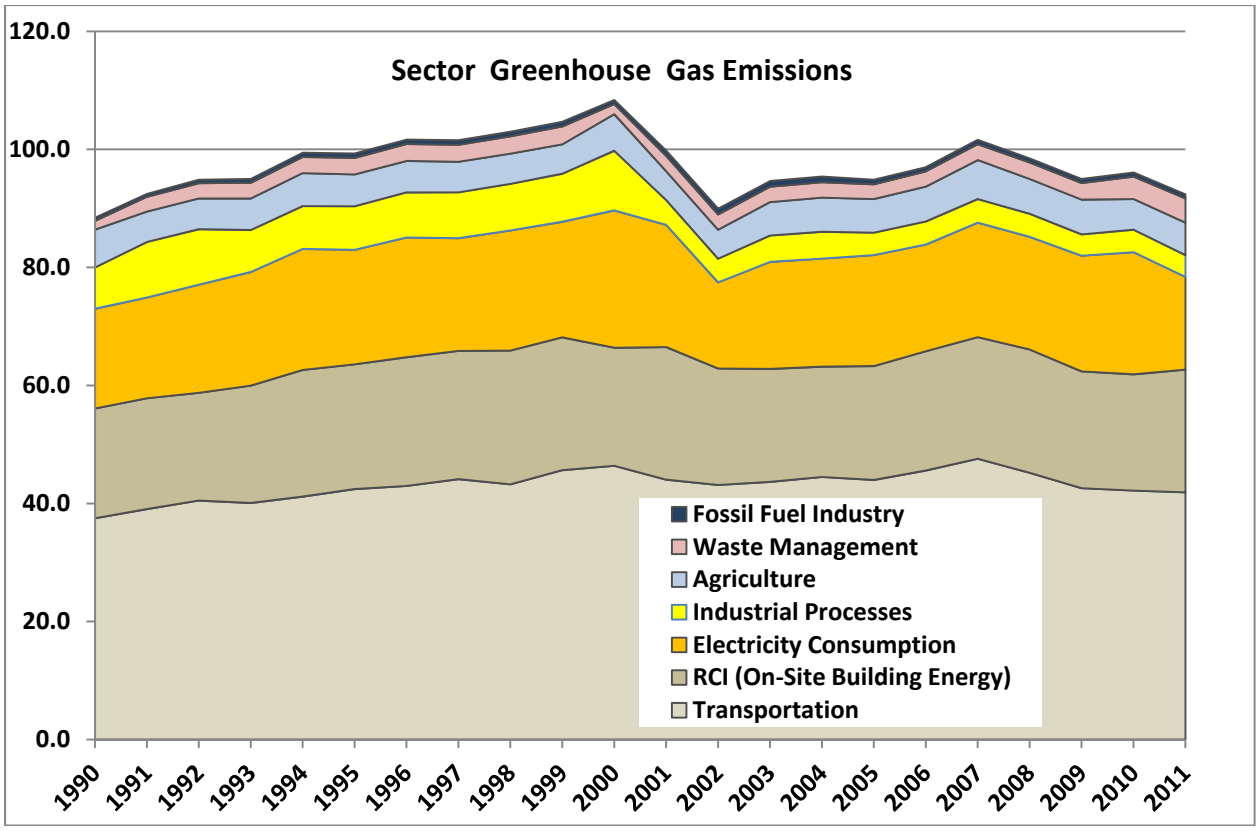

Figure 2 - WA GHG emissions, Trends by Sector, from 1990 to 2011 (Source Washington Department of Ecology)

Latest Knowledge on Human-Caused Climate Change

Significant advances in understanding the impacts of greenhouse gas emissions on the atmosphere and the oceans have been made since 2007. The scientific reports, listed in Box 2, have strengthened and added regional and local details about the causes and consequences of climate change and the role that human activities are playing in changing climatic conditions and ocean chemistry.

