Comments Received during the Public Review Period on the "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008."

Reviewer: Bill Allen

General Comment

***Comment**: It's cooling and temperatures are below the levels of the 1930s! CO_2 is not causing warming! Collecting data on "greenhouse" emissions is a total waste of tax payer money! CO_2 is required for life to exist on this planet and the more we have the better is for all plant life.*

***Comment**: We don't need to be wasting taxpayer money on collecting data on green house gases! This is a surface temperature measurement for Yemassee, SC and as you can see, temperatures have declined since the 1930s; 1934 is officially the hottest year on record in the US. You should be aware of the "urban heating effect" which causes surface temperatures in urban areas to be warmer due to the effects of human activities. The temperatures in downtown large cities are as much as 8 degrees warmer than the surrounding rural areas! There is absolutely no reason to regulate CO_2!*

***Comment**: The attachment shows how the temperature data shows a warming bias due to the urban heat effect. The first graph shows the temperature much closer to what it really has been, with the hottest years in the 30s.* [See Appendix A for additional details.]

Reviewer: Francis Jeffrey & Janine Gonsenhauser, Circular Sea [TM] Consulatants

Annex 5: Assessment of the Sources and Sinks of Greenhouse Gas Emissions Excluded

***Comment**: We wish to point out that in the section, Annex 5 (PDF) (6 pp, 180K) - Assessment of the Sources and Sinks of Greenhouse Gas Emissions Excluded, the treatment of the Ocean in the category of "non-anthropogenic" effects, or as indeterminate, may be very misleading. By our own science-based estimates, the Ocean system provides an annual net sink of about 10Gt [CO_2], of which about 5Gt [CO_2] is recycled into oxygen returned to the atmosphere.   The former figure is in positive relationship with (chiefly) the CO_2 concentration of the atmosphere (now around 388 ppm [by volume], versus some 280 ppm pre-industrially). The latter figure (ie, 5Gt.) is in positive relationship with the health and productivity of the ocean, on average, which has declined about 20% over the same time-frame (as quantified by the statistic called "NPP" -- cf: the Panetta and Watkins committees, for assessments of recent decline.)   The United States is largest national source of influences upon both Ocean sink figures, the former (directly) via net CO_2 emissions, and the latter (indirectly and inversely) via water pollution; consequently the changes in these statistics are properly anthropogenic effects, which are on the same order of magnitude as the figures themselves, when considered on decadenal time-scales. (In addition, decreases and degradations of marine biomass may amount to net and cumulative emissions of greenhouse gasses, and the cumulative absorption of un-recycled CO_2 in the Ocean amounts to* *acidification which modifies the physical environment adversely for beneficial biota and carbon-sequestering components [such as the carbonate capsids of some phytoplankton, for example].)*

Reviewer: Giles Ragsdale

Executive Summary

Comment*: Given the recent contentious events related to climate change data manipulation, exactly how far back and how often is "recent" historical data updated (per the Executive Summary)?*

Comment*: Overall an increase of 14% is noted in the total US emissions. Has any thought been given to at least noting the rate of CO_2 emissions/Net emissions on a per capita basis year over year in order to provide some context related to the US population increase and whether emissions are trending up or down per capita?*

Trends

Comment*: A comparison is made between 2007 and 2008. Why is no mention made that the 2008 MTCO2eq total is also lower than 2005, 2006, as well as 2007 and is the lowest since 2000? Ditto for the totals for Fossil Fuel Combustion and overall Net Emissions, etc. There are circumstances but these trends seems significant and noteworthy.*

Reviewer: Bernard Kutter

General Comment

Comment*: It is time for America to take responsibility for our actions. America has caused the vast majority of the Worlds atmospheric increase in CO_2 and other green house gasses. The results are already affecting the world in the form of increased ocean acidity killing corals, melting of glaciers, changing weather patterns. We will always have the excuse that reducing our emissions is too hard, that it will cost too much, that the developing world should reduce their emissions. The reality is that America can reduce our emissions while simultaneously enhancing our long term economic prospects. Indigenously produced wind turbines, solar, geothermal and nuclear combined can reduce our emissions to levels well below 1990. Please put strong curbs on the allowed emissions of CO_2 and other green house gases.*

Reviewer: Eric Johnson

General Comment

Comment*: The U.S. Environmental Protection Agency's work on the 2010 Draft U.S Greenhouse Gas Inventory is excellent. This will provide an important reference for evaluating environmental impacts of greenhouse gas emissions and for identifying priority areas for reducing greenhouse gas emissions. The tables and figures on greenhouse gas emissions by economic sector and trends in greenhouse gas emissions are very useful. This document establishes important benchmarks for comparison with other nations and to evaluate the* *effectiveness of future greenhouse gas reduction efforts. Thank you for your detailed work on this document.*

Reviewer: Robert Vincin

General Comment

Comment*: The point is missed about cause effect solution on climate change. I sat in UNTAD UNFCCC etc assemblies from 1996. I am in PRC lowering CO_2 as invited foreign expert since 2005. Volcanoes emitted mass CO_2e nitrates sulfate for living matter to breath sequester. Emissions from power stations steel-mills are micro volcanoes. The principal climate change issue is mass land use land use clearing desertifcation and now no working no C4 CO_2 sinks. I am a foreign expert guest in PRC since 2005 lowering CO_2 and in so doing reversing deserts and the mass global cloud, restarting rain cycles. USA Senators are looking in the wrong place. The historians of tomorrow cannot wait until it is their turn 2020-50 as the bees birds micro organism are failing to work. Rain and trace element cycles along with CO_2 cycles have stalled. The Senate should come visit work as a global unit. We need new thinking working practicing delegates at COP16 to detail simple low cost solution BAU We borrowed the Planet from the historians let up put it back in working and balanced order.*

Reviewer: Michael Wondsidler

General Comment

Comment*: The US GHG Inventory should integrate a systems-based view and include this along with the normal sector-based view. When viewed together, the traditional sector-based view and the systems-based view offer a broader and easier to understand view of US GHG emissions. Both citizens and government representatives can benefit from a systems-based view and find this approach enlightening and educational in formulating choices and political actions to find solutions to counteract climate change.*

Comment*: Emissions resulting from personal and organizational consumption should be included in the US Greenhouse Gas Inventory. The US Greenhouse Gas Inventory should be state that the inventory is limited to emissions that physically originate within the national borders of the US. It should relate that imports for US consumption creates emissions that are counted in the inventories of other nations. Emissions from US exports are less than those from goods the US imports. Since we must also include the impacts of our consumption, the GHG emissions of the US is higher than suggested by the current IPCC accounting methods. This is really important:*

Consumption is the reasons for the emissions, and not including this will give critics of the EPA justification that the US Inventory is not a realistic picture of how much the US contributes to GHG emissions. Also, this encourages businesses and economic value to leave the US for other countries not counted in our inventory.

Comment*: Since we need to reduce the current and short term impacts of GHGs, we should also include the US inventory results using both the 100-year and 20-year global warming potentials*

(GWPs). This analysis would be helpful to citizens and governmental planners and decision makers.

Reviewer: Peter Schultze, Environmental Programs Analyst, City of Emeryville Public Works Department

General Comment

Comment*: Products and consumption of products and their domestic and international GHG related emissions need to be formally addressed in the inventory. It is something sorely lacking in most CAPs including the one developed by me for my jurisdiction.*

General Comment

Comment*: The views of emissions both by sector and systems analysis need to be presented so that more of the whole picture is understood.*

General Comment

Comment*: Shorter-term GWPs are illustrative of important issues; such as the differences between methane and* CO_2 *emissions, for example, and the relation to organic materials in the landfill. A 20 year GWP analysis would be helpful in creating our local policies and should be considered for the document.*

Reviewer: Chris Cuomo

General Comment

Comment*: My comment is that the public needs to know more about greenhouse gas emissions and other pollution caused by the military, at home and abroad. I therefore request that that information be included in the final report. The fact that the IPCC does not require reporting is irrelevant to the American public's need to know.*

Comment*: My question is whether you are able to direct me to any sources for [information about greenhouse gas emissions and other pollution caused by the military, at home and abroad].*

Reviewer: Bailey Payne, Waste Reduction Coordinator, Marion County Public Works

General Comment

Comment*: I've been working with a group called the West Coast Climate Forum which is made up of people working for the EPA, state & local governments. We have been discussing the importance of integrating a system-based view with the traditional sector-based view when it comes to inventorying where green houses come from. Much of the greenhouse gases associated with materials are released when natural resources are extracted or products are manufactured* *and this isn't well reflected in the traditional sector-based model. Thank you for your consideration.*

Reviewer: Sego Jackson, Principal Planner, Snohomish County Solid Waste Division

General Comment

Comment*: The US Inventory should integrate a systems-based or consumption-based view and present it alongside the sector-based view. Even if a detailed analysis is not available, providing text and graphics that demonstrate how an alternate view provides valuable information for policy and program development would be tremendsouly helpful to the public, stakeholders, policy makers and planners. coupled with the traditional sector-based view, the systems-based view offers a much more comprehensive perspective on how the US contributes to GHG emissions. At the very least this should be included under "planned improvements" in the waste section.* [See Appendix B for additional details.]

Comment*: Consumption-related emissions should be formally acknowledged in the US Greenhouse Gas Inventory. The US Greenhouse Gas Inventory should be much more explicit in stating that the inventory is limited to emissions that physically originate within the national borders of the US. It should explain that the US also contributes to emissions that are counted in the inventories of other nations, as a consequence of imports. The emissions associated with US exports are less that those associated with US imports. When viewed from the perspective of consumption, the greenhouse gas impact of the US is higher than suggested by the traditional IPCC accounting standard. This is of great importances: consumption is the root cause of emissions. Until this is clearly explained and addressed, stakeholders, policy makers, and planners will not understand the key overarching strategy of reducing consumption of energy and resources.* [See Appendix B for additional details.]

Comment*: Please include both 100-year and 20-year global warming potentials (GWPs) in the Inventory. While the Inventory points out that other GWPs are also available it would be more useful to actually include that analysis in the Inventory to assist policymakers, planners, and stakeholders.* [See Appendix B for additional details.]

Reviewer: Ralph J. Villani, Esq.

Energy

Comment*: Why not use methane gases from coal mines as an energy source instead of scubbing it into the atmosphere; maybe that might prevent another coal mine disaster and loss of life.*

Reviewer: Carey Hamilton, Executive Director, Indiana Recycling Coalition

General Comment

Comment*: On behalf of the Indiana Recycling Coalition (IRC), I am writing to encourage the U.S. Environmental Protection Agency to integrate the systems-based view in the U.S. Greenhouse Gas Inventory and present it alongside the traditional sector-based view. EPA recently published a "systems-based view" - see chart, p. 11, of GHG emissions. Coupled with the traditional sector-based view, the systems-based view offers a much more comprehensive perspective on how the US contributes to GHG emissions, in particular in the area of materials management. As a statewide education and advocacy organization the IRC works to advance a more sustainable materials management system, including advocating for stronger waste reduction, reuse, recycling and composting policies, in our state. We find the systems-based view to be very informative and instructional in developing policy actions to advance these efforts while simultaneously addressing climate change. Thank you for the opportunity to comment on this policy-making process. I can be reached at the number below should you have any questions about the IRC's position on this important issue.*

Reviewer: Jennifer Dawani, Environmental Scientist, Air and Waste Management Division of U.S. EPA (Region 7)

General Comment

Comment*: Adding a systems-based viewpoint on our emissions consistent with OSWERs report - http://www.epa.gov/oswer/docs/ghg_land_and_materials_management.pdf> see chart, p. 11, of GHG emissions. to give a more comprehensive perspective on how the US contributes to GHG emissions. Regardless of data limitations, I sincerely urge you to formally acknowledge consumption-related emissions in the inventory. The inventory should be much more explicit in stating that the inventory is limited to emissions that physically originate within the national borders of the US and acknowledge that the US also contributes to emissions attributed to other nations, as a consequence of our imports. This is important because consumption is the root cause of emissions, that we must at least acknowledge.*

Reviewer: Edward A. Mainland, Co-chair of Energy-Climate Committee, Sierra Club California

Landfills

Comment*: Methane Emissions from Landfills. Methane emissions are one of the most dangerous near-term emissions problem in the entire GHG picture. Most widely used methods unfortunately may seriously underestimate the problem of methane emissions from landfills. They particular underestimate the near-term emissions (three years) which are most significant. They also underestimate the greenhouse power of these emissions. They underestimate the percentage of GHG emissions caused by landfills. And they miscalculate how much methane can be recovered and used in Landfill Gas To Energy operations and they overly credit the GHG reduction benefit of these operations.   EPA's Inventory is the logical place to immediately rectify these analytic and factual shortcomings and misapprehensions. As a separate filing, you will be receiving a recent paper on this problem by Jim Stewart, Sierra Club's Los Angeles Chapter. The need to reduce short-term impacts of GHGs such as landfill methane is imperative. EPA's inventory should present GHG results using both 100-year and 20-year global warming impacts*

(GWPs). IPCC standards require the use of 100-year Global Warming Potentials (GWPs). EPA's inventory should not only point out that other GWPs are available but should include the other, alternative underlying analyses so that policymakers, state and local government energy staffers, and the public may be aware of them and start taking them more into account in policy and operations.

***Comment**: Acknowledge consumption-related emissions. Please ensure that EPA's GHG Inventory is crystal clear in noting that the Inventory is focussed only to those GHG emissions that are produced inside U.S. borders. The Inventory also should make clear that the U.S. also emits carbon that other nation's inventories count. That's because of imports. Carbon emissions from U.S. exports are smaller than those reckoned from imports to this country. That means that consumption-wise, U.S. carbon impacts are considerably higher than conventional IPCC reckoning admits. The EPA Inventory should explain why this is do. It's widely recognized that the chief source of emissions is consumption. EPA presumably would wish to avoid criticism that it's failing to assess and measure all these consumption impacts. EPA needs to convince decision makers, the media and the public that the Inventory really does give a complete and reliable picture of U.S. carbon emissions. EPA doesn't need to engender this kind of criticism unnecessarily. By giving a full look at consumption impacts, EPA can and should avoid causing complaints that EPA is indirectly rewarding off-shoring of emissions and the employment that goes along with that.*

***Comment**: Priority to systems-based view over traditional sector-based view. EPA's recently published a "systems-based view" http://www.epa.gov/oswer/docs/ghg_land_and_materials_management.pdf (chart, p. 11, GHG emissions) was welcome and beneficial. A systems-based view clearly presents a more complete and useful approach to assessing how much the United States is responsible for world carbon emissions. EPA should give the systems-based approach more visibility so that local officials and the public at large can work from a sounder basis in formulating actions to address carbon emissions more productively, effectively and scientifically.*

Reviewer: Matt Korot, Resource Conservation & Recycling Program Director, Metro

General Comment

***Comment**: Metro, the elected regional government serving nearly 1.5 million citizens in the Portland, Oregon metropolitan area, recently conducted an inventory of greenhouse gases for our region. In developing this inventory, Metro utilized the systems-based approach detailed in EPA's Opportunities to Reduce Greenhouse Gas Emissions through Materials and Land Management Practices report. As a national leader in developing policies and programs to reduce waste, Metro finds the systems-based approach to be a useful tool for identifying and analyzing additional policies to reduce emissions. It enables us to explicitly show how consumption of goods and food makes a significant contribution to greenhouse gas emissions. I strongly encourage you to include the systems-based inventory methodology alongside the traditional sector-based accounting approach contained in the draft U.S. inventory. Integrating the systems view into the U.S. inventory report would encourage other states and local governments to consider this approach, resulting in a more comprehensive set of policy tools to address emissions.*

Comment*: In addition, I encourage you to include in your report both the 100-year Global Warming Potential (GWP) and a 20-year GWP. The shorter timeframe provides more consistency with our regional planning efforts and provides a better frame of reference by which to actively engage our citizens.*

Reviewer: Julie Muir, PSSI/Stanford Recycling

General Comment

Comment*: The US Inventory should integrate the systems-based view and present it alongside the traditional sector-based view. EPA recently published a "systems-based view" < http://www.epa.gov/oswer/docs/ghg_land_and_materials_management.pdf > see chart, p. 11, of GHG emissions. Coupled with the traditional sector-based view, the systems-based view offers a much more comprehensive perspective on how the US contributes to GHG emissions. The sector based view only deals with end of the tailpipe solutions and doesn't put to solutions that will get us to 80% reduction. The general public and local policy makers find the systems-based view to be very informative and instructional in developing personal and policy actions to address climate change.*

Comment*: Consumption-related emissions should be formally acknowledged in the US Greenhouse Gas Inventory. The US Greenhouse Gas Inventory should be much more explicit in stating that the inventory is limited to emissions that physically originate within the national borders of the US. It should explain that the US also contributes to emissions that are counted in the inventories of other nations, as a consequence of imports. The emissions associated with US exports are less than those associated with US imports. When viewed from the perspective of consumption, the greenhouse gas impact of the US is higher than suggested by the traditional IPCC accounting standard. This is of great importance: consumption is the root cause of emissions, and failure to at least acknowledge the impacts of consumption exposes EPA to unnecessary criticism that the US Inventory is providing an incomplete picture of how the nation contributes to emissions (and indirectly, rewarding off-shoring of emissions and associated jobs).*

Comment*: Given the need to reduce the short-term impacts of greenhouse gases, it would be very helpful if the US Inventory portrayed results using both 100-year, and 20-year GWPs. While the IPCC standards require the use of 100-year Global Warming Potentials (GWPs), the Inventory correctly points out that other GWPs are also available, and including that analysis would be helpful to planners, policymakers, and the public.*

Comment*: The information in the EPA report on Products and Packaging should be included.*

Waste

Comment*: The bizarre treatment of landfills and incinerators as well as biogenic emissions makes it difficult to advocate for the proper solutions to material management, leading to more wasting of materials. It also undermines work in this field at the state-level.*

Reviewer: Laurence K. Lau, Deputy Director for Environmental Health, State of Hawaii

Waste

***Comment**: While the draft seems very comprehensive, I ask that it or future versions include an analysis of materials management. For example, the EPA OSWER presented in Hawaii another look at emissions that provided a useful perspective. Closing the Loop on Climate Change, Edward Chu, October 23, 2008 (Center for Program Analysis, OSWER, chu.ed@epa.gov) It highlights the roles of buildings, land use patterns, and providing goods, items that are indirectly covered by the draft inventory. The materials management approach is easier for some people to grasp, and policy makers benefit from having a variety of tools.*

General Comment

***Comment**: I also ask for some analysis of life cycle issues. Life cycle analyses may be necessary to describe materials management properly, as "things" often represent imbedded energy and emission costs.*

Reviewer: Rick Albright, Director, Office of Air, Waste & Toxics, U.S. EPA Region 10

General Comment

***Comment**: The Executive Summary of the 2010 Draft U.S. Greenhouse Gas (GHG) Inventory provides a discussion of an alternative view of GHG emissions with the inclusion of "emissions by economic sector." We recommend that this be expanded to also include a presentation of emissions by economic system, based on the systems approach to the U.S. GHG Inventory included in OSWER's 2009 report, Opportunities to Reduce Greenhouse Gas Emissions through Materials and Land Management Practices.*

Assisting government, business and public understanding of the complex connections between the economy, consumption and GHG emissions is one of EPA's essential roles. OSWER's 2009 report provides important new thinking on GHG emissions by re-casting the U.S. GHG Inventory into a system-based view of the data. By presenting a life cycle perspective of GHG emissions associated with providing goods and food to the economy, the systems-based view demonstrates important opportunities to reduce GHG emissions through the management of materials from resource extraction through end-of-life. The systems-based inventory also illustrates the important connections between land management decisions and GHG emissions, especially emissions from transportation. As discussed in the OSWER report, this perspective daylights important prevention-oriented mitigation strategies that can enhance the overall effectiveness of our climate protection program. Several large cities on the West Coast are already beginning to incorporate this thinking into their climate actions plans.

Reviewer: Shannon Binns, Program Manager, Green Press Initiative

General Comment

***Comment**: As a member of the Land Use Technical Working Group (TWG) for the new GHG Protocol Product Life Cycle Accounting and Reporting Standard, I can also tell you there is a strong interest from organizations who are measuring and trying to reduce their GHG impacts to have guidance in this area as well, and that has been our working group's task. We have recognized that despite the complexity of measuring product carbon footprints for products that rely heavily on the harvesting of natural resources -- such as paper products -- it is necessary to provide some guidance for measuring these impacts and have done so in the new draft standard. The draft standard has already been tested by 60 companies and as you can read in this article, "Increasingly, companies are looking beyond their own boundaries and developing strategies to reduce GHG emissions in their supply chains and in the products they make and sell," [said] Bjorn Stigson, president of WBCSD. "By taking a comprehensive approach to GHG measurement and management, businesses and policymakers can focus attention on the greatest opportunities to reduce emissions within the full value chain, leading to more sustainable decisions about the products companies buy, sell, and produce."*

Reviewer: John Davies, Sustainable Transport and Climate Change Team, Office of Natural and Human Environment, Federal Highway Administration

Mobile Combustion

***Comment**: The impact of rising biofuel utilization on transportation CO_2 trends should be clarified in EPA's inventory. DOT recognizes that biofuel combustion CO_2 is not included in energy sector totals, since it's assumed that CO_2 released during combustion is re-absorbed as biofuel crops regenerate. However, the inventory's combustion-only estimates are often used as the basis for calculating upstream emissions, which can be considerable for biofuels. This suggests the need for an expanded discussion of GHG accounting issues in the context of transportation GHG trends, as well as the inclusion of placeholder data to allow for the fuel cycle calculation.*

***Comment**: Transportation estimates in Tables such as 2-15 and 3-12 could include tailpipe biofuel combustion estimates as an italicized item similar to the "wood biomass and ethanol consumption" estimate currently presented in Tables ES-2 and 3-1. It would also be worthwhile to include a footnote explaining why these emissions are not included in the total.*

***Comment**: It could also be very helpful to include actual transportation biofuel consumption data in the Annex. This information could be included as an italicized subitem (beneath the main table) in Annex 2 Tables A-10 to A-29, or in the front section of Annex section 3.2.*

***Comment**: The impact of increased biofuel consumption (and the related accounting issues) could also be discussed in the transportation narratives of Sections 2.1 and 3.1, which could also point to the RFS literature for details on upstream analysis of transportation fuels.*

Reviewer: Joe Carriero, National Park Service

General Comment

***Comment**: Under the Executive Order "Federal Leadership in Environmental, Energy, and Economic Performance" issued in October 2009, federal agencies are now required to "measure, report, and reduce their greenhouse gas (GHG) emissions from direct and indirect activities." The Department of Energy (DOE) Federal Energy Management Program (FEMP) in cooperation with other federal agencies has developed the Federal Greenhouse Gas Accounting and Reporting Guidance to define methods for reporting emissions. EPA should ensure that methods used in this annual inventory of greenhouse gas emissions and sinks are consistent with the FEMP methodologies. If source categories or reporting methods differ, it would be appropriate to define the basis for differences in a new section added to this report.* [See Appendix C for additional details.]

Land Use, Land Use Change, and Forestry

***Comment**: The inventory results are informative and for the most part clearly presented. While we agree that currently available methods make it difficult to specifically quantify the impacts of forest fires on net carbon sequestration in forests, EPA should acknowledge the numerous efforts by federal agencies to improve methods to characterize fire emissions. Future inventories may be able to refine these estimates.* [See Appendix C for additional details.]

Reviewer: S. Rao Chitikela, Ph.D, P.E., BCEE

Wastewater

***Comment**: Are the CO_2 emissions of wastewater treatment using aerobic/anaerobic bio-processes considered in this report?*

-- CO_2 emissions of biological activated sludge processes and other nitrification/denitrification processes are significant.

***Comment**: Are the CO_2 emissions of fuel combustion operations at the POTWs considered for this report?*

-- For example, fuel-oil or natural gas (or recovered biogas or other fuel) is fired in the sludge heaters to maintain the mesophilic temperatures of the anaerobic sludge digesters.

Reviewer: Tom Huetteman, Associate Director, Waste Management Division, U.S. EPA Region 9

General Comment

***Comment**: The Executive Summary of the 2010 Draft U.S. Greenhouse Gas (GHG) Inventory provides a discussion of an alternative view of GHG emissions with the inclusion of "emissions by economic sector." We recommend that this be expanded to also include a presentation of emissions by economic system, based on the systems approach to the U.S. GHG Inventory included in OSWER's 2009 report, Opportunities to Reduce Greenhouse Gas Emissions through Materials and Land Management Practices. Assisting government, business and public understanding of the complex connections between the economy, consumption and GHG emissions is one of EPA's essential roles. OSWER's 2009 report provides important new thinking on GHG emissions by re-casting the U.S. GHG Inventory into a system-based view of* *the data. By presenting a life cycle perspective of GHG emissions associated with providing goods and food to the economy, the systems-based view demonstrates important opportunities to reduce GHG emissions through the management of materials from resource extraction through end-of-life. The systems-based inventory also illustrates the important connections between land management decisions and GHG emissions, especially emissions from transportation. As discussed in the OSWER report, this perspective daylights important prevention-oriented mitigation strategies that can enhance the overall effectiveness of our climate protection program. Several large cities on the West Coast are already beginning to incorporate this thinking into their climate actions plans. We recognize the need for careful deliberation when making changes to the Inventory, and we would like to begin a robust internal dialogue on this recommendation. Please feel free to contact me to discuss further our recommendation.*

Reviewer: Paula Wise, Deconstruction & ReUse Network

Waste

Comment*: This is a incredibly important act. I hope that you will to incorporate Reuse and deconstruction into the mix. I understand Recycling is included. Recycling is good, but reuse is better. Keeping items in there original state reduces greenhouse gases. I ask that you please consider this.*

Reviewer: Joyce Dillard

Energy, Oil & Gas

Comment*: Since oil wells are on residential property in the City of Los Angeles, how are emissions gauged separately in relationship to automobiles or other industry emissions? Is there a danger that these emissions can be masked under an industrial veil and not production?*

Comment*: How is fracking being addressed for oil extraction?*

Comment*: How is subsidence being handled in relationship to gas leakage?*

General Comment

Comment*: Is there a groundwater quality standard for landfills and/or oil fields.*

Comment*: Are there requirements to report and measure any de-watering as a Methane Mitigation?*

Comment*: Methane Mitigation Standards do not seem to exist. Are there Federal standards? If so, do they address NPDES requirements?*

Reviewer: Kyle Meisterling

Annex 3

Comment*: Annex 3, "Methodology for Estimating CH_4 emissions from Landfills" (p A-280), The heading # reads "3.1." should probably be 3.14.*

Reviewer: Karin Ritter, American Petroleum Institute

Energy, Petroleum Systems

Comment*: API recently revised the API Compendium. References to emission factors from the API Compendium should be updated to reflect the 2009 version of API's Compendium of Greenhouse Gas Emissions Estimation Methodologies for the Oil and Gas Industry. For example, Section 3.7 Petroleum Systems (p. 3-49, line 22 and p. 3-50, line 27) and Annex 3.5 Petroleum Systems (p. A-149, line 32) reference "API (2004)". Note: the emission factors referenced in these citations did not change between the 2004 and 2009 editions.*

Comment*: The most significant change noted in the 2008 national inventory was the addition of asphalt blowing* CO_2 *emissions for refineries in the Petroleum Systems category. This emission source accounts for 36% of the total non-combustion* CO_2 *emissions from petroleum systems in 2008. The* CH_4 *factor for asphalt blowing is the same as is used in the 2007 EPA Inventory of Greenhouse Gas Emissions and Sinks. However, neither emission factor is consistent with the 2009 API Compendium.*

The 2009 API Compendium cites a simple emission factor for uncontrolled asphalt blowing from AP-42 (EPA, AP-42, Section 5.1.2.10, 1995). The AP-42 emission factor for asphalt blowing is assumed to be on an air-free basis (AP-42 does not specify this, but notes the factor represents "emissions"). Asphalt blowing exhaust composition data (13 mol% CH_4 *and 9 mol%* CO_2*, on an air free basis) presented in an Oil & Gas Journal article is applied to derive the* CH_4 *and* CO_2 *emission factors of 5.55E-4 tonnes* CH_4*/bbl asphalt blown and 1.01E-3 tonnes* CO_2*/bbl asphalt blown, respectively. (Further details on the derivation of these emission factors is provided in Appendix B of the 2009 API Compendium.)*

For comparison, the EPA emission factors converted to a similar basis are 4.9E-5 tonnes CH_4*/bbl and 1.09E-3 tonnes* CO_2*/bbl. However, the primary distinction between the API Compendium emission factors and those used in the EPA inventory is the units of measure applied to the activity factor. The API emission factors are based on the volume (or mass) of asphalt blown, while the EPA emission factors appear to be based on the total volume of asphalt produced (411 Mbbl/cd production). As a result, the EPA emission factors result in much higher emission estimates.*

Energy, Natural Gas & Petroleum Systems

Comment*: EPA notes under planned improvements for both the Natural Gas Systems and Petroleum Systems source categories that results from two studies on flashing losses from oil and condensate tanks will be reviewed for the next inventory update cycle. API and its member companies provided comments last August on the study by the Texas Commission on Environmental Quality. API expressed serious concerns over the presentation of results from that study, where differences between model-estimated values and field data were reported as errors in the model calculations, and in the lack of information provided to evaluate measurement data quality. API is concerned that this report inadequately portrays the reliability of emissions estimation methods commonly used in the oil and natural gas industry, and may result in erroneous conclusions about the credibility of widely used flash emission models. In addition, the extrapolation of the report findings to estimating methane emissions from work specifically addressing Volatile Organic Compounds emissions is inappropriate.*

***Comment**: There are a number of sources that do not appear to be included in the national GHG inventory. For the refining sector, these include CO_2 emissions from flares, catalytic cracking units, fluid coking units, catalytic reforming units, sulfur recovery units, and coke calcining units. Emissions from each of these sources are required to be reported under the Mandatory GHG Reporting Regulation (MRR), and for which EPA had to assess the emissions as part of the justification for their inclusion in the MRR. The inventory should incorporate EPA's current understanding of these emissions or document why they are excluded from the inventory.*

Annex 3.4, Natural Gas Systems

***Comment**: Emission factors and activity factors are only provided for 2008 (with the exception of "key activity data drivers" provided in Table A-114), yet emissions are shown for multiple years. Recommend adding emission and activity factors for all years for which emissions are being estimated, for full disclosure. (In addition, it is discussed in Step 1 that activity factors vary by year.)*

***Comment**: If emission factors determined for 1995 are assumed to be representative of emissions from each source type over the period 1990 through 2008, recommend adding that information to Step 1 or Step 3, similar to the text in Annex 3.5 Petroleum Systems, p. A-149, line 19.*

***Comment**: Table A-112 - Recommend showing non-zero values for emission factors for the following activity types: Turbines (Storage), Generators (Engines), and Generators (Turbines). Emissions from these sources are not zero; therefore the emission factor must also not be zero.*

***Comment**: Table A-114 - Activity counts for "Non-associated Gas Wells" correspond to the sum of the count of "Non-associated Gas Wells" and "Unconventional Gas Wells" presented in Table A-110 and A-117. Recommend adding a footnote to Table A-114 to reflect this summation.*

***Comment**: Emissions for the year 2000 are missing from all tables in this annex; however, they are shown in Section 3.6 (Tables 3-37 through 3-40). Emissions (and all data used to derive emissions) for the year 2000 should be added to Annex 3.4.*

***Comment**: Activity factors are only provided for 2008, yet emissions are shown for multiple years. Recommend adding activity factors for all years for which emissions are being estimated, for full disclosure. (In addition, it is discussed in Step 2 that activity factors vary by year.) Text should also be added to Annex 3.5 defining the sources of the activity factor data.*

Reviewer: Kevin Bundy, Senior Attorney, Center for Biological Diversity

Biomass Burning

***Comment**: EPA's inventory document repeats a pernicious assumption that has profound consequences for both the climate and the nation's forests: the assumption that biomass combustion is "carbon neutral." EPA recognizes, as it must, that the combustion of biomass and biofuels produces CO_2 and other greenhouse gases. Yet EPA declines to include these emissions in national totals "because biomass fuels are of biogenic origin." According to EPA, "[i]t is assumed that the carbon (C) released during the consumption of biomass is recycled as U.S. forests and crops regenerate, causing no net addition of CO_2 to the atmosphere." As described in detail below, scientists have concluded that this assumption represents a critical error in*

EPA's climate accounting methodology. This error pervades all of EPA's biomass calculations, but it is especially glaring as applied to facilities that burn woody biomass from tree plantations, forest thinning projects, or fire salvage projects. Promotion of new and expanded biomass energy facilities predicated on this assumption is beginning to threaten both the ecology of the nation's forests and the stability of the world's climate. EPA thus should revise the Inventory to eliminate reliance on the "carbon neutrality" assumption and should adopt accounting methods that accurately measure emissions from both biomass combustion and associated land use change on time scales relevant to climate protection efforts. [See Appendix D for additional details.]

Reviewer: Bill Sheehan, Product Policy Institute (plus 62 other organizations' signatures)

General Comment

***Comment**: The US Inventory should integrate "systems-based" greenhouse accounting -- and present it alongside the traditional sector-based view.*

***Comment**: Consumption-related emissions should be formally acknowledged in the US Greenhouse Gas Inventory. The US Greenhouse Gas Inventory should be much more explicit in stating that the inventory is limited to emissions that physically originate within the national borders of the US. It should explain that the US also contributes to emissions that are counted in the inventories of other nations, as a consequence of imports.*

***Comment**: Given the need to reduce the short-term impacts of greenhouse gases, the US Inventory should portray results using both 100-year, and 20-year Global Warming Potentials. While the IPCC standards require the use of 100-year Global Warming Potentials (GWPs), the Inventory correctly points out that other GWPs are also available, and including that analysis would be helpful to planners, policymakers, and the public.*

Reviewer: Cynthia A. Finley, Ph.D, Director, National Association of Clean Water Agencies

Water – Wastewater Treatment

***Comment**: NACWA believes that using the literature nitrogen loading values or EPA-collected values from U.S. POTWs would better reflect the actual emissions from POTWs in the U.S. than the current methods based on the IPCC Guidelines. The IPCC Guidelines do not necessarily reflect actual conditions at POTWs throughout the U.S. This is illustrated by the emission factor ("EF1") of 3.2 g N_2O/person-year for plants with no intentional denitrification, used in the Draft Inventory and in the IPCC Guidelines to calculate nitrous oxide emissions from centralized wastewater treatment plants. This value was obtained from a single study of a very small wastewater treatment plant (1.06 million gallons per day, or MGD) in a small university town in New Hampshire. The population of this town is 12,500 during the school year, but drops to 6,200 in the summer months, during which most of the measurements for this study were made. If the IPCC can use this single study to define an emission factor that is used for centralized treatment facilities all over the world, certainly EPA can justify changing the nitrogen loading* *rate for facilities in the U.S. based on multiple literature values and data that it can collect from POTWs across the nation.* [See Appendix E for complete comment.]

Comment*: In the $N_2O_{WOUT\ NIT/DENIT}$ equation (line 44, page 8-13), the FIND-COM factor should be moved outside of the square brackets. This is a typographical error rather than an error that affects the calculations.*

Comment*: In the $N_2O_{EFFLUENT}$ equation (line 45, page 8-13), the USPOP factor should be multiplied by the WWTP factor, as it is in the $N_2O_{WOUT\ NIT/DENIT}$ equation, since septic system users should not be included in the amount of effluent discharged to aquatic environments. NACWA recommends that any nitrous oxide contributions from septic systems be calculated in a separate equation if they are even included in the Inventory.*

Comment*: The units provided in the definitions of N_2O_{TOTAL}, N_2O_{PLANT}, $N_2O_{NIT/DENIT}$, and $N_2O_{WOUT\ NIT/DENIT}$ (lines 2-7, page 8-14) should be Gg, not kg, since conversions are made to Gg in the equations used to calculate these values.*

Comment*: The value of 269 Tg N for N_{SLUDGE} (line 37, page 8-14) appears to be an error, resulting in a negative value for $N_2O_{EFFLUENT}$. The value of 141 Gg N found in the Annex in Table A-193 (page A-231) is a more appropriate magnitude. However, even substituting this 141 Gg N value for N_{SLUDGE} does not result in a $N_{TOTA}L$ value that agrees with the value of 15.9 Gg N_2O in Table 8-7. EPA should review the equation for $N_2O_{EFFLUENT}$ and all of the values used in it for accuracy.*

Reviewer: John Davis

Landfills

Comment*: Landfills emit methane. The Inventory should acknowledge that methane is standardized to CO_2's 100-year atmospheric life, therefore understating methane's real 20-year impact. Please see the attached article "Lifetime Leveraging: An Approach to Achieving International Agreement and Effective Climate Protection Using Mitigation of Short-Lived Greenhouse Gases".* [See Appendix F for article.]

Comment*: Landfills are credited with carbon sequestration, thereby perversely reducing their methane impact. Common sense dictates that burying anthropogenic carbon should not be considered a GHG reduction. Sequestration credit is particularly perverse in rewarding activities that reduce recycling and composting, where real GHG reduction occurs. Methane avoidance, through recycling and composting, should be acknowledged in the Inventory and full methane production, independent of sequestration, should be presented.*

Waste

Comment*: Recycling avoids primary extraction and processing, with its associated GHG emissions. Composting reduces GHG emissions from synthetic fertilizer and pesticide production. Food and landscape materials composting avoids methane generation. The Inventory should demonstrate the potential for full recycling and composting benefits, including landfill methane avoidance.*

General Comment

***Comment**: EPA's seminal work on materials consumption needs to be incorporated in the Inventory. The 2009 report "Opportunities to Reduce Greenhouse Gas Emissions Through Materials and Land Management Practices" demonstrates the impact of global consumption patterns and systems views, rather than narrowly focused sector based impacts. The Inventory should acknowledge the system and consumption work that will lead to significant policy development.*

Reviewer: Peter Anderson, Executive Director, Center for a Competitive Waste Industry

Landfills

***Comment**: Global warming potential. Include in the table showing each sector's responsibility for anthropogenic greenhouse gas emissions the applicable value when current instead of obsolete Global Warming Potential multipliers are used.* [See Appendix G for additional details.] .