Globally, the Intergovernmental Panel on Climate Change has become progressively more certain about human influence on the climate system, as illustrated in the following quotes from the five IPCC Assessment Reports released to date (1990, 1995, 2001, 2007, and 2013):

- “Emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases…” (IPCC 1990, Working Group 1, Summary for Policy Makers)
- "The balance of evidence suggests a discernible human influence on global climate." (IPCC 1995, Working Group 1, Summary for Policy Makers)

- “There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.” (IPCC 2001, Working Group 1, Summary for Policy Makers)
- “Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG [greenhouse gas] concentrations.” (IPCC 2007, Working Group 1, Summary for Policy Makers)
- "Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century." (IPCC 2013, Working Group 1, Summary for Policy Makers)

The effects of greenhouse gases are cumulative, and future risks are directly tied to past and present decisions on emissions reductions. In 2013, the IPCC produced four greenhouse gas concentration pathways (referred to as Representative Concentration Pathways (RCPs). The pathways are used for climate modeling of 21st century greenhouse gas concentrations and global temperatures. Each pathway is associated with different cumulative carbon budgets. Three pathways, RCPs # 2.6, #4.5 and #6.0 represent various mitigation policies. The fourth RCP #8.5 represents more of a business-as-usual case (no climate policies). Global surface temperature increases and keep rising beyond 2100 in all scenarios except the lowest-concentration pathway (RCP #2.6), which would require stringent emissions reductions policies to keep warming below 3.6° F (2 °C). In the scenarios with higher concentration rates, warming is expected to be greater than 3.6° F (2 °C) by 2100 and could even exceed 8.5° F.

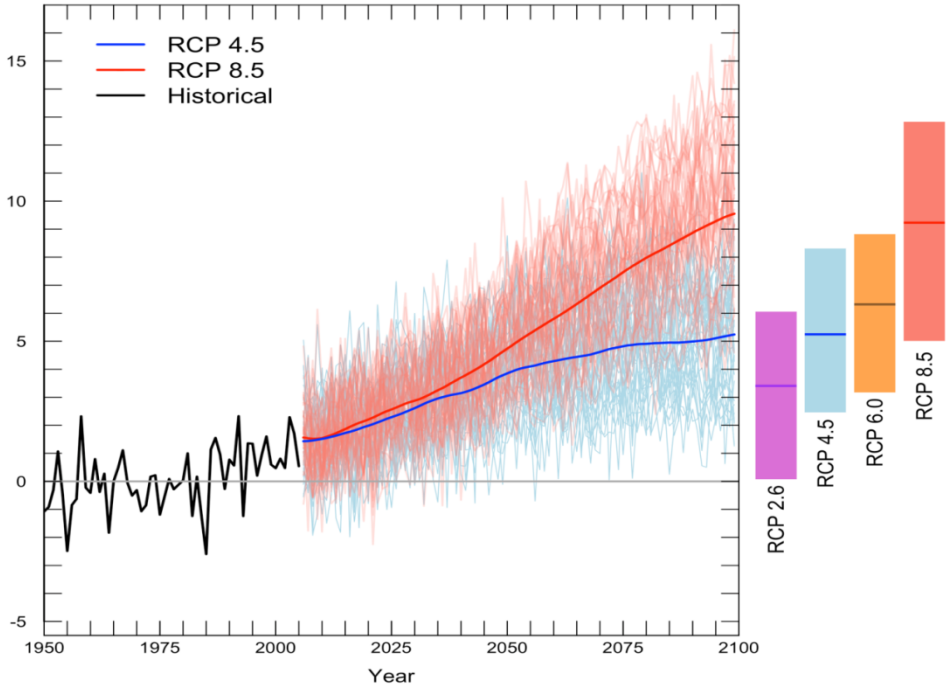

Figure 3 - Global mean surface temperature increase as a function of cumulative total global CO2 emissions from various lines of evidence. The colored plume illustrates the multi-model spread over the four RCP scenarios. (Source: IPCC Working Group I A)

Climate change scientific updates make a compelling case that globally climate change is no longer a future threat, it is taking place now. To better understand the latest research on climate change impacts in Washington State, the Department of Ecology requested (pursuant to RCW 70.235.040) that the University of Washington Climate Impacts Group prepare a summary report synthesizing current knowledge about observed trends and projected climate change impacts in Washington State and the Pacific Northwest. *Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers*[23] was released by the Climate Impacts Group in December 2013.