***Comment**: Short-term strategies. Employ a two-pronged strategy that includes a short-term along with the long-term approach in reported inventory values.* [See Appendix G for additional details.] .

***Comment**: First Order Decay Model. Replace the First Order Decay Model, which fails to account for internal moisture levels critical for gas generation, with a revised model that does.* [See Appendix G for additional details.] .

Reviewer: Garrett Fitzgerald, Sustainability Coordinator, City of Oakland

General Comment

***Comment**: Include a "systems" or "consumption"-based perspective on GHG emissions within the Draft Inventory.* [See Appendix H for additional details.]

Reviewer: MaryEllen Etienne, Executive Director, Reuse Alliance

General Comment

***Comment**: Mention reuse wherever materials management and/or recycling is mentioned in order to acknowledge its significance within the EPA waste management hierarchy and in the handling of GHGs (it is not currently found in the current documentation).*

***Comment**: Consider the energy savings and emission reductions of reuse.*

***Comment**: Take account of the full life-cycle of materials, from research, extraction, transportation retail, use, and disposal.*

***Comment**: Creates a systems-based analysis of direct and indirect emissions or of energy consumption related to materials management.*

Reviewer: Barbara Warren, Executive Director, Citizens' Environmental Coalition

Waste

Comment*: Seek global agreement to update the methodology so that it reflects the best current scientific information.*

General Comment

Comment*: Continue to use the agreed upon 2nd IPCC assessment guidance, but add a supplement to the inventory that reflects current understanding of better scientific information. This also will help identify additional opportunities for greenhouse gas reductions. For example, see our discussion of issues related to WASTE below. [Issues discussed are: failure to include upstream GHGs and embodied energy in solid waste, mis-using the SAR 100 year GWP for Methane (should be 20 year), over-estimating LF gas collection efficiency, incorrect treatment of biogenic emissions.]* [See Appendix I for additional details.]

Comment*: Identify solutions and best practices which can be implemented immediately by state and local governments. All solutions and best practices should be sustainable, offering benefits in 3 spheres -economic, environmental and social-- with no damaging or detrimental drawbacks. Adopting sustainable solutions becomes easy, when multiple benefits, beyond GHG reductions, are within reach.*

Comment*: Do more analysis at the micro-level. What is the most efficient way to get food from the farm to household dinner tables? the most efficient way to deliver health care? How energy efficient can supermarkets be made? Hospitals? Sewage treatment plants? Schools? Various industries? Etc.*

Comment*: Strive to make all of the systems we use and rely on - sustainable. Until we do we will not be able to address climate change.*

Comment*: Immediately address WASTE and WASTING in a much more substantial way. Post World War II we have dramatically increased the amount of waste we generate. WASTE and WASTING are similar to energy losses, except that waste involves the loss or destruction of material resources as well as embedded energy.*

Reviewer: Margaret M. Guerriero, Director, Land and Chemicals Division – EPA Region 5

General Comment

Comment*: We encourage you to revise the draft inventory to include, at a minimum, a reference to this important and insightful EPA, peer-reviewed resource. Ideally, future versions of the inventory will include both a sector-based and a systems-based view to present a more comprehensive picture of U.S. GHG emissions.* [See Appendix J for additional details.]

Appendix A

UNITED STATES AND GLOBAL DATA INTEGRITY ISSUES

By Joseph D'Aleo
Update October 8, 2009

ABSTRACT

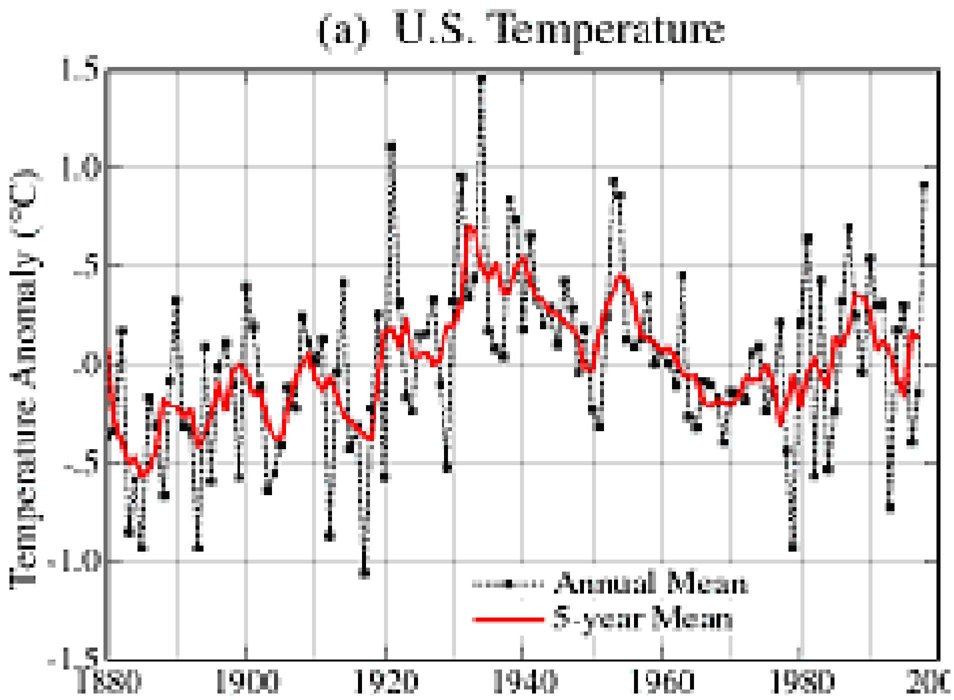
Issues with the United States and especially the global data bases make them inadequate to use for trend analysis and thus any important policy decisions based on climate change. These issues include inadequate adjustments for urban data, bad instrument siting, use of instruments with proven biases that are not adjusted for, major global station dropout, an increase in missing monthly data and questionable adjustment practices.

We hear official press releases announcing 2008 was the 8th, 9th or tenth warmest in 127 to 147 years in the various global data bases. Yet the NASA satellite record shows the year for the globe was the coldest this decade and 14th coldest in the 30 years of satellite monitoring. Here we will show how these global estimates are contaminated and can't be trusted and certainly should not be used for important policy decisions.

US CLIMATE DATA

NOAA NCDC USHCN

When first implemented in 1990 as USHCN version1, it employed 1221 stations across the United States. In 1999, NASA's James Hansen published this graph of USHCN version 1 annual mean temperatures:



About which Hansen correctly noted: ***"The U.S. has warmed during the past century, but the warming hardly exceeds year-to-year variability. Indeed, in the U.S. the warmest decade was the 1930s and the warmest year was 1934."***

USHCN was generally accepted as the world's best data base of temperatures with the stations most continuous and stable, and adjustments made for time of observation, urbanization, known land use changes around sites, and instrumentation changes, each of which can produce major contamination issues for temperature data.

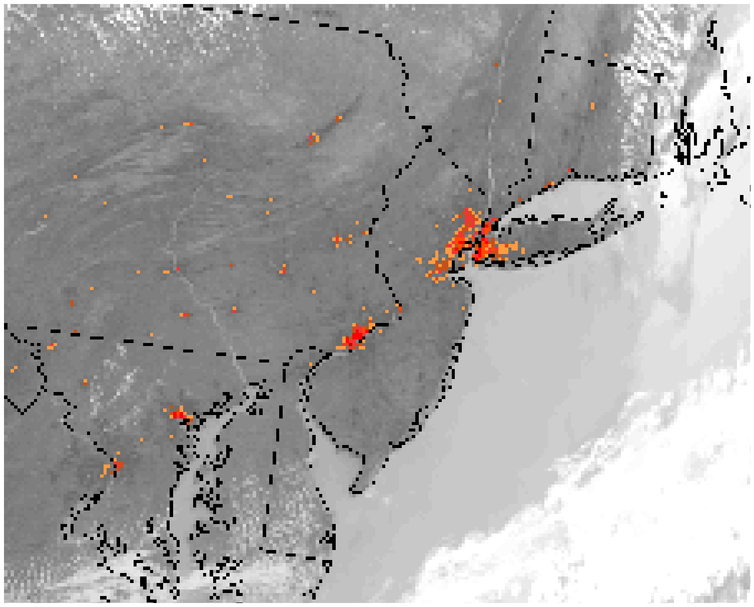
URBAN HEAT ISLAND

There is no real dispute that weather data from cities, as collected by meteorological stations, is contaminated by urban heat island (UHI) bias, and that this has to be removed to identify climatic changes or trends. In cities, vertical walls, steel and concrete absorb the sun's heat and are slow to cool at night. More and more of the world is urbanized (population increased from 1.5 B to 6 B in 1900s).

The UHI effect occurs not only for big cities but also for towns. Oke (who won the 2008 American Meteorological Society's Helmut Landsberg award for his pioneer work on urbanization) had a formula for the warming that is tied to population. Oke (1973) found that the UHI (in °C) increases according to the formula

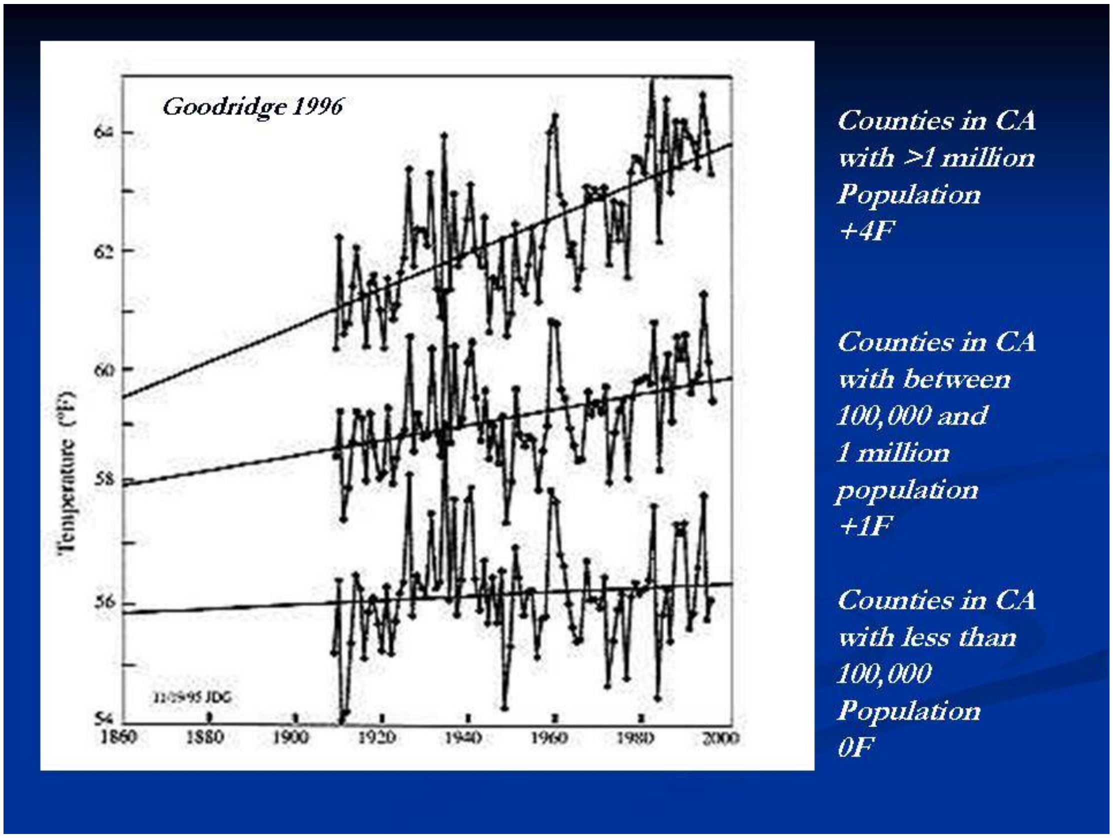
$$UHI = 0.73 \log_{10} \text{POP}$$

where *pop* denotes population. This means that a village with a population of 10 has a warm bias of 0.73°C, a village with 100 has a warm bias of 1.46°C, a town with a population of 1000 people has a warm bias of 2.2C°, and a large city with a million people has a warm bias of 4.4°C.



Urban heat islands as seen from infrared sensors onboard satellites.

Goodrich (1996) showed the importance of urbanization to temperatures in his study of California counties in 1996. He found for countires with a million or more population the warming from 1910 to 1995 was 4F, for counties with 100,000 to 1 million, 1F and for counties with less than 100,000, no change (0.1F).



NCDC's Tom Karl (1988) employed a similar scheme for the first USHCN data base (released in 1990) that was the best data set available at that time. He noted that the national climate network formerly consisted of predominantly rural or small towns with populations below 25,000 (as of 1980 census) and yet that a UHI effect was clearly evident.

Tom Karl et al's adjustments were smaller than Oke had found (0.22°C annually on a town of 10,000 and 1.81°C on a city of 1 million and 3.73°C for a city of 5 million).

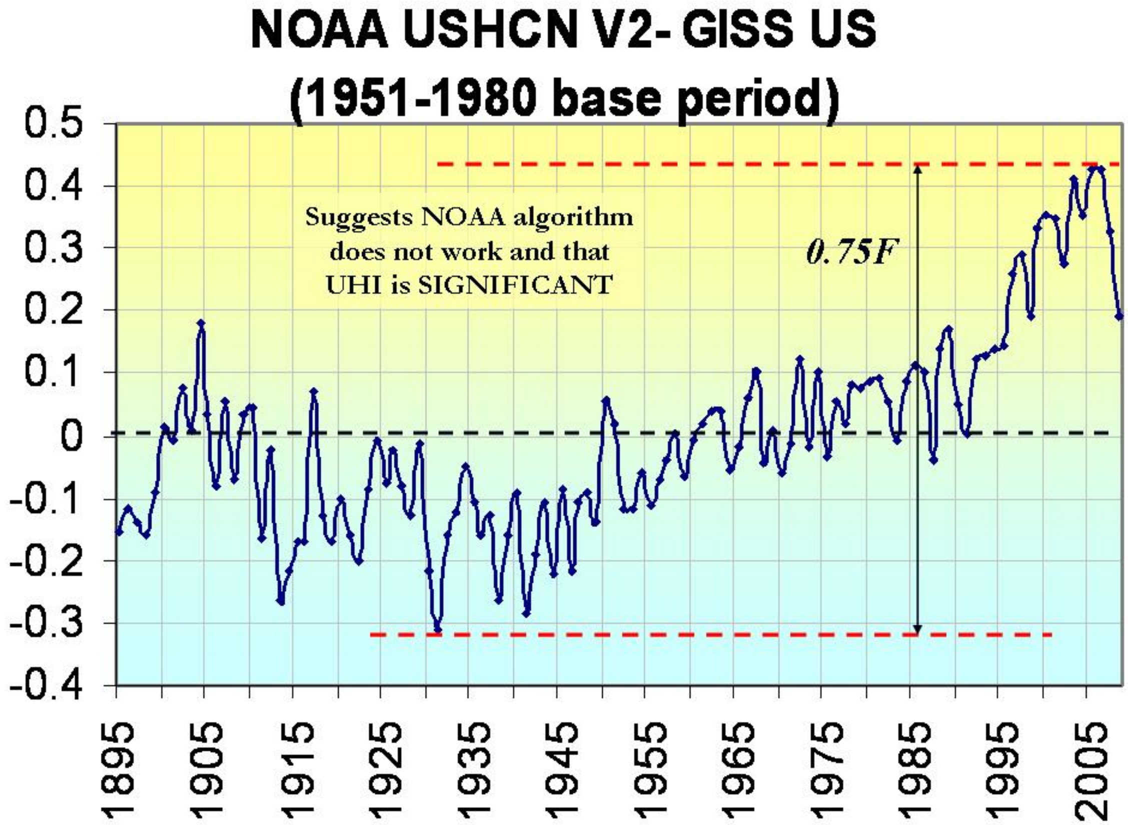
Karl observed that in smaller towns and rural areas the net UHI contamination was relatively small but that significant anomalies showed up in rapidly growing population centers.

USHCN also maintained a METADATA base (not perfect) that identified changes in observing site locations and instrumentation and supposedly made adjustments accordingly, along with adjustment for change in the time of observation over the years.

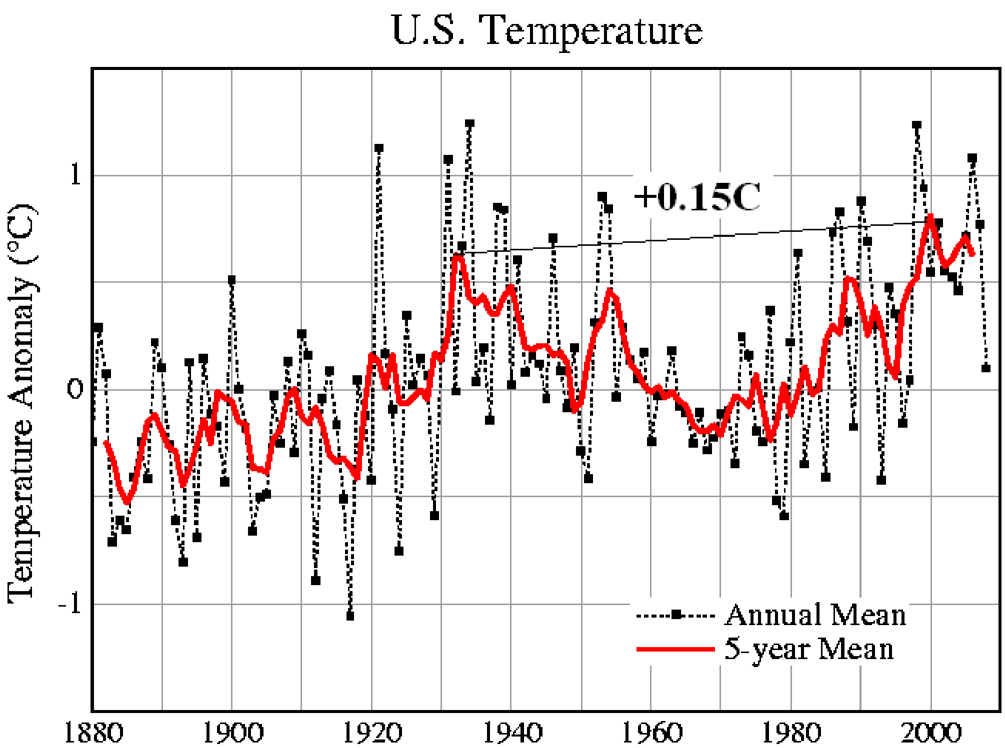
NASA GISS US

GISS uses in the USA, southern Canada and northern Mexico an urbanization adjustment based on the amount of night time light measured by satellites from the station locations. Unlit stations are classified as rural stations. This does produce some adjustment and a reasonable plot of temperatures but as GISS notes, this is just less than 2% of the globe."