The "State of Knowledge" report was based on recent global, national, and regional assessments as well as peer-reviewed publications and other reports. Emphasis was placed on research published since 2007. (See Box 1)

As noted in the "State of Knowledge" report, Washington State and the Pacific Northwest are seeing long-term changes consistent with what is expected as a result of climate change. More than twenty years of research on Pacific Northwest climate change consistently finds that these impacts will grow substantially in the coming decades if we continue on our current path. These changes will likely challenge the state's economy, natural resources, communities, and citizens.

Box 1. Examples of Global, National and Local Scientific Reports

In 2009, the Climate Impacts Group released the *Washington State Climate Change Impacts Assessment*.

In 2010, the National Academies of Sciences released a four-report series on climate change, *America's Climate Choices.*
In 2011, the Intergovernmental Panel on Climate Change (IPCC) released a special report on *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*.

In September 2013 and March 2014, the IPCC released its Fifth Assessment Report on global climate change.

In 2013, the National Academies of Science released the Abrupt Impacts of Climate Change: Anticipating Surprises.

A separate full-length report on climate change in the Northwest, Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities, was published by Island Press in November 2013.

In May 2014, the Third U.S. National Climate Assessment was released, with a chapter focusing on impacts on the Northwest.

Highlights of Climate Change Risks to Washington State

Washington and the Pacific Northwest have experienced long-term warming, a lengthening of the frost-free season, and more frequent nighttime heat waves. Sea level is rising along most of Washington's coast. Coastal ocean acidity has increased. Glacial area and spring snowpack have declined, and peak stream flows in many rivers have shifted earlier. In addition, climate extremes (floods, drought, fires, and landslides) are already costly to Washington State.
Significant changes in the Pacific Northwest and Washington's climate are projected for the 21st century and beyond as a result of rising greenhouse gas emissions. All scenarios indicate

[23] http://cses.washington.edu/cig/reports.shtml#sok

continued warming. Projected changes through mid-century appear to be largely inevitable, driven by the warming that is already "in the pipeline" due to past emissions of greenhouse gases.

Current and future choices about greenhouse gas emissions will have a significant effect on the amount of change that occurs in the PNW after mid-century. For example:

- Average annual temperature for 2050s is projected to range from an increase of $+4.3^0$F (range: $+2.0^0$F to $+ 6.7^0$F) for a low greenhouse gas scenario (RCP 4.5) to $+5.8^0$F (range: $+3.1^0$F to 8.5^0F) under a high "business as usual" scenario (RCP 8.5) (relative to 1950-1999).
- Average April 1 snowpack for 2040s is projected to decrease by 38% to 46% for a low and a medium greenhouse gas scenario, respectively relative to 1916-2006.
- Sea level for 2100 is projected to rise by 4 to 56 inches for a low to high greenhouse gas scenarios (relative to 2000). Local amounts of sea level rise will vary due to differences in rates of uplift and subsidence at individual locations.
- Ocean acidity is projected to increase 38 to 41% for a low greenhouse gas scenario and 100 to 109% for a high greenhouse gas scenario by 2100, relative to 1986-2005.

These projected changes are expected to result in a wide range of impacts to our human health, water resources, forests, species and ecosystems, coasts, infrastructure, agriculture, and ocean resources.

Reduced Water Supply: Washington is projected to experience decreasing snowpack, a shifting balance between snow and rain, increasing stream temperatures, and changes in streamflow timing, flooding, and summer minimum flows as a result of warming temperatures. These changes are expected to reduce summer water supplies, causing "far-reaching ecological and socioeconomic consequences" (NCA Highlights: Northwest)[24]. For example, water shortage years in the Yakima Basin are projected to increase from 14% of years historically (1979-1999) to 43% to 68% of years by the 2080s (2070-2099) for a low and a medium greenhouse gas scenario, respectively. Washington State's $46 billion food and agriculture industry employs approximately 160,000 people and contributes 13% to the state's economy (Washington Department of Agriculture 2011).