The difference from their adjusted values and the NOAA no longer adjusted shows NOAA was misguided in their removal of the urban adjustment, with a net cooling of 0.2F in 1930s and warming of 0.4F near 2005. NOAA data adjusted to the GISS base period of 1951-1980.



The net warming in the UHI adjusted GISS US data set from the peak around 1930 to the peak near 2000 was a meager 0.15C. It may be assumed the same would be true for the world if we could make a similar needed UHI adjustment.



GISS Adjusted US Temperatures

INSTRUMENT CHANGES

Dr. Ben Herman at the University of Arizona confirmed in working with the climate station in Tucson, AZ that the new HO83 had a significant warm bias. This observation was based on the work by Gall et al. (1992) and Jones (1995). Stephen McIntyre has summarized in The HO-83 Hygro-thermometer (http://www.climateaudit.org/?p=1954) the findings by Tom Karl at al in 1995 of a discontinuity of about 0.5ºC before and after switchover. This change to the HO-83 seemingly went unadjusted for in the USHCN data base for the period from the 1980s to the late 1990s when the instruments were replaced.

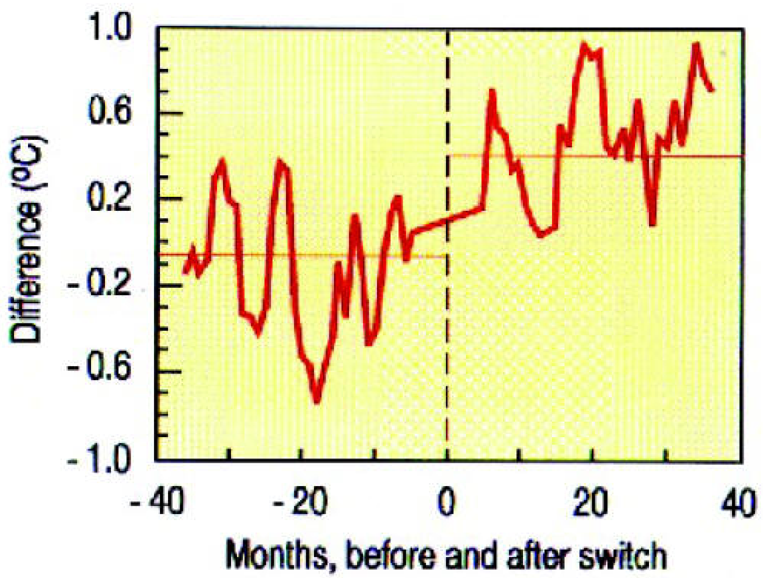


FIG. 2. Effects of changing instruments from the HO63 to the HO83 series on the maximum temperature in the United States (Karl et al. 1995).

BAD SITING

Pielke and Davey (2005) found a majority of stations including climate stations in eastern Colorado did not meet WMO requirements for proper siting. He has extensively documented poor siting and land use change issues in numerous peer review papers, many summarized in the landmark paper Unresolved issues with the assessment of multi-decadal global land surface temperature trends (2007).

Anthony Watts started a volunteer effort to document siting issues with all 1221 stations in US. He and his team is now through over 919 stations. See the results on http://surfacestations.org and numerous examples highlighted on http://wattsupwiththat.wordpress.com. All of these siting issues identified introduce a warm bias.

Here are some examples:

USHCN Station Hopkinsville, KY (Pielke et al 2006)

Max/Min sensor near John Martin Reservoir, CO (Davey 2005)

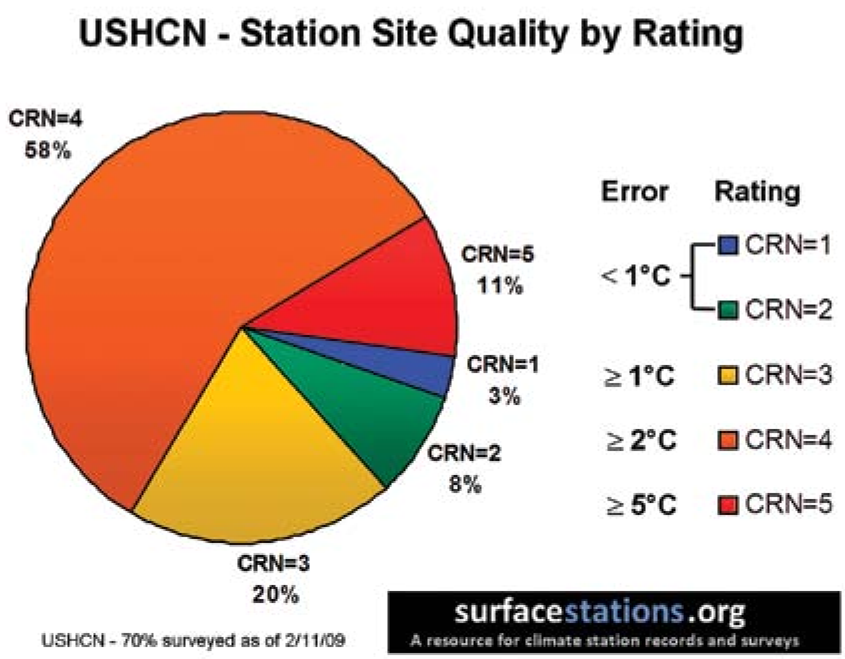
Tucson , Arizona in a parking lot on pavement.

Wickenburg, Arizona next to a building on a paved surface

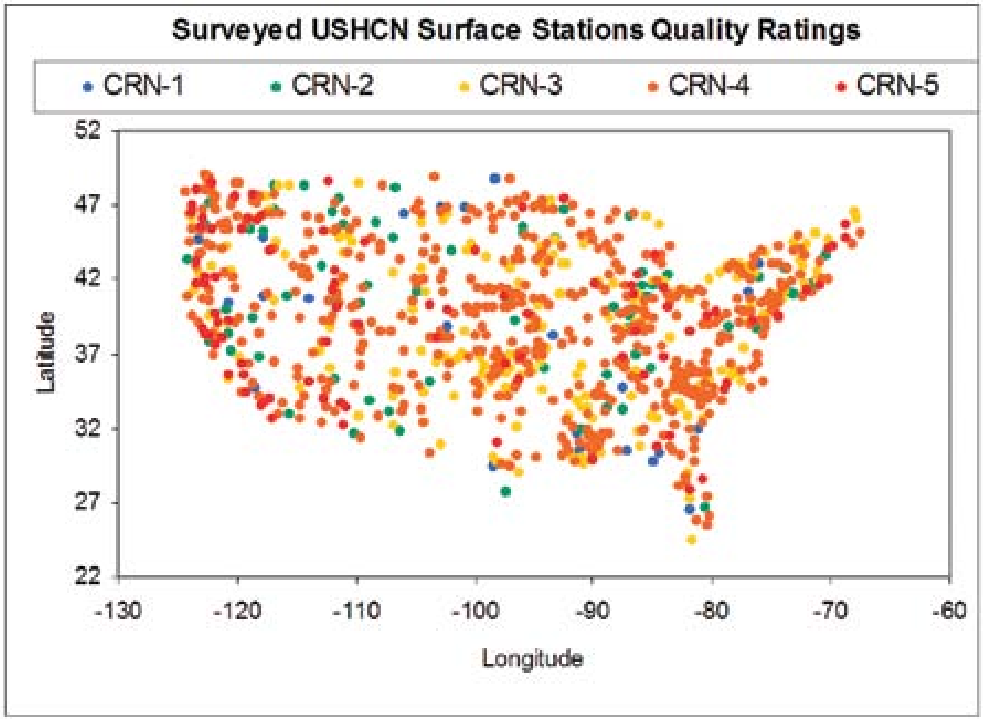
Waterville, WA over volcanic cinders

The vast majority of stations did not meet the governments own criteria for siting as established in the documentation for the Climate Reference Network.

Using the government's own rating system, Anthony has shown a majority of the stations are inadequately sited (89% are CRN 3-5, 69% CRN 4-5 poor to very poor)



The distribution of poor and very poor (CRN 4, CRN 5) was widespread across all the states.



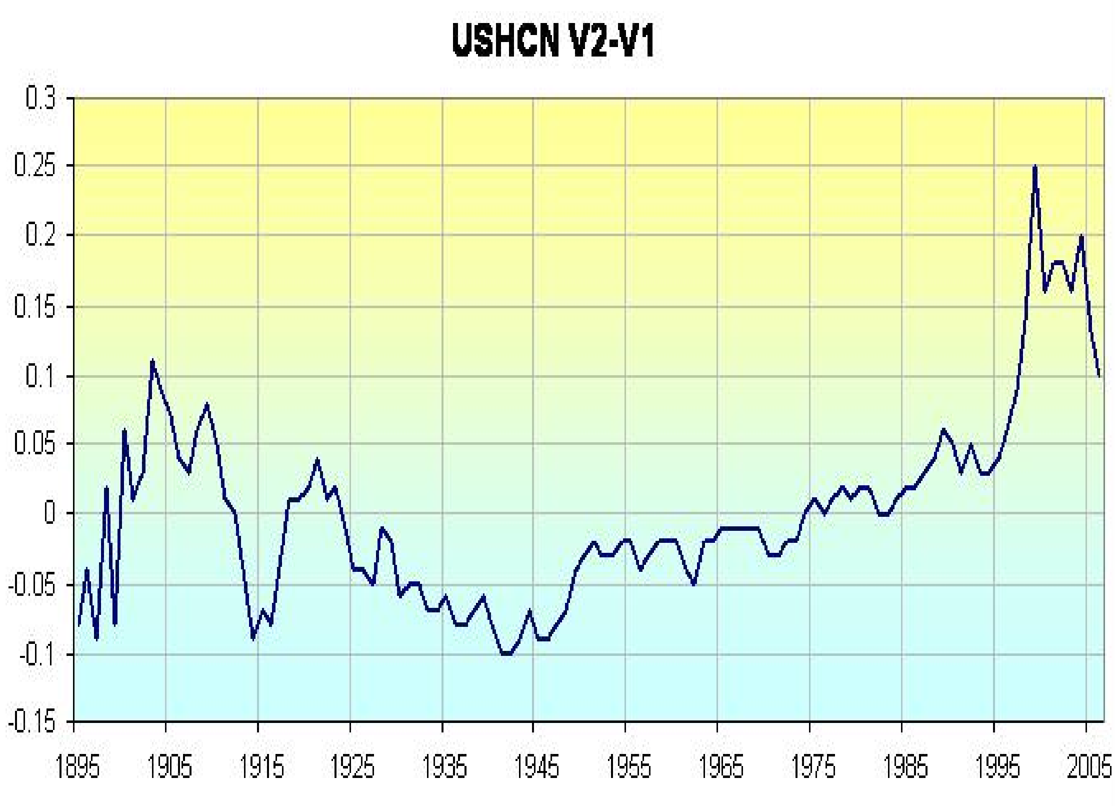
MAJOR CHANGES TO USHCN IN 2007

In 2007 the NCDC (the National Climatic Data Center), in its version 2 of USHCN, inexplicably removed the Karl UHI adjustment and substituted a CHANGE POINT ALGORITHM that looks for sudden shifts (discontinuities). This is best suited for finding site moves or local land use changes (like paving a road or building next to sensors or shelters) but not the slow ramp up characteristic of a growing town or city.

I had a conversation with NCDC's Tom Karl two years ago when the USHCN version 2 was announced. I told Tom I had endorsed his 1988 Journal of Climate paper (Urbanization: Its Detection and Effect in the United States Climate Record) having been a fan of the work that Landsberg and Oke on whose work that paper depended on.

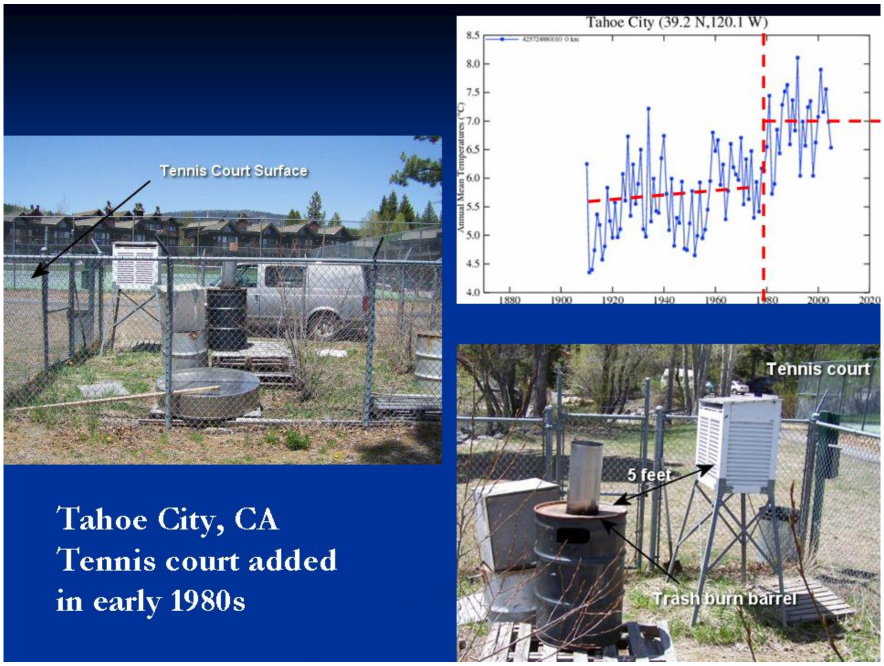
I asked him if USHCNv2 would no longer have an urbanization adjustment. After a few moments of silence, he told me he had asked those who had worked on version 2 that question and was reassured that the new algorithms would catch urban warming and other changes – including "previously undocumented inhomogeneities" (discontinuities that suggest some local site changes or moves that were never documented).

The difference between the old and new is shown here. Note the significant post 1995 warming and mid 20th century cooling due to deurbanization of the data base.

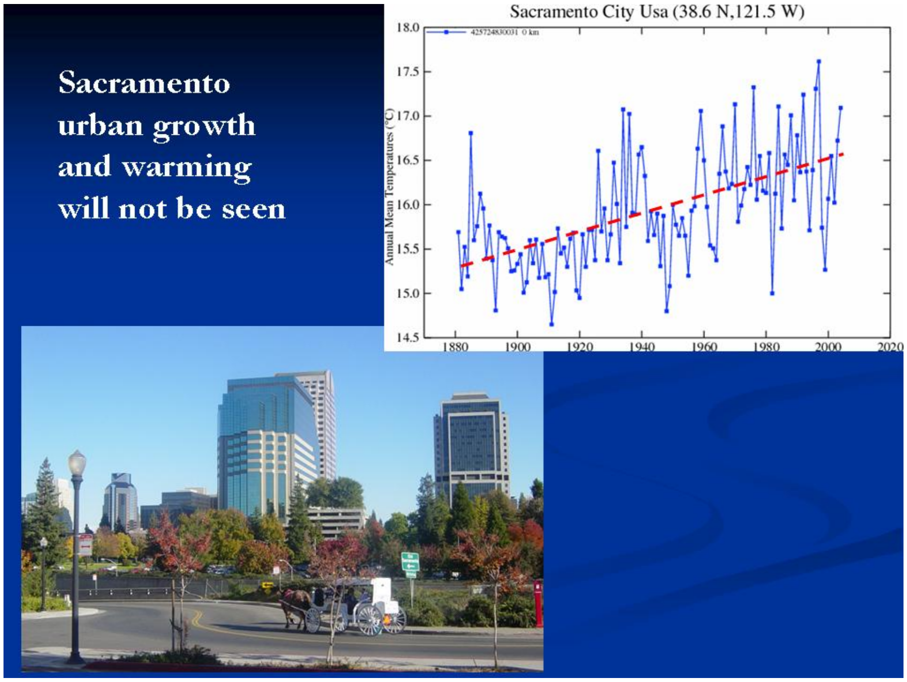


The change can be seen clearly in [this animation](#).

The new algorithms are supposed to correct for urbanization, changes in siting and instrumentation by recognizing sudden shifts in the temperatures.



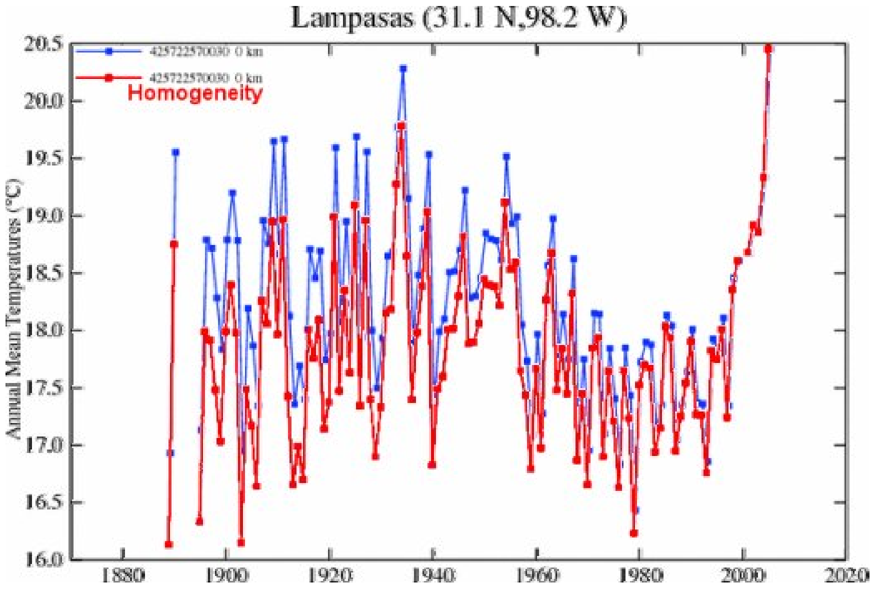
It should catch this kind of change above in Tahoe City, CA.