Forests: Washington's forests are likely to experience significant changes in the establishment, growth, and distribution of tree species as a result of increasing temperatures, declining snowpack, and changes in soil moisture. A rise in forest mortality is also expected due to increasing wildfire, insect outbreaks, and diseases. Area burned by fire in the Columbia River Basin is projected to double by the 2020s, triple by the 2040s, and quintuple (x5) by the 2080s, relative to median for 1916-2006.

[24] National Climate Assessment, 2014; *nca2014.globalchange.gov/*

Loss of Fish, Wildlife and Natural Systems: Higher water temperatures, shifts in streamflows, and altered estuarine and ocean conditions associated with projected climate change will affect the recovery for many federally-listed endangered and threatened species, including salmon, trout, and steelhead[25]. Fishing and hunting, salmon and shellfish production, and tourism added nearly $3.1 billion to Washington's economy in 2006. Areas of suitable climate for many plants and animals are projected to shift considerably by the end of the 21st century. Many species may be unable to move fast enough to keep up, resulting in local species losses and changes in the composition of plant and animal communities. Climate change may also be affecting the benefits and services that diverse ecosystems provide, increasing the likelihood of impacts. Ecosystems also provide other benefits such as food, fuel, clean water, flood and storm protection, and cultural heritage. The annual benefit of ecosystem services in the Puget Sound watershed is conservatively estimated to range between $9.7 billion and $83 billion.[26]

Coasts and Oceans: More than 140,000 acres of coastal lands lie within 3.3 feet elevation of high tide in Washington and Oregon, exposing public and private property, infrastructure, and habitat to climate impacts (NRC 2012). For example, Padilla Bay, Skagit Bay, and Port Susan Bay could see a 77% decline in brackish marsh and 91% decline in estuarine beach by 2100, due to sea level rise. The oceans have absorbed about half of the human-made carbon dioxide, causing ocean acidification and negatively impacting shellfish, plankton, and corals. Recent studies suggest that oceans are becoming less able to absorb carbon dioxide and may be less able to buffer against climate change.[27]Sea level rise, rising temperature in coastal ocean, and ocean acidification will also affect the geographical range, abundance, and diversity of Pacific Coast marine species. These include key components of the marine food web (phytoplankton and zooplankton) as well as juvenile Chinook salmon and commercially important species such as Pacific mackerel, Pacific hake, oysters, mussels, English sole, and yellowtail rockfish.

Built Infrastructure: Sea level rise and increased river flooding are important causes of impacts on infrastructure located near the coast or current floodplains. Climate change is expected to affect the reliability and longevity of the State's infrastructure system. Most climate change impacts are likely to increase the potential for damage and service disruptions. Higher operating costs and reduced asset life are also expected. In Puget Sound counties, structures valued at approximately $29 billion are located in flood hazard areas, placing them at risk of flood damage[28]. In 2007 and 2008, weather-related closures of I-5 and I-90 resulted in $80 million in economic losses to the trucking industry, about $23 million in damages to interstate and state highways, and $39 million to city and county roads[29].

[25] Climate Change in the Northwest, Implications for Our Landscapes, Waters, and Communities; ISLANDPRES, 2013
[26] Batker *et al*. (2010)
[27] Vicki, M., A. Navarra; and P.C. Fogli, 2013: "Adjustment of natural ocean carbon cycle to negative emission rates." Climate Change, May 1, 2013
[28] King County Climate Plan
[29] Washington Department of Transportation, 2008

Agriculture: Washington crops and livestock will be affected by climate change via increasing temperatures and water stress, declining availability of irrigation water, rising atmospheric carbon dioxide, and changing pressures from pests, weeds, and pathogens. Some impacts on agriculture may be beneficial while others may lead to losses – the consequences will vary by cropping system and location. The overall vulnerability of Washington's agricultural sector to climate change is expected to be low due in part to the high adaptability of farming. However, given the combination of increasing water demands and decreasing water supplies in summer, water stress will continue to be a key issue going forward.

Human Health: Climate change threatens human health and well-being of our communities in many ways, including through impacts from increased extreme weather events, wildfires, and decreased air quality. Health impacts include higher rates of heat-related illnesses; respiratory illnesses; vector-, water-, and food-borne diseases; and mental health stress. These impacts can lead to increased absences from schools and work, reduced productivity and more emergency room visits, hospitalizations, and deaths.

Economy: Emissions of greenhouse gases can have major economic consequences, especially if no or inadequate reduction actions are taken. Several recent reports have examined the economic threats of climate change inaction. A 2010 study conducted by the University of Oregon for Washington State found that the effects of climate change on water supplies, public health, coastal and storm damage, wildfires, and other impacts, will cost Washington almost $10 billion per year after 2020, unless we take additional actions to mitigate these effects.[30]

In 2013, a national report[31] by CERES[32] on the growing costs to taxpayers of inaction on climate change from crop losses, flooding, wildfires, and relief from extreme weather events, concluded that the costs are more than $300 per person or total of $110 billion for 2012. Worsening climate change will drive up future losses.

In July 2014, the White House released a report "The Cost of Delaying Action to Stem Climate Change."[33] The report reaffirmed that delaying action is costly, with costs taking the form of greater damages from impacts of climate change or higher costs associated with implementing more rapid reductions of greenhouse gas emissions. The report concluded that these costs can be large:

- "Based on a leading aggregate damage estimate in the climate economics literature, a delay that results in warming of 3° C (5.4° F) above preindustrial levels, instead of 2° C (3.6° F), could increase economic damages by approximately 0.9 percent of global output. To put this percentage in perspective, 0.9 percent of estimated 2014 U.S. Gross Domestic Product (GDP) is approximately $150 billion. The incremental cost of an additional degree of warming beyond 3° Celsius would be even greater. Moreover, these costs are not one-time, but rather are incurred year after year because of the permanent damage caused by increased climate change resulting from the delay."

[30] 2010 Economic Impacts Report**:** Additional Analysis of the Potential Economic Costs to the State of Washington of a Business-As-Usual Approach to Climate Change: Lost Snowpack Water Storage and Bark Beetle Impacts,
[31] Inaction on Climate Change: The Cost to Taxpayers; CERES Report, October 2013
[32] CERES is the Coalition of Environmentally Responsible Economies
[33] http://www.whitehouse.gov/sites/default/files/docs/the_cost_of_delaying_action_to_stem_climate_change.pdf

International Commitment to Climate Stabilization

Globally, 2013 was the fourth warmest year on record. Globally averaged temperature has increased by 1.5°F or 0.85°C between 1880 and 2012. The Intergovernmental Panel on Climate Change confirmed that continuing the current pattern of greenhouse gas emissions would likely lead to a rise in temperature which will pose unprecedented risks to people's lives and well-being. To prevent the most severe impacts of climate change, a temperature benchmark for "safe warming" was agreed to - at least in principle - in Copenhagen in December 2009 by over 140 members of the UN Framework Convention (including the United States). The commitment was to keep the rise in average global surface temperature at less than ***3.6°F or 2°C*** above the preindustrial period average.

To have a reasonable chance of staying below the *3.6°F or 2°C* target, scientists from the IPCC, National Academies of Science and others laid out several conditions, such as but not limited, to the following:

- The atmospheric concentration of greenhouse gases needs to be kept between *400 to 450* parts per million of carbon dioxide equivalents (ppm CO_2e) or less. A 450 ppm CO_2e level corresponds to about 20 to 70 percent probability of staying below the target, while a 400 ppm CO_2e level corresponds to a probability of between 40 and 90 percent.