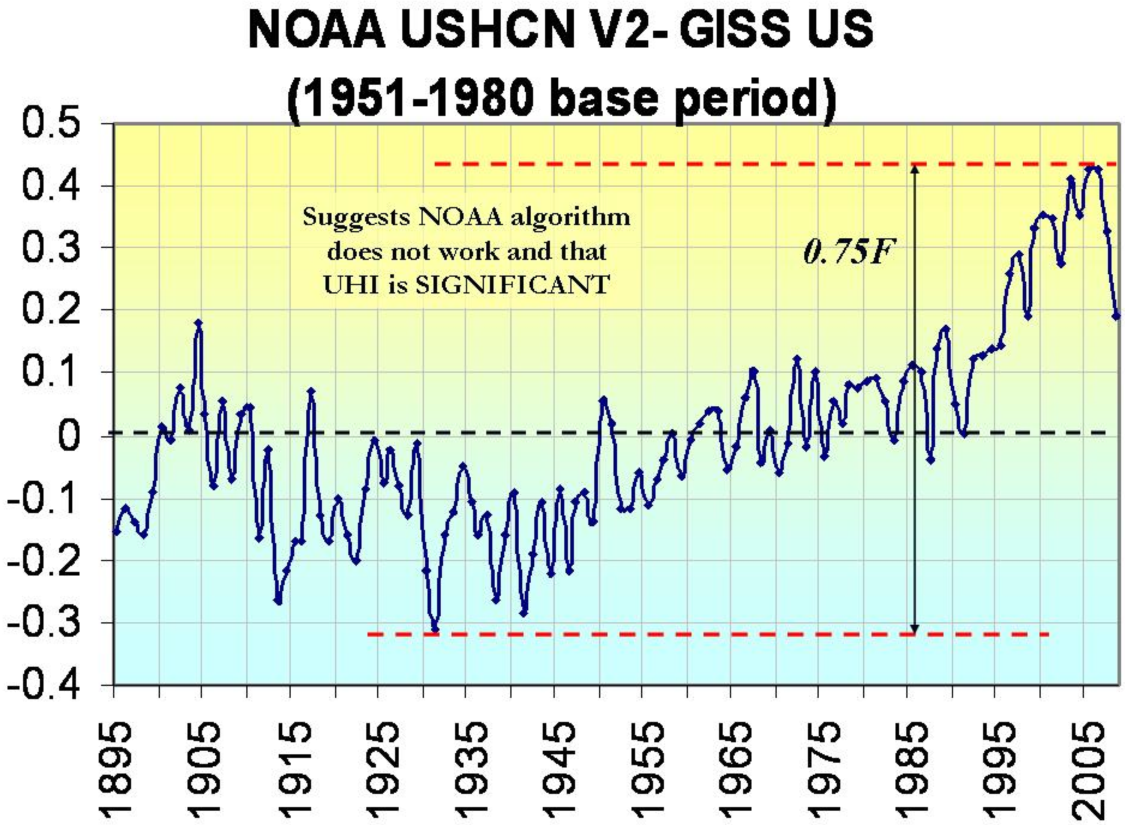
It is unlikely to catch the slow warming associated with the growth over many years of cities and towns as in Sacramento, CA above.

There is even some evidence that the algorithm does not catch some site changes it should catch. Take for example Lampasas, Texas as identified by Anthony Watts.

Lampasas, Texas site moved to near a building and street from a more appropriate grassy site after 2001. Note even with the new "homogeneity" adjustment (red) this artificial warming is left although the old data (blue) is cooled to accentuate warming even further.



The net result is to make the recent warm cycle max more important relative to the early century max in the 1930s.



Comparison of the new USHCN to the GISS USHCN which does a UHI adjustment based on night lights shows the NOAA version has increased the warming relative to the GISS by 0.75F since3 1930.

I asked Tom Karl about the problems with siting and why they could not speed up the plans for a Climate Reference Network (at that time called NERON). He said he had presented a case for that to NOAA but had it turned down with the excuse from high levels at NOAA that the surface stations did not matter <u>because we had satellite monitoring.</u> The Climate reference network was capped at 114 stations but won't provide meaningful trend assessment for about 10 years.

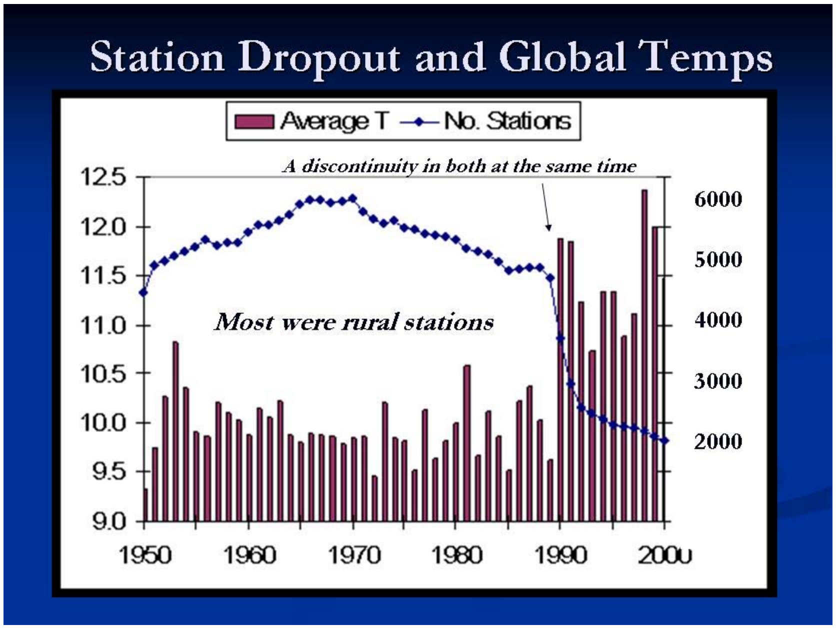
The NOAA attitude that the stations don't matter is manifested in the disregard for the siting as Anthony Watts has now with 2/3rds of the network surveyed found only 12 % satisfactory (3% CRN#1 and 9% CRN#2) and with no attempts to resolve the issues Anthony has found and presented to the NCDC staff. The change of the algorithms which worked fine was either an attempt to find an easy way to detect previously unrecorded site changes or to make the USHCN show more recent warming to be more in line with the global data bases. In monthly press releases, no satellite measurements are ever mentioned although NOAA claimed that was the future of observations.

THE GLOBAL DATA BASES

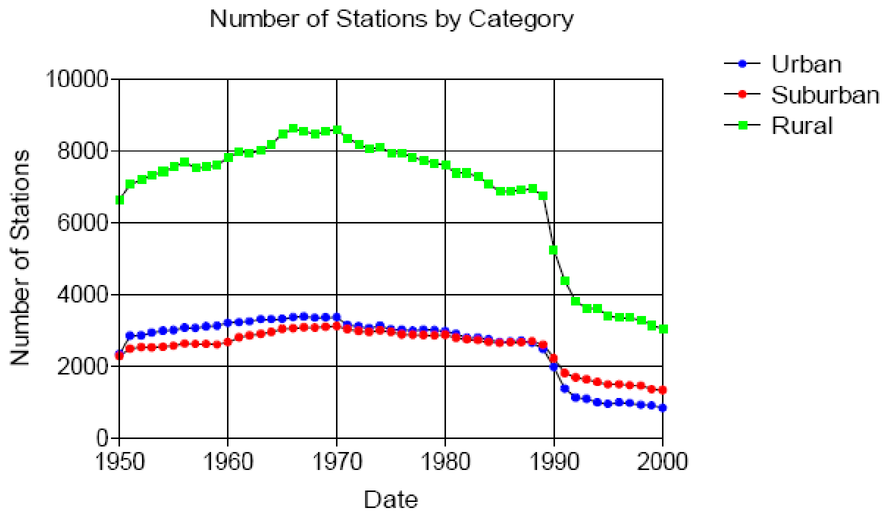
NOAA gathers global station and ocean ship data and makes it available for the NCDC GHCN and NASA GISS analyses. NCDC and NASA perform adjustments on this data, slightly different but generally similar in magnitude. They are hampered by issues in the global network which are greater in number and magnitude than for the United States.

STATION DROPOUT AND OTHER INTEGRITY ISSUES

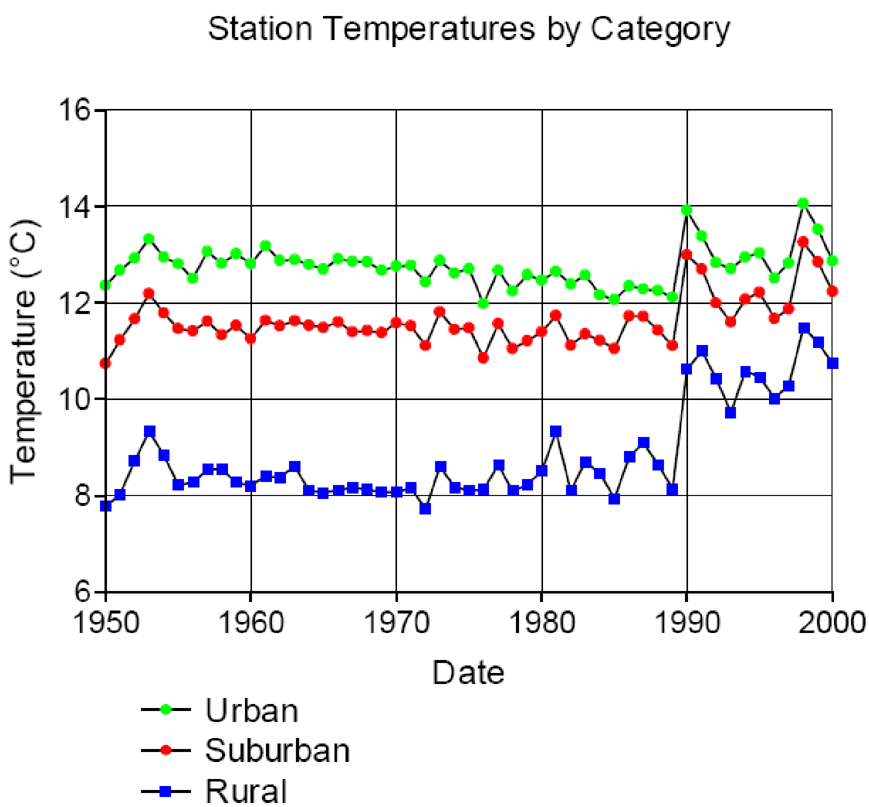
Globally a major issue is station dropout. Over 2/3rds of the world's stations, many of them rural areas in the former Soviet Union, stopped reporting around 1990. Dr. Kenji Matsuura and Dr. Cort J. Willmott at the University of Delaware has prepared this animation. See the lights go out in 1990. The animation shows that Siberia suffered the biggest station falloff.



In the chart above you see how this drop off of global sites coincides with a sudden rise in mean of all remaining stations. The analysis below of station count is broken down by rural, suburban and urban categories. It clearly shows a substantial drop in the number of rural stations. The numbers of stations are higher because many stations are given new numbers for every documented move or change.

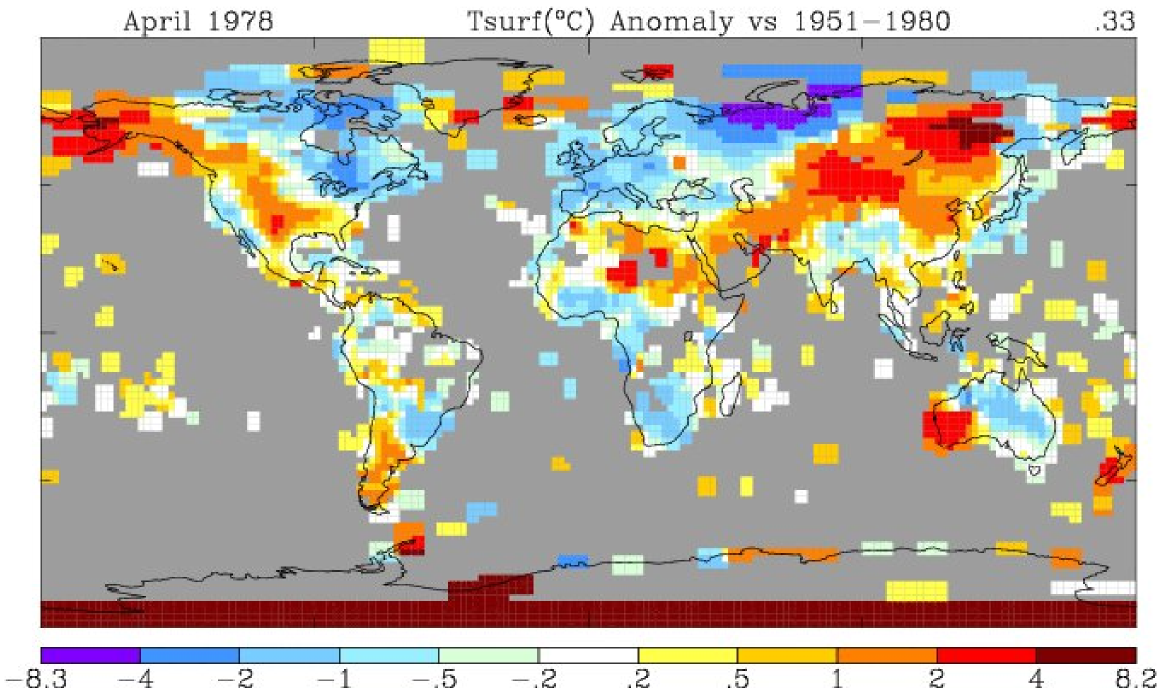


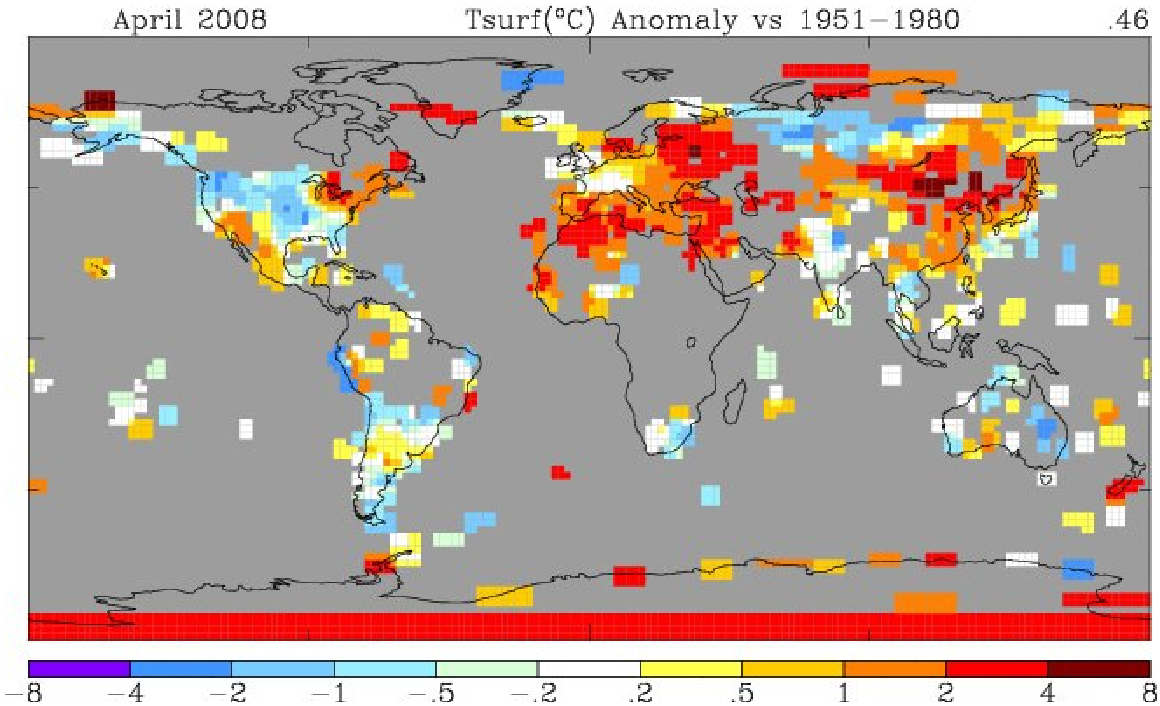
Average temperatures jumped when these other stations dropped out in all three categories but most notably in the rural data, suggesting that it was mainly colder, smaller, higher latitude stations that were no longer in the record (analyses above and below from Jonathan Drake)..



Global data bases all compile data into latitude/longitude based grid squares and calculate temperatures inside the square using data from the stations within it - or use the closest stations (weighted by distance) in nearby boxes. Thus a grid square, which at one time had rural stations, will find its mean temperature increasingly determined by the urban areas within that square or distant squares. This is why global data suggests that the greatest warming has occurred in Siberia, where the greatest dropout has occurred.

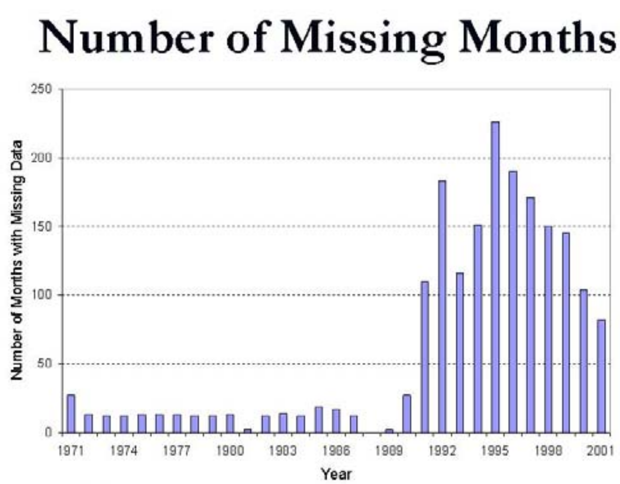
See the huge dropout of data in Africa, Canada and Siberia in the two maps from NASA GISS with 250 km smoothing from 1978 to 2008.





MISSING DATA INCREASES

In addition to station dropout, there has been a tenfold increase in missing months of data in places like the former Soviet Union.

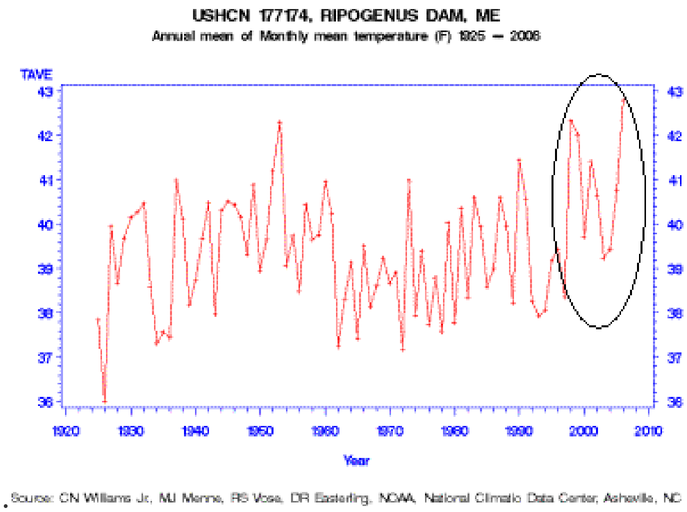


For the 110 Russian weather stations reporting weather data continuously from 1971 to 2001, the total number of missing monthly observations each year (McKitrick and Michaels)

For these stations that are missing periods or some stations that are now closed, surrounding stations are used. One example is Ripogenus Dam in Maine.

Last summer, volunteers completed surveys of the United States Historic Climate Network (USHCN) temperature stations in Maine for Anthony Watts surface station evaluation project. The survey determined that every one of the stations in Maine was subject to microclimate or urbanization biases. One station especially surprised the surveyors, Ripogenus Dam, a station that was officially closed in 1995.

Despite being closed in 1995, USHCN data for this station is publicly available until 2006!



Part of the USHCN data is created by a computer program called “filnet” which estimates missing values. According to the NOAA, filnet works by using a weighted average of values from neighboring stations. In this example, data was created for a no longer existing station from surrounding stations, which in this case as we noted were all subject to microclimate and urban bias, no longer adjusted for. Note the rise in temperatures after this, perhaps before the best sited truly rural station in Maine was closed.

NO REAL URBAN ADJUSTMENT

HADLEY AND NOAA

Jones et al 1990 (Hadley CRU) concluded that UHI bias in gridded data could be capped at 0.05 deg C (not per decade, per century). Peterson et al (1998) agreed with the conclusions of Jones and Easterling *et al* (1997) that urban effects on 20th century globally and hemispherically-averaged land air temperature time-series do not exceed about 0.05°C over the period 1900 to 1990. Peterson (2003) and Parker (2004) argue urban adjustment thus is not really necessary. Yet recall Oke showed a town of 1000 could produce a 2.2C (3.4F warming).

The most recent exposition of CRU methodology is Brohan et al 2006, which stated with respect to UHI that they included an allowance of 0.1 deg C/century in the **uncertainty**, but does not describe any "correction" to the reported average temperature. To make an urbanization assessment for all the stations used in the HadCRUT dataset would require suitable meta-data (population, siting, location, instrumentation, etc) for each station for the whole period since 1850. No such complete meta-data are available.

The homepage for the NOAA temperature index here cites Smith and Reynolds (2005) as authority. Smith and Reynolds, in turn, state that they use the **identical** procedure as CRU, i.e. they make an allowance in uncertainty, but do not *correct* the temperature index itself. The population of the world went from 1.5 to 6.5 billion from 1900 to 2000, yet NOAA and CRU ignore population growth in the data base with only a 0.1C uncertainty adjustment.

Runnalls and Oke (2006) concluded that "Gradual changes in the immediate environment over time, such as vegetation growth, or encroachment by built features such as paths, roads, runways, fences, parking lots, and buildings into the vicinity of the instrument site typically lead to trends in the series.

Distinct régime transitions can be caused by seemingly minor instrument relocations (such as from one side of the airport to another, or even within the same instrument enclosure) or due to vegetation clearance.

This contradicts the view that only substantial station moves, involving significant changes in elevation and/or exposure are detectable in temperature data."

More than half dozen peer reviewed papers found that the lack of adequate UHI and local land use change adjustments could account for up to 50% of the warming since 1900.

In the areas of greatest warming, Siberia, besides dropout and a tenfold increase in missing monthly data, there were numerous issues related to prior temperatures In the Soviet era. city and town temperatures determined allocations for funds and fuel, so it is believed that cold temperatures were exaggerated in the past, which introduced an apparent warming when more honest measurements began to be made. Also Anthony Watts has found that in many Russian towns and cities, heating pipes are in the open. Any sensors near these pipes would be affected.

GISS GLOBAL

Is NASA better? Steve McIntyre has taken an in-depth look at the data adjustments made to NASA's GISS data set. The findings are summarized very well in Ken Gregory of Friends of Science's "*Correct the Correction*".

> "NASA's Goddard Institute of Space Studies (GISS) publishes a global temperature index. The temperature record is contaminated by the effects of urban development and land use changes. NASA applies an "urbanization adjustment" to adjust the temperature histories to eliminate these effects. The resulting GISS temperature index is supposed to represent what the temperatures would have been in the absence of urbanization and land use changes. Most scientists assume that these adjustments are done correctly.

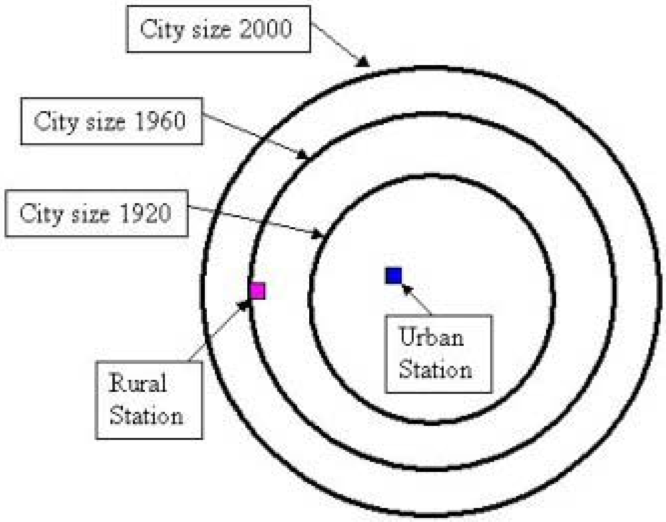
An audit by researcher Steve McIntyre reveals that NASA has made urban adjustments of temperature data in its GISS temperature record in the wrong direction. The urban adjustment is supposed to remove the effects of urbanization, but the NASA negative adjustments increases the urbanization effects. The result is that the surface temperature trend utilized by the International Panel on Climate Change (IPCC) is exaggerated.

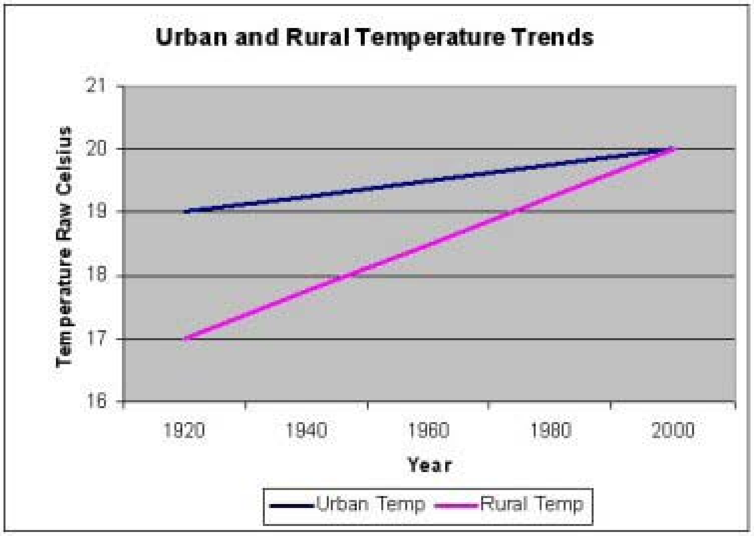
“Outside of the USA, southern Canada and northern Mexico, GISS uses population data to define rural stations. “We use the definition of Peterson et al 1997 for these categories: that is, rural areas have a recent population of less than 10,000, small towns between 10,000 and 50,000 and urban areas more than 50,000. These populations refer to approximately 1980.”

The GISS sites are defined to be “rural” if the town has a population of under 10,000. Unfortunately, the population data utilized by GISS to classify the stations is out of date. Stations at cities with populations greatly exceeding 10,000 are incorrectly classified as rural. For example, in Peru, there are 13 stations classified as rural. Of these, one station is located at a city with a population of 400,000. Five stations are at cities with populations between 50,000 and 135,000.

Steve McIntyre says here, “If the supposedly “rural” comparanda are actually “urban” or “small towns” within the Hansen definitions, then the GISS “adjustment” ends up being an almost completely meaningless adjustment of one set of urban values by another set of urban values. No wonder these adjustments seem so random.”

A population increase of 500 in a town of 2000 people would have a much larger effect on temperature measurements than the same increase in a city of 500,000 people. A city with a growing population generally increases its area. A temperature station inside the city would be little affected by the expansion of the suburbs. However, a temperature station located just outside a city would be greatly affected by the city expanding around the station. This effect is shown in the following diagram.

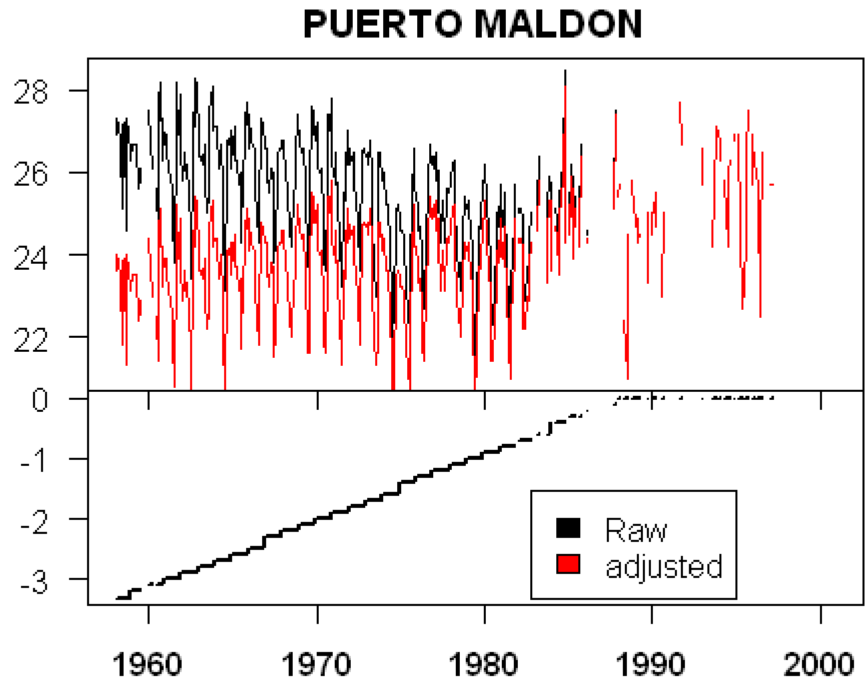




A hypothetical urban station is shown located in a city and a rural station is located outside the city in the year 1920. By 1960, the city has grown out to the rural station. The city growth has little effect on the urban station, but a much larger affect on the rural station. By 2000, the rural station is completely surrounded by the city, so it has the same temperature as the urban station...

Now, as indicated in the graph, the unadjusted rural temperature trend is much greater than the urban station trend. ***According to the GISS urban adjustment procedure, the urban station trend is increased to match the rural station trend by reducing the past temperatures.***

Here is an example of an urban negative adjustment from Peru:



Note that the raw data shows no warming, but after applying the GISS urban adjustment, the adjusted data shows a significant warming trend. The adjustments are applied to reduce the past temperatures by up to 3 degrees Celsius. This is a very large adjustment when compared to the total warming of the twentieth century of 0.6 Celsius estimated by the IPCC.

A proper urban correction algorithm would reduce the warming trends of both stations to make an adjusted temperature record represent what would have happened if nobody lived near the stations.

Ross McKitrick and Patrick Michaels in December 2007 showed a strong correlation between urbanization indicators and the "urban adjusted" temperatures, indicating that the adjustments are inadequate. Their conclusion is: "Fully correcting the surface temperature data for 'non-climatic effects reduce the estimated 1980-2002 global average temperature trend over land by about half."

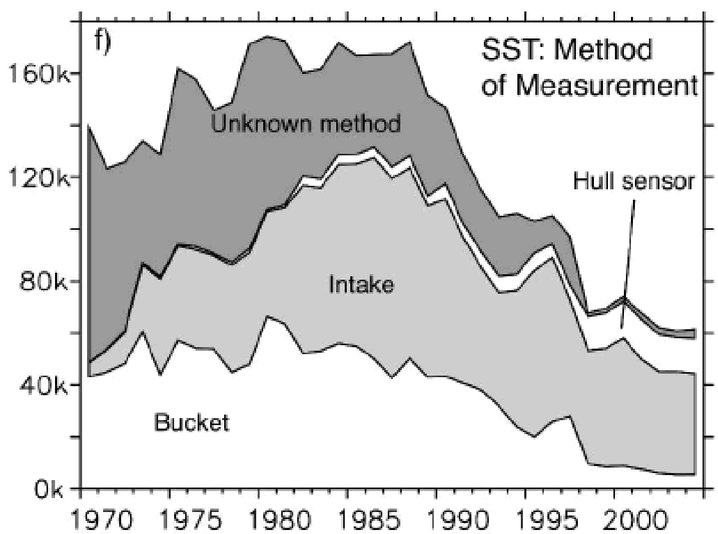
Dutch meteorologists, Jos de Laat and Ahilleas Maurellis, showed (2006) that climate models predict there should be no correlation between the spatial pattern of warming in climate data and the spatial pattern of industrial development. But they found that this correlation does exist and is statistically significant. They also concluded it adds a large upward bias to the measured global warming trend.

These studies convincingly show that urban "corrections" fail to correct for the effects of urbanization, but do not indicate why the corrections fail. The audit of GISS urban adjustments by Steve McIntyre shows why the corrections fail. "

A2008 paper by Hadley's Jones etal, has shown a considerable contamination in China, the equivalent of 1F per decade, an order of magnitude greater than the amount previously assumed (0.1F uncertainty). This vindicates our position on the UHI issue.

OCEANS HAVE ISSUES TOO

The world is 70% ocean. Hadley only trusts their own merchant ship data, mainly derived from northern hemisphere routes. Hadley has virtually no data from the southern hemisphere's oceans (80% of the hemisphere). NOAA and NASA use ship data reconstructions. The gradual change of buckets to ship intakes for taking ocean temperature measurements introduces uncertainties. Different sampling levels will make results slightly different. How to adjust for this introduced difference and get reliable data set has yet to be resolved adequately, especially since the transition occurred over many decades. *Chart from Kent (2007).*



We have reanalysis data based on reconstructions from ships and buoys (subject to some of the same adjustment issues) and satellites which see only ocean surface skin temperatures but are hampered by cloud cover. That data was removed by NOAA in July 2009 because of alleged "complaints" about a cold bias in the southern hemisphere. Immediately the results was a bump up of ocean and ocean/land global temperatures and the warmest ever July and August for the world's oceans.

SUMMARY

The United States and global data bases have serious problems that render them highly questionable for determining accurate long term temperature trends. Especially since most of the issues mentioned produces a warm bias in the data.

As shown here, though there has clearly been some cyclical warming in recent decades (most notably 1979 to 1998), the global surface station based data is seriously compromised by urbanization and other local factors (land-use/land-cover, improper siting, station dropout, instrument changes unaccounted for and missing data) and uncertainties in ocean temperatures. Thus the data bases can't be relied on to determine accurate trends. These factors all lead to overestimation of temperatures. Numerous peer-reviewed papers (referenced below in bold) in the last several years have shown this overestimation is the order of 30 to 50% from these issues alone.

See my and other relevant presentations and videos of some excellent keynote addresses at the Second Annual ICCC in New York City March 8-10, 2009 here.

References:

Block, A, Keuler, K., Schaller, E., 2004, Impacts of anthropogenic heat on regional climate patterns, Geophysical Research Letters, 31, L12211, DOI:10.1029/2004GL019852

Brohan, P., J.J. Kennedy, I. Harris, S.F.B. Tett and P.D. Jones, 2006: Uncertainty estimates in regional and global observed temperature changes: a new dataset from 1850. J. Geophysical Research ***111****, D12106, DOI:10.1029/2005JD006548*

Davey, C.A., and R.A. Pielke Sr. (2005) "Microclimate Exposures of Surface-based Weather Stations - Implications for the Assessment of Long-term Temperature Trends." Bulletin of the American Meteorological Society 86(4) 497–504

de Laat, A.T.J., and A.N. Maurellis (2006). "Evidence for Influence of Anthropogenic Surface Processes on Lower Tropospheric and Surface Temperature Trends." International Journal of Climatology 26:897—913.

Easterling DR, Horton B, Jones PD, Peterson TC, Karl TR, Parker DE, Salinger MJ, Razuvayev V, Plummer N, Jamason P, Folland CK (1997) Maximum and minimum temperature trends for the globe. Science 277:364-367

Gall, R, Young, K., Schotland, R, Schmitz, J.: 1992. The Recent Maximum temperature Anomalies In Tucson. Are they real or an Instrument Problem, Journal of Climate, 5, 657-664.

Goodridge, JD (1996) Comments on "Regional Simulations of Greenhouse Warming including Natural Variability" . Bull, Amer. Meteorological Society 77:1588-1599

Hansen, J., Ruedy, R., Glascoe, J. and Sato, M. 1999. GISS analysis of surface temperature change. Journal of Geophysical Research 104: 30,997-31,022

Hansen, J, R. Ruedy, M. Sato, M. Imhoff, W. Lawrence, D. Easterling, T. Peterson, and T. Karl, 2001: A closer look at United States and global surface temperature change. Journal of geophysical research, 106 (D20), 23947-23963.

Hinkel, K.M., Nelson, F.E., Klene, S.E., Bell, J.H.:(2003). The Urban Heat Island In Winter At Barrow, Alaska, International Journal Of Climatology. ***23****: 1889–1905, DOI: 10.1002/joc.971*

Jones, C.G., Young , K.C.,:)1995) An Investigation of Temperature Discontinuities Introduced by the Installation of the HO-83 Thermometer Journal of Climate Volume 8, Issue 5 (May 1995) pp. 1394

Jones PD, Groisman PYa, Coughlan M, Plummer N, Wangl WC, Karl TR (1990) Assessment of urbanization effects in time series of surface air temperatures over land. Nature 347:169-172

Jones, P. D., D. H. Lister, and Q. Li (2008), Urbanization effects in large-scale temperature records, with an emphasis on China, J. Geophys. Res., 113, D16122, doi:10.1029/2008JD009916.

Kalnay, E., Cai, M., Impacts of urbanization and land-use change on climate, 2003, Nature, 423, 528-531

Karl, T.R., H.F. Diaz, and G. Kukla, 1988: Urbanization: its detection and effect in the United States climate record, J. Climate, ***1****, 1099-1123*

Karl, T.R, 1995: Critical issues for long-term climate monitoring. Climate Change, 31, 185.

Kent, E. C., S. D. Woodruff, and D. I. Berry. 2007. Metadata from WMO Publication No. 47 and an Assessment of Voluntary Observing Ship Observation Heights in ICOADS. Journal of Atmospheric and Oceanic Technology 24, no. 2: 214-234

Landsberg, H.E., 1981: The Urban Climate, Academic Press

Li, Q. et al., 2004: Urban Heat Island Effect on Annual Mean Temperatures during the Last 50 Years in China. Theor. Appl. Climatol., 79, 165-174.

McKitrick, R.R. and P.J. Michaels (2007), Quantifying the influence of anthropogenic surface processes and inhomogeneities on gridded global climate data, J. Geophys. Res., 112, D24S09, doi:10.1029/2007JD008465.

McKitrick, R and P. J. Michaels (2004). "A Test of Corrections for Extraneous Signals in Gridded Surface Temperature Data" Climate Research 26(2) pp. 159-173. "Erratum," Climate Research 27(3) 265—268.

Moberg, D. and A. 2003. Hemispheric and Large-Scale Air Temperature Variations: An Extensive Revision and Update to 2001. Journal of Climate, 16, 206-223.

Oke, T.R. 1973. City size and the urban heat island. Atmospheric Environment ***7****: 769-779.*

Parker, D.E. (2004). "Climate: Large-Scale Warming is not Urban." Nature 432, 290 (18 November 2004); DOI:10.1038/432290a

Peterson T.C. and R.S. Vose (1997) "An Overview of the Global Historical Climatology Network Temperature Database." *Bulletin of the American Meteorological Society* 78:2837—2849.

Peterson, T.C. (2003). "Assessment of Urban Versus Rural in situ Surface Temperatures in the Contiguous United States: No Difference Found." Journal of Climate 16(18) 2941—2959.