  The business-as-usual *climate cha*nge scenario (the scenario that assumes continued rapid rise in greenhouse gas emissions and little to no mitigation, or RCP 8.5) modeled by the Intergovernmental Panel on Climate Change shows an increase in global average surface temper**a**ture in 2100 of 4.7°F (2.6°C) to 8.6°F (4.8°C) relative to 1986 to 2005. The greenhouse gas concentration under this BAU scenario will exceed the 450 parts per million (ppm) CO_2e by 2030 and reach concentration levels of more than 1300 ppm CO_2e by 2100. (Excerpts from 2014 IPCC Summary for Policymakers)

- According to the 2014 IPCC 5th Report, to have a better than two-thirds chance (75 percent) of limiting warming to less than 2°C (3.6°F) from pre-industrial levels, the total cumulative carbon dioxide emissions from all human sources since the start of the industrial era would need to be limited to about ***1,000 gigatons*** of carbon ($GtCO_2e$) by 2050. Because CO_2 is not the only greenhouse gas, the IPCC report suggests that if a projection of the non-CO_2 gases is taken into account, the carbon budget associated with the 2°C (3.6°F) temperature limit is only 820 gigatons (IPCC, 2013).

  About half of the budget has already been emitted by 2011. At the current emission rates (around 10 gigatons per year) the carbon budget will be used up by around 2035[34]. Meeting the internationally agreed target of 2°C will require spending what remains of the carbon budget wisely (i.e., halting the increase in global greenhouse gas emissions by around 2020 and decreasing emissions thereafter). (IPCC, 2013).

[34] Fifth Assessment Report (AR5), and http://www.climatechange2013.org/

- Emission reductions in excess of what have been pledged by nations are required to limit warming to less than 2°C (3.6°F) from pre-industrial levels. According to the IPCC:
    - Delaying mitigation efforts beyond those in place today through 2030 is estimated to substantially increase the difficulty of the transition to low longer-term emissions levels and narrow the range of options consistent with maintaining temperature change below 2 °C relative to pre-industrial levels.
    - Current pledges by governments to reduce emission by 2020 have set the world on a path between 5.4°F /3°C and 9.7°F /5°C of warming by 2100.
    - Scenarios reaching atmospheric concentration levels of about 450 ppm CO2eq by 2100 (consistent with a likely chance to keep temperature change below 2 °C relative to pre-industrial levels) include substantial cuts in anthropogenic greenhouse gas emissions by mid-century through large-scale changes in energy systems and potentially land use.
    - Scenarios reaching these concentrations by 2100 are characterized by lower global greenhouse emissions in **2050 than in 2010, 40% to 70% lower globally**, and emissions levels near zero GtCO2eq or below in 2100." [35]

As early as 2010, the National Academy of Sciences issued a report on a climate stabilization target[36] stating that stabilizing atmospheric carbon dioxide will require deep reductions in the amount of carbon dioxide emitted. Emissions reductions larger than 80 percent, relative to peak global emissions rate, are required.

The European Union is on its ways to attain its target of 20 percent below 1990 by 2020. The European Commission, in 2014, proposed a policy framework for the period of 2030, offering to step up the 2020 cut to 30% if other major economies agree to do their fair share of a global reduction effort. The framework includes a 2030 greenhouse gas reduction target of 40 percent below the 1990 level. Achieving this will require an estimated 43 percent reduction by the sectors in the European Trading System (ETS), which will be accomplished by lowering the ETS cap.

The European Commission also set the emissions reduction objective for Europe and other developed economies at 80-95% below 1990 levels by 2050. To reach the target, the European Union developed Roadmap 2050[37]: a "cost-efficient, practical guide to a low-carbon Europe." It outlines pathways to achieve much deeper emissions cuts by 2030 (40 %), 2040 (60 percent) and 2050 (80 %), while maintaining or improving levels of electricity supply reliability, energy security, and economic growth and prosperity.