Peterson, 2006 Examination of potential biases in air temperature caused by poor station locations. Bull. Amer. Meteor. Soc., 87, 1073-1089

Pielke Sr., R.A., C. Davey, D. Niyogi, S. Fall, J. Steinweg-Woods, K. Hubbard, X. Lin, M. Cai, Y.-K. Lim, H. Li, J. Nielsen-Gammon, K. Gallo, R. Hale, R. Mahmood, S. Foster, R.T. McNider, and P. Blanken, 2007: Unresolved issues with the assessment of multi-decadal global land surface temperature trends. J. Geophys. Res., 112, D24S08, doi:10.1029/2006JD008229

Pielke Sr., R.A. J. Nielsen-Gammon, C. Davey, J. Angel, O. Bliss, N. Doesken, M. Cai., S. Fall, D. Niyogi, K. Gallo, R. Hale, K.G. Hubbard, X. Lin, H. Li, and S. Raman, 2007: Documentation of uncertainties and biases associated with surface temperature measurement sites for climate change assessment. Bull. Amer. Meteor. Soc., 88:6, 913-928.

Runnalls, K.E. and Oke, T.R. 2006. A technique to detect microclimatic inhomogeneities in historical records of screen-level air temperature. Journal of Climate ***19****: 959-978.*

Smith, T. M., and R. W. Reynolds (2004), Improved extended reconstruction of SST (1854-1997), J. Climate, ***17****, 2466-2477.*

Smith, T. M., and R. W. Reynolds (2005), A global merged land air and sea surface temperature reconstruction based on historical observations (1880-1997), J. Climate, ***18****, 2021-2036*

Zhou, L., Dickinson, R, Tian, Y., Fang, J, Qingziang, L., Kaufman, R, Myneni, R., Tucker, C., 2004, Rapid Urbanization warming China's climate faster than other areas, Proceedings of the National Academy of Science, June 29, 2004

Appendix B

Snohomish County
Public Works

Aaron Reardon
County Executive

3000 Rockefeller Ave., M/S 607
Everett, WA 98201-4046

(425) 388-3488
FAX (425) 388-6449

March 30, 2010

Electronic comments submitted via email to Leif Hockstad at hockstad.leif@epa.gov

Mr. Leif Hockstad
Environmental Protection Agency
Climate Change Division (6207J)
1200 Pennsylvania Ave., NW
Washington, DC 20460

Dear Mr. Hockstad:

Thank you for the opportunity to submit comments on the Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008.

I served in support of and as the alternate for Executive Aaron Reardon in his role as an appointed member of the Governor's Climate Action Team (CAT). I also served as co-chair of the Beyond Waste Implementation Work Group of the Washington State CAT and have assisted in the development of our local Snohomish County GHG inventory and climate action plan.

Through all of this work, a consistent problem has been the misimpression of the importance (or lack thereof) of addressing material management, due to the inventory methodology, explanation, and presentation. Because the inventories do not use or present a systems or consumption-based view, decision makers and planners see local, state and national inventories that show a scant 2-4% of green house gases attributed to "waste". The result is that addressing "waste" is considered immaterial or minimized, and "waste" discussions and strategies, if considered at all, are lumped with other incompatible sectors, such as agriculture and forestry, and are given few resources and little time.

This is quite a problem and you can find it reflected in most state and local inventories and climate action plans.

I am often asked to speak to local groups, such as Climate Stewards or Carbon Masters about "waste". I have attached several of my power point slides from a recent presentation. At these presentations, I usually begin by apologizing for what a terrible mistake the organizers have made in inviting me. "If you are a decision maker who has looked at the national, state or local inventories, you know that waste isn't relevant" (and I show the corresponding pie charts). Then I show the alternate pie charts based off of EPA's recently published report, *Opportunities to Reduce Greenhouse Gases Through Materials and Land Use Management* and the Product Policy Institute's White Paper on the same subject, to reframe what I am talking about and its importance. I receive strong positive feedback for providing this clarification about what the inventories show us, or don't.

The Washington State Inventory can be viewed at:
http://www.ecy.wa.gov/climatechange/docs/Updated1990GHGreport20071219.pdf

You can read the summary related to "waste" on page 5 (ES-3). You can see the summary on "data gaps and unresolved questions" on page 6 (ES-4). In neither case is there any indication that the inventory methodology does not address the issue of material management and consumption in a way that can be translated to policy and programmatic actions. This is despite providing comment to the consultants developing the report, who though sympathetic and recognizing the problem, stated that currently accepted inventory protocols did not provide for a systems or consumption view. You can see under the "waste" Appendix G that we were unsuccessful in getting any reference to the limits of what this type of inventory shows related to consumption and managing of materials (products and packaging for instance). The text explains what the inventory covers, but fails to state what it doesn't include (all upstream impacts related to in-state consumption of resources).

This immediately created confusion with some stakeholders and particularly entrenched interests, who protested the need to even address waste at all in the climate action plan and strategy process, as the inventory showed that there was no GHG implications to simply land filling most materials, "waste" was insignificant, and addressing "waste" strategies would be a distraction from addressing the "important" areas generating GHGs.

Fortunately, due to a clearer understanding by our Department of Ecology on GHG implications of material management and upstream impacts, we were able to prioritize further work on materials management. The Beyond Waste Implementation Work Group (BW IWG) became one of four IWGs formed to develop early action recommendations and key strategies and legislative proposals for the CAT.

The next challenge resulting from the inventory's methodology and lack of clarity on what it does and doesn't document, was that stakeholders and many CAT members did not initially believe the significant GHG reductions that could be achieved through some of the strategies recommended by the BW IWG. These strategies can be seen at http://www.ecy.wa.gov/climatechange/2008CATdocs/ltw_app_v2.pdf , Appendix 5. They questioned how it could be possible to accomplish such significant GHG reductions, more so than some of the key transportation and energy related recommendations, when "waste" resulted in such a small percent of GHG emissions to start with. Again, the lack of providing clarity on what the current protocol does and doesn't do, what alternative views would show, and implications, was quite a road block. The CAT, BW IWG and our consultants struggled with how to address this.

You will see on pages 51 and 52 that we developed a chart that showed in-state emissions that "counted" and out-of-state emissions that didn't "count" but were critical. Note the explanatory text in the footnote on page 51.

Similar challenges resulted from the locally developed inventory, using ICLEI's methodology.

The Draft *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008* repeats these inadequacies and will replicate our state and local challenges in appropriately addressing materials management through policy and programs many times over. It is not enough to simply provide the inventory without regard to how inventories are used and understood. It is not adequate to state what the inventory does – the document needs to explain what it doesn't do, what alternate methodologies might show, and implications for policy makers and climate change program planners.

In the draft inventory, you have included an alternative sector view, using Economic Sectors. I think this is useful, and hope that you do the same for a systems or consumption based view. As the Economic Sector approach completely eliminates reference to a "waste" sector, I don't know if this will result in even less attention to upstream material management strategies or open up those strategies for more robust consideration by not pigeon-holing them under "waste".

I have also personally found it confusing that the global warming potentials that are required to be used are 100 year potentials. When I make presentations, I cringe at questions from the public who are interested in knowing that we and they can respond quickly, when it looks like some of our methodologies don't really show impacts during the correct time frames. It would be helpful to provide additional information on other warming potential time frames.

For these reasons, I recommend the following:

1. The US Inventory should integrate a systems-based or consumption-based view and present it alongside the sector-based view. Even if a detailed analysis is not available, providing text and graphics that demonstrate how an alternate view provides valuable information for policy and program development would be tremendously helpful to the public, stakeholders, policy makers and planners. Coupled with the traditional sector-based view, the systems-based view offers a much more comprehensive perspective on how the US contributes to GHG emissions. At the very least this should be included under "planned improvements" in the waste section.

2. Consumption-related emissions should be formally acknowledged in the US Greenhouse Gas Inventory. The US Greenhouse Gas Inventory should be much more explicit in stating that the inventory is limited to emissions that physically originate within the national borders of the US. It should explain that the US also contributes to emissions that are counted in the inventories of other nations, as a consequence of imports. The emissions associated with US exports are less than those associated with US imports. When viewed from the perspective of consumption, the greenhouse gas impact of the US is higher than suggested by the traditional IPCC accounting standard. This is of great importance: consumption is the root cause of emissions. Until this is clearly explained and addressed, stakeholders, policy makers and planners will not understand the key overarching strategy of reducing consumption of energy and resources.

3. Please include both 100-year, and 20-year global warming potentials (GWPs) in the Inventory. While the Inventory points out that other GWPs are also available, it would be more useful to actually include that analysis in the Inventory to assist policymakers, planners and stakeholders.

These changes would make the inventory more understandable and useful at the both the state and local level, and would be a first step in moving inventories at all levels to providing a more comprehensive analysis.

Thank you for the chance to comment.

Sincerely,

Sego Jackson
Principal Planner
Snohomish County Solid Waste Division

Appendix C

United States Department of the Interior

NATIONAL PARK SERVICE
Environmental Quality Division
P.O. Box 25287
Denver, CO 80225-0287

IN REPLY REFER TO:

ELECTRONIC TRANSMISSION ONLY – NO HARD COPY TO FOLLOW
April 13, 2010

(2310)

Docket ID No. FRL-9126-3
Leif Hockstad
Environmental Protection Agency
Climate Change Division (Mailcode 6207J)
1200 Pennsylvania Avenue, NW
Washington, D.C. 20460

Dear Mr. Hockstad

These comments are submitted on behalf of the National Park Service (NPS) in response to the U.S. Environmental Protection Agency's (EPA) March 15, 2010, Federal Register Notice requesting review and comment on the Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008.

EPA produces an annual inventory of greenhouse gas emissions and sinks using methodologies that are consistent with those recommended by the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (most recently updated in 2006). This allows U.S. emissions to be directly compared with inventories of other nations participating in the United Nations Framework Convention on Climate Change. Each year, emissions and sinks are recalculated for all years in the inventory from 1990 to the current year, to incorporate improvements in emissions methods and data.

Separately, under the Executive Order "Federal Leadership in Environmental, Energy, and Economic Performance" issued in October 2009, federal agencies are now required to "measure, report, and reduce their greenhouse gas (GHG) emissions from direct and indirect activities." The Department of Energy (DOE) Federal Energy Management Program (FEMP) in cooperation with other federal agencies has developed the Federal Greenhouse Gas Accounting and Reporting Guidance to define methods for reporting emissions. EPA should ensure that methods used in this annual inventory of greenhouse gas emissions and sinks are consistent with the FEMP methodologies. If source categories or reporting methods differ, it would be appropriate to define the basis for differences in a new section added to this report.

The inventory results are informative and for the most part clearly presented. While we agree that currently available methods make it difficult to specifically quantify the impacts of forest fires on net carbon sequestration in forests, EPA should acknowledge the numerous efforts by federal agencies to improve methods to characterize fire emissions. Future inventories may be able to refine these estimates.

For further information, please contact Pat Brewer, Air Resources Division, at 303-969-2153.

Sincerely,

/s/ Joe Carriero
External Affairs Program Manager
Environmental Quality Division

cc:
Patricia Brewer, NPS Air Resources Division
Julie Thomas NPS McNamee, Air Resources Division
John Bunyak, NPS Air Resources Division

Appendix D

BIOMASS ACCOUNTABILITY PROJECT • CENTER FOR BIOLOGICAL DIVERSITY • ENERGY JUSTICE NETWORK • GLOBAL ALLIANCE FOR INCINERATOR ALTERNATIVES • GREEN BERKSHIRES • MASSACHUSETTS FOREST WATCH

April 14, 2010

Via email: hockstad.leif@epa.gov and regulations.gov

Leif Hockstad
Environmental Protection Agency
Climate Change Division (6207J)
1200 Pennsylvania Ave., NW
Washington, DC 20460

Re: Inventory of U.S. Greenhouse Gas Emissions and Sinks

Dear Mr. Hockstad:

The undersigned organizations respectfully submit the following comments on the United States Environmental Protection Agency's ("EPA") Inventory of U.S. Greenhouse Gas Emissions and Sinks (the "Inventory").

EPA's inventory document repeats a pernicious assumption that has profound consequences for both the climate and the nation's forests: the assumption that biomass combustion is "carbon neutral." EPA recognizes, as it must, that the combustion of biomass and biofuels produces CO_2 and other greenhouse gases. Yet EPA declines to include these emissions in national totals "because biomass fuels are of biogenic origin."[1] According to EPA, "[i]t is *assumed* that the carbon (C) released during the consumption of biomass is recycled as U.S. forests and crops regenerate, causing no net addition of CO_2 to the atmosphere."[2]

As described in detail below, scientists have concluded that this assumption represents a critical error in EPA's climate accounting methodology. This error pervades all of EPA's biomass calculations, but it is especially glaring as applied to facilities that burn woody biomass from tree plantations, forest thinning projects, or fire salvage projects. Promotion of new and expanded biomass energy facilities predicated on this assumption is beginning to threaten both the ecology of the nation's forests and the stability of the world's climate. EPA thus should revise the Inventory to eliminate reliance on the "carbon neutrality" assumption and should adopt accounting methods that

---

[1] U.S. EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2008; Public Review Draft (March 9, 2010), Ch. 3 (Energy) at 1.
[2] *Id.* (emphasis added).

accurately measure emissions from both biomass combustion and associated land use change on time scales relevant to climate protection efforts.

I. Scientists Have Identified Critical Errors in EPA's Carbon Accounting Methods.

Recent scientific work has identified a "critical climate accounting error" in the EPA's inventory method: namely, its failure to account accurately for carbon emissions associated with biomass and biofuels in the land use sector.[3] Specifically, EPA's accounting "erroneously treats all bioenergy as carbon neutral regardless of the source of the biomass, which may cause large differences in net emissions. For example, the clearing of long-established forests to burn wood or grow energy crops is counted as a 100% reduction in energy emissions despite causing large releases of carbon."[4]

Energy generated from biomass reduces greenhouse gas emissions "only if the growth and harvesting of the biomass for energy captures carbon above and beyond what would be sequestered anyway."[5] Scientists thus believe that the better solution is to focus first on carbon emissions from the smokestack, and then to factor in emissions and reductions associated with land use change. According to Searchinger, et al. (2009):

> The straightforward solution is to fix the accounting of bioenergy. That means tracing the actual flows of carbon and counting emissions from tailpipes and smokestacks whether from fossil energy or bioenergy. Instead of an assumption that all biomass offsets energy emissions, biomass should receive credit to the extent that its use results in additional carbon from enhanced plant growth or from the use of residues or biowastes. Under any crediting system, credits must reflect net changes in carbon stocks, emissions of non-CO_2 greenhouse gases, and leakage emissions resulting from changes in land-use activities to replace crops or timber diverted to bioenergy.[6]

Such accounting also must include site-specific and regional analysis of energy generation, distribution, consumption, and demand trends sufficient to support any conclusion that biomass generation will actually offset fossil-fired generation. As discussed below, moreover, proper accounting also demands that the short-term impacts of biomass combustion be considered especially significant in light of the long time period required for resequestration of released carbon. Accurate accounting is absolutely critical to determining whether smokestack emissions from biomass combustion can be treated as "carbon neutral" in the manner proposed by EPA.

---

[3] Timothy Searchinger, et al., *Fixing a Critical Climate Accounting Error*, 326 SCIENCE 527 (2009).
[4] *Id.* at 527. As described in more detail below, this error is not limited to situations where forests are cleared entirely or converted to energy crops; rather, this error also infects analysis of the carbon impacts of thinning existing forests for biomass fuels.
[5] *Id.* at 528.
[6] *Id.*

II. The Carbon Neutrality Assumption Ignores the Critical Time Lapse Between Present Carbon Dioxide Emissions and Future Carbon Sequestration.

The claim that biomass combustion is "carbon neutral" because biomass is "biogenic" is both false and dangerous, primarily because it ignores the fact that carbon emitted during biomass combustion may remain in the atmosphere for decades or centuries before being resequestered. The claim thus ignores the critical temporal relationships between present carbon emissions and the future effects of global warming and climate change. In other words, because meeting (or exceeding) atmospheric CO_2 targets has a strong temporal element, the time that it takes for CO_2 released into the atmosphere today to be reabsorbed is of critical importance in assessing the climate impacts of carbon emissions, regardless of their "biogenic" origin.

Scientists agree that "[t]he amount of carbon sequestered by forest ecosystems plays an important role in regulating atmospheric levels of carbon dioxide."[7] The removal and processing of forest biomass reduces storage in forest carbon pools and results in short-term emissions of greenhouse gases, even when some of that biomass remains sequestered for a period of time in commercial forest products.[8] According to recent studies, "[t]ypically 30–50% of the harvested C is lost in manufacturing and initial use, a loss that is larger than could be expected from even the most extreme forest fire."[9] Where harvested biomass is combusted for energy, rather than processed into wood products, short-term emissions are necessarily far greater, and long-term sequestration in forest products is eliminated altogether.

Thinning and post-fire salvage operations reduce the future carbon sequestration potential of a given forest stand by removing trees that otherwise would have continued to draw CO_2 from the atmosphere.[10] This is true even for projects that are intended to reduce fuel loads in order to lessen the potential severity of future wildfires. One recent study concluded that "fuel removal almost always reduces C storage more than the additional C that a stand is able to store when made more resistant to wildfire. . . . [I]t is inefficient to remove large amounts of biomass to reduce the fraction by which other

---

[7] Tara Hudiburg, et al., *Carbon Dynamics of Oregon and Northern California Forests and Potential Land-Based Carbon Storage*, 19 ECOLOGICAL APPLICATIONS 163, 163 (2009).

[8] *See id.* at 176-77 (discussing carbon storage reductions associated with shorter rotations and emissions caused by logging); *see also* Mark E. Harmon, et al., *Modeling Carbon Stores in Oregon and Washington Forest Products: 1900-1992*, 33 CLIMATIC CHANGE 521 (1996) (concluding that harvesting for sawtimber results in sequestration of only about 60% of carbon previously stored in forest pools).

[9] Mark E. Harmon, et al., *Effects of Partial Harvest on the Carbon Stores in Douglas-fir/Western Hemlock Forests: A Simulation Study*, 12 ECOSYSTEMS 777, 778 (2009).

[10] *See* Brooks M. Depro, et al., *Public Land, Timber Harvests, and Climate Mitigation: Quantifying Carbon Sequestration Potential on U.S. Public Timberlands*, 255 FOREST ECOLOGY & MGMT. 1122 (2008) (concluding that eliminating timber harvest on public lands would increase forest carbon storage capacity by roughly 40-50% over "business as usual").

biomass components are consumed via combustion."[11] Another recent study confirms that significant amounts of carbon remain sequestered in forest pools even following a high-intensity wildfire.[12] Surveys of the world's most carbon-dense forests, including the moist temperate conifer forests of North America, have confirmed that the greatest accumulations of carbon biomass occur in the absence of human land-use disturbance.[13]

Removal of forest biomass also affects long-term carbon storage in forest soils. Thinning and harvesting operations can reduce carbon inputs to soils and stimulate soil respiration, resulting in both reduced soil sequestration and near-term emissions.[14] Some studies have shown that forests remain net sources of carbon emissions for more than a decade after logging operations, primarily due to increased soil respiration.[15] Fuel treatments that change the amount and composition of decomposing forest biomass can influence long-term below-ground carbon storage.[16]

The time between harvest and complete reabsorption of lost carbon by a forest stand can extend into hundreds of years. For example, one recent study concluded that even assuming perfect conversion of biomass to energy and a one-to-one displacement of fossil-fired generation, it still took from 34 to 228 years for western forests to reach carbon neutrality for biomass used directly for energy generation, and between 201 and 459 years if the biomass was converted to biofuels (the ranges depending upon the characteristics of the trees, forests and fire return intervals).[17] Accordingly, because forest biomass utilization is not carbon neutral in the near term, the near-term effects of carbon emissions associated with biomass combustion must be considered.