In November 2013, at the Warsaw climate conference, members of the United Nations Framework Convention on Climate Change (UNFCCC), including the U.S. and members of other developed, developing and major emerging countries, agreed to a timeline for developing and submitting new emissions reduction commitments "well in advance" of the Paris 2015

[35] IPCC statements in 2014 Fifth Assessment Report
[36] Climate Stabilization Targets, 2010 National Academy of Sciences, the study was part of five Congressionally-requested studies on climate change.
[37] http://www.roadmap2050.eu/attachments/files/Roadmap2050-AllData-MinimalSize.pdf

conference, "by the first quarter of 2015 for those parties ready to do so." The countries contributions to reducing or limiting emissions will be a key part of the negotiations of the 2015 agreement. Collectively, the contributions will need to be sufficient to keep global warming below 3°F/ 2°C. The negotiations will focus on how best to fairly allocate emission reduction targets to developed, developing, and emerging countries. New targets will go into effect in 2020.

It is not known whether members of the UNFCCC will pledge to a keep temperature to a lower level than the 3.6°F/ 2°C, based on recommendations from many researchers (Box 2) and what emission reductions levels they will be pledged for 2050 and beyond.

Box 2. Rethinking the *3.6°F/ 2°C*

Many researchers are arguing that 3.6°F/ 2°C no longer constitutes the threshold of dangerous climate change, given the changes already seen in the climate system with the 1.5°F (0.8°C) of warming that occurred between 1880 and 2012.

Scientists are urging countries to rethink the CO2 concentration level of 450 and the maximum temperature rise by considering CO_2 stabilization at 350 ppm and lowering maximum temperature change to 2.7°F/ 1.5°C.
http://www.nature.com/nclimate/journal/v4/n3/full/nclimate2148.html

The U.S. is seeking an agreement that will result in significant greenhouse gas emissions reductions and that is inclusive of all countries, particularly the largest carbon emitters. The Administration is actively working on its post-2020 contributions to reduce greenhouse gas emissions and intends to submit it no later than the first quarter of 2015.[38]

Conclusion and Recommendation Regarding Statutory Emissions Limits

Washington's existing statutory limits were shaped in part on the premise of doing our part to help stabilize the global climate. Since Washington's adoption of the statutory limits in 2008 the global, national and regional climate science is increasingly clear:

- Annual global emissions due to human activities are continuing to increase, concentrations of greenhouse gases in the atmosphere and the ocean have risen, and global temperatures are on the rise.
- Many scientific bodies have concluded that avoiding the most severe outcomes will require holding atmospheric concentrations of CO_2 to 450 part per million (ppm) and the total global average warming to no more than 3.6°F/ 2°C relative to pre-industrial levels (about 2°F/ 1.1°C above present levels).
- If we delay action by even a few years, the rate of reduction needed to achieve these goals would have to be beyond anything achieved historically and could be very costly.

[38] President Obama's Climate Action Plan, Progress Report, June 2014

- The costs of temperature increases of 3.6°F/ 2°C above preindustrial levels are likely to result in aggregate economic damages that are a small fraction of GDP[39]. However, for temperature increases of *5.4°F /3°C* or more above preindustrial levels, the aggregate economic damages from climate change are expected to increase sharply.

Climate change is not a far off risk. Globally, it is happening now and is worse than previously predicted, and it is forecasted to get worse. We are imposing risks on future generations (causing intergenerational inequities) and liability for the harm that will be caused by climate change that we are unable or unwilling to avoid.

Washington State's existing statutory limits should be adjusted to better reflect the current science. The limits need to be more aggressive in order for Washington to do its part to address climate risks and to align our limits with other jurisdictions that are taking responsibility to address these risks. Several United Nations member countries, including the United States government, several states, and local jurisdictions) that are actively addressing climate change, have adopted or pledged more stringent greenhouse gas emissions targets than Washington State's statutory limits.

In response to the legislative requirement under RCW 70.235.040, Ecology concludes that Washington's existing statutory statewide reductions limits under RCW 70.235.020, especially limits for 2035 and 2050, need to be updated through changes to the statute. However, Ecology recommends that no changes be made to the state's statutory emission limits at this time. International negotiations are under way regarding new emissions reductions targets, in preparation for the UN climate conference in December 2015, to be held in Paris. Ecology recommends waiting until the negotiations are concluded, as the result could better inform how Washington's limits should be adjusted.

[39] Working Group III Contribution to the IPCC Fifth Assessment Report Climate Change 2014: Mitigation of Climate Change