It is well established as a matter of science and policy that in order to avoid the worst impacts of global warming and climate change, global temperatures must not be allowed to exceed 2°C over pre-industrial levels.[18] Whether we exceed the 2°C threshold depends on the level at which atmospheric CO_2 levels are eventually stabilized. The greater the CO_2 levels, the greater the risk of exceeding this threshold and triggering

[11] Stephen R. Mitchell, et al., *Forest Fuel Reduction Alters Fire Severity and Long-Term Carbon Storage in Three Pacific Northwest Ecosystems*, 19 ECOLOGICAL APPLICATIONS 643, 652 (2009); *see also* CHAD HANSON, THE MYTH OF "CATASTROPHIC" WILDFIRE: A NEW ECOLOGICAL PARADIGM OF FOREST HEALTH (2010).
[12] Garrett W. Meigs, et al., *Forest Fire Impacts on Carbon Uptake, Storage, and Emission: The Role of Burn Severity in the Eastern Cascades, Oregon*, 12 ECOSYSTEMS 1246 (2009).
[13] *See* Heather Keith, et al., *Re-evaluation of Forest Biomass Carbon Stocks and Lessons from the World's Most Carbon-Dense Forests*, 106 PROC. NAT'L ACADEMY OF SCI. 11,635 (2009).
[14] Robert Jandl, et al., *How Strongly Can Forest Management Influence Soil Carbon Sequestration?*, 137 GEODERMA 253, 257-58 (2007).
[15] *Id.* at 258.
[16] Mitchell 2009 at 652.
[17] Mitchell 2009 at 651.
[18] J. Hansen, et al., *Target Atmospheric CO_2: Where Should Humanity Aim?*, 2 OPEN ATMOS. SCI. J. 217 (2008).

likely catastrophic climate changes. The probability of overshooting 2°C is as follows according to Hare and Meinshausen (2006) [19]:

85% (68-99%) at 550 ppm CO_2 eq (= 475 ppm CO_2)
47% (26-76%) at 450 ppm CO_2 eq (=400 ppm CO_2)
27% (2-57%) at 400 ppm CO_2 eq (= 350 ppm CO_2)
8% (0-31%) at 350 ppm CO_2 eq

According to these scientists, "[o]nly scenarios that aim at stabilization levels at or below 400 ppm CO_2 equivalence (~350 ppm CO_2) can limit the probability of exceeding 2°C to reasonable levels."[20] But in order to achieve stabilization levels that avert the worst impacts of climate change, emissions must peak by about 2015, and must decline very rapidly thereafter.[21]

In short, minimizing CO_2 emissions in the *next few years* is critically important to meeting climate targets, even if some of all of that CO_2 might in theory be reabsorbed from the atmosphere in the decades or centuries to come. The science makes clear that the time frame for resequestration of CO_2 emitted from forest biomass combustion is on the order of decades or centuries, not years. Indeed, in evaluating carbon emissions from other biofuels, independent scientists have begun to develop strategies for evaluating the carbon impacts of biofuels in relation to the high social and environmental cost of short-term emissions.[22] Even EPA has begun to recognize the importance of this temporal analysis in other contexts.[23] Short-term CO_2 emissions from woody biomass combustion are thus *significant*—not "neutral"—in the context of efforts to avoid the worst impacts of climate change, and should be treated as such in both environmental analysis and air permitting decisions. EPA's failure to acknowledge this fact in the context of the annual emissions inventory is arbitrary and unsupportable.

---

[19] B. Hare & M. Meinshausen, *How Much Warming Are We Committed To and How Much Can Be Avoided?*, 75 CLIMATIC CHANGE 111 (2006).
[20] *Id.* at 137.
[21] *See* IAN ALLISON, ET AL., THE COPENHAGEN DIAGNOSIS: UPDATING THE WORLD ON THE LATEST CLIMATE SCIENCE 9 (2009); *see also* M. den Elzen & N. Höhne, *Reductions of greenhouse gas emissions in Annex I and non-Annex I countries for meeting concentration stabilisation targets*, 91 CLIMATIC CHANGE 249 (2008).
[22] *See* M. O'Hare et al., *Proper Accounting for Time Increases Crop-Based Biofuels' Greenhouse Gas Deficit Versus Petroleum*, 4 ENVTL. RESEARCH LETT. 024001 (2009) (applying discount rate to account for importance of early emissions).
[23] *See* U.S. EPA, *EPA Lifecycle Analysis of Greenhouse Gas Emissions from Renewable Fuels* (2009) ("[T]he time horizon over which emissions are analyzed and the application of a discount rate to value near-term versus longer-term emissions are critical factors").

III. Logging for Biomass Combustion Is Potentially More Harmful to the Climate and the Forest than Natural Fire.

Although EPA does not specifically mention it, another common justification for treating forest biomass as "carbon neutral" is that if not removed and burned for energy, wood is likely to burn up in forest fires, resulting in both uncontrolled carbon emissions and substantial ecological damage. Once again, recent scientific analysis has shown this premise to be false in terms of both carbon accounting and forest ecology.

Combustion of trees, brush, and litter in forest fires releases carbon emissions. Yet the emissions from fires may be far lower (and far fewer live trees may be killed) than previously believed, depending upon forest type and fire intensity.[24] Carbon lost in fires also may rapidly be resequestered by early successional species following disturbance.[25] Furthermore, recent scientific studies call into question the entire enterprise of removing (and burning) biomass in order to avoid carbon emissions associated with wildfire:

> [F]uel removal almost always reduces C storage more than the additional C that a stand is able to store when made more resistant to wildfire. Leaves and leaf litter can and do have the majority of their biomass consumed in a high-severity wildfire, but most of the C stored in forest biomass (stem wood, branches, coarse woody debris) remains unconsumed even by high-severity wildfires. For this reason, it is inefficient to remove large amounts of biomass to reduce the fraction by which other biomass components are consumed via combustion.[26]

Accordingly, it is not accurate to assume that carbon emissions from biomass combustion would have occurred in the forest anyway, on the same time scales and to the same degree, as a result of fire. Indeed, biomass energy generation ensures that forest biomass is converted into carbon dioxide on a very short time scale, whether or not similar emissions would have occurred as a result of fire, and regardless of whether logging is as effective as natural succession in facilitating sequestration of those emissions. Once again, these detailed questions must be answered before any particular biomass energy project can claim to be "carbon-neutral."

Current scientific work also indicates that fire, even the high-intensity variety, is a natural event that we should accept and encourage, not attempt to forestall through speculative, intensive, and destructive logging projects aimed at "forest cleaning" or "fuel reduction."[27] The dead trees left standing after a high-intensity fire provide critical wildlife habitat as well as soil nutrients that encourage rapid growth of early successional species. Moreover, unlike emissions produced in biomass energy facilities, carbon in standing dead trees and forest floor pools remains sequestered for a long time following

---

[24] *See, e.g.*, Meigs 2009.
[25] *See id.* at 1260-61.
[26] Mitchell 2009 at 652.
[27] *See generally* Hanson 2010.

even a high-intensity fire, and decays slowly into the atmosphere even as new plant growth recolonizes a burned area. The eventuality of forest fire cannot be used as an excuse for wholesale logging and burning of forests to create energy.

Finally, the demand for wood created by large-scale construction of biomass energy facilities is likely to be more than our forests can sustain, and thus may have very significant cumulative impacts on biodiversity, water quality, and forest health.[28] In addition, if each of these facilities were to claim "carbon neutrality," in the absence of any evidence or analysis, the result could be a dramatic and uncontrolled overall increase in near-term CO_2 emissions during precisely the time period when emissions most need to be curtailed.

IV. Conclusion

The "carbon neutrality" assumption is just that—an assumption, not a fact. "Carbon neutrality," if it exists at all, must be demonstrated on a project-specific basis, taking into account all emissions from biomass production, transport, processing, and combustion, all emissions and lost sequestration capacity associated with forest thinning and clearing operations, and actual analysis of fossil fuel displacement. In the absence of such a demonstration, the actual emissions from biomass combustion must be counted in EPA's annual emissions inventory. EPA must revise the Inventory to eliminate reliance on the "carbon neutrality" myth, and must replace it with an accurate and comprehensive accounting methodology for biomass emissions.

Thank you for your consideration of our comments. Please feel free to contact Kevin Bundy at (415) 462-9683 x313 with any questions.

Sincerely,

Kevin P. Bundy
Senior Attorney
Center for Biological Diversity

Margaret E. Sheehan, Esq.
Director
The Biomass Accountability Project, Inc.

Mike Ewall
Founder and Director
Energy Justice Network

Ananda Lee Tan
North American Program Coordinator
Global Alliance for Incinerator Alternatives

Eleanor Tillinghast
President
Green Berkshires, Inc.

Chris Matera
Founder
Massachusetts Forest Watch

[28] *See, e.g.*, V.A. Sample, *Summary/synthesis: What Role Will Forests Play in America's Long-Term Energy Future?* (2009) at 16-17.

References Cited

Ian Allison, et al., *The Copenhagen Diagnosis, 2009: Updating the world on the Latest Climate Science* (2009).

Brooks M. Depro, et al., *Public Land, Timber Harvests, and Climate Mitigation: Quantifying Carbon Sequestration Potential on U.S. Public Timberlands*, 255 FOREST ECOLOGY & MGMT. 1122 (2008).

M. den Elzen & N. Höhne, *Reductions of greenhouse gas emissions in Annex I and non-Annex I countries for meeting concentration stabilisation targets*, 91 CLIMATIC CHANGE 249 (2008).

James Hansen, et al., *Target Atmospheric CO_2: Where Should Humanity Aim?*, 2 OPEN ATMOS. SCI. J. 217 (2008).

Chad Hanson, *The Myth of "Catastrophic" Wildfire: A New Ecological Paradigm of Forest Health* (2010).

B. Hare & M. Meinshausen, *How Much Warming Are We Committed To and How Much Can Be Avoided?*, 75 CLIMATIC CHANGE 111 (2006).

Mark E. Harmon, et al., *Effects of Partial Harvest on the Carbon Stores in Douglas-fir/Western Hemlock Forests: A Simulation Study*, 12 ECOSYSTEMS 777, 778 (2009).

Mark E. Harmon, et al., *Modeling Carbon Stores in Oregon and Washington Forest Products: 1900-1992*, 33 CLIMATIC CHANGE 521 (1996).

Tara Hudiburg, et al., *Carbon Dynamics of Oregon and Northern California Forests and Potential Land-Based Carbon Storage*, 19 ECOLOGICAL APPLICATIONS 163, 163 (2009).

Robert Jandl, et al., *How Strongly Can Forest Management Influence Soil Carbon Sequestration?*, 137 GEODERMA 253, 257-58 (2007).

Heather Keith, et al., *Re-evaluation of Forest Biomass Carbon Stocks and Lessons from the World's Most Carbon-Dense Forests*, 106 PROC. NAT'L ACADEMY OF SCI. 11,635 (2009).

Garrett W. Meigs, et al., *Forest Fire Impacts on Carbon Uptake, Storage, and Emission: The Role of Burn Severity in the Eastern Cascades, Oregon*, 12 ECOSYSTEMS 1246 (2009).

Stephen R. Mitchell, et al., *Forest Fuel Reduction Alters Fire Severity and Long-Term Carbon Storage in Three Pacific Northwest Ecosystems*, 19 ECOLOGICAL APPLICATIONS 643, 652 (2009).

M. O'Hare et al., *Proper Accounting for Time Increases Crop-Based Biofuels' Greenhouse Gas Deficit Versus Petroleum*, 4 ENVTL. RESEARCH LETT. 024001 (2009).

V.A. Sample, *Summary/synthesis: What Role Will Forests Play in America's Long-Term Energy Future?* (2009).

Timothy Searchinger, et al., *Fixing a Critical Climate Accounting Error*, 326 SCIENCE 527 (2009).

U.S. EPA, *EPA Lifecycle Analysis of Greenhouse Gas Emissions from Renewable Fuels* (2009).

Appendix E

NACWA
A Clear Commitment to America's Waters

April 14, 2010

Leif Hockstad
U.S. Environmental Protection Agency
Climate Change Division (6207J)
1200 Pennsylvania Ave, NW
Washington, DC 20460
Via Email: Hockstad.Leif@epa.gov

Re: NACWA Comments on Wastewater Treatment Emissions Estimates in EPA's Draft *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*

Dear Mr. Hockstad:

The National Association of Clean Water Agencies (NACWA) has reviewed Section 8.2, *Wastewater Treatment*, of the U.S. Environmental Protection Agency's (EPA) draft *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008* (*Draft Inventory*) and offers the following comments and technical information. NACWA represents the interests of nearly 300 publicly owned wastewater treatment agencies nationwide, serving the majority of the sewered population in the U.S. NACWA members are very much aware of the growing importance of global climate change and are already engaged in efforts to reduce greenhouse gas (GHG) emissions. The wastewater treatment category of the *Inventory* consistently ranks in the top categories for nitrous oxide and methane emissions in the U.S., although the emissions are much smaller in magnitude than for the highest ranked categories. The wastewater category is broad, including publicly owned treatment works (POTWs), septic systems, and industrial wastewater treatment systems. Our review focused on the portion of the wastewater treatment emissions from POTWs, which are a fraction of the total wastewater treatment emissions.

NACWA submitted comments on the three previous *Inventories*, and we appreciate EPA's response to these comments and the Agency's willingness to work with NACWA to refine the GHG emissions estimates for POTWs. Some adjustments have been made in past years to the methods used to calculate GHG emissions from POTWs, and NACWA has supported these changes. No significant changes were made between the 2007 and 2008 *Inventories*, however, and NACWA believes that the *Inventory* emission calculation methods could still be improved to more accurately reflect actual emissions from POTWs.

National Association of
Clean Water Agencies
1816 Jefferson Place, NW
Washington DC 20036-2505

p 202.833.2672 f 202.833.4657
www.nacwa.org · info@nacwa.org

In the past, the *Inventory* has been used only for information purposes, not for regulation. However, in EPA's proposed *Prevention of Significant Deterioration and Title V GHG Tailoring Rule* ("Proposed Tailoring Rule"), the methods for calculating GHG emissions in the *Inventory* were cited as the methods that a facility must use to calculate whether the threshold for regulation of GHG emissions under the Clean Air Act (CAA) is exceeded. If EPA plans to use the *Inventory* in its regulations, then it is especially important that the *Inventory* calculation methods accurately reflect actual emissions from facilities. However, the *Inventory* calculation methods may not be the best tool for regulatory compliance. As NACWA pointed out in its comments to EPA on the Proposed Tailoring Rule, the *Inventory* is meant to provide a nationwide estimate of emissions from broad categories of facilities, not emissions from individual facilities. In addition, the methods used to calculate emissions in the *Inventory* for POTWs differ from the methods that POTWs must use to calculate their emissions under the *Mandatory Reporting of Greenhouse Gases Rule*. NACWA believes that the Agency must determine one calculation method to be used in all of its GHG-related regulations, rather than requiring facilities such as POTWs to use different calculations for different regulations.

In the comments below, NACWA presents recommendations for changes that should be made to the *Draft Inventory* to improve its estimates of emissions from centralized treatment facilities. NACWA recommends that whenever possible, the domestic sources of emission should be broken down into septic system and centralized treatment sources. For the nitrous oxide emissions estimates, NACWA urges EPA to consider published literature values of nitrogen loading rates to POTWs, and to collect its own data if necessary to verify these rates. In addition, several changes need to be made to the equations used to calculate nitrous oxide emissions to fix typographical errors and to make the values calculated by EPA reproducible.

Wastewater Treatment Emissions Summary

Tables 8-6 and 8-7 in the *Draft Inventory* provide a summary of methane and nitrous oxide emissions, showing total emissions as well as the separate contributions from domestic and industrial wastewater treatment. NACWA recommends that the domestic emissions be broken down into emissions from septic systems and from centralized systems. In Table 8-9, the methane emissions from industrial sources are broken down according to each industrial sector, but no similar division is shown for domestic sources. Septic systems contribute most of the methane emissions from domestic sources, while centralized systems are shown to be responsible for all of the nitrous oxide emissions. Given these significant differences, dividing domestic emissions between septic and centralized systems would more clearly illustrate and summarize the emission sources.

Domestic Wastewater Nitrous Oxide Emission Estimates

The *Draft Inventory* calculates nitrous oxide emissions from POTWs using estimated nitrogen loadings to wastewater that are based on reported annual protein consumption. This is the methodology used in the Intergovernmental Panel on Climate Change (IPCC) protocol document[1] (*IPCC Guidelines*). Expressed as nitrogen (N), the estimated nitrogen loading rate to POTWs for domestic sources is:

(32.4 kg consumed protein/capita-year) x (0.16 kg N/kg protein) x (1.4 factor for non-consumed protein)
= 7.26 kg N/capita-year

---

[1] IPCC, *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Prepared by the National 18 Greenhouse Gas Inventories Programme, Eggleston H.S., Buenida L., Miwa K., Ngara T., and Tanabe K. (eds.) 19 Published: IGES, Japan, 2006.

Changing the units of this value to grams of nitrogen on a daily basis results in:

(7.26 kg N/capita-year) x (1000 g/kg) x (1 year/365 days)
= 19.9 g N/capita-day

The nitrogen loading rate is further increased by a factor of 1.25 to account for industrial and commercial contributions, as follows:

1.25 x (19.75 g N/capita-year)
= 24.9 g N/capita-day

Comparison of EPA's Estimated Nitrogen Loading Rates to Published and Surveyed Rates

NACWA believes that both of the above loading rates are too high, and that EPA needs to conduct more research to determine more accurate loading rates to use in the *Inventory*. As NACWA has pointed out in its previous comments on the *Inventory*, the rates currently used in the *Draft Inventory* are higher than rates presented in standard references such as Metcalf & Eddy[2]. Metcalf & Eddy report per capita nitrogen loading rates to wastewater of 15 g N/capita-day, a value usually considered the "industry standard" by POTWs. These values are supported by a wealth of data and have been widely confirmed in U.S. practice. The type of data used in Metcalf & Eddy represents all domestic sources of nitrogen, including meal production and consumption, the use of other nitrogen containing compounds, and both residential and commercial sources.

In NACWA's comments on the *Draft Inventory* for 1990-2007, we presented the results of a literature review to find other nitrogen loading rates. In addition, NACWA conducted a survey of measured total nitrogen loading rates for 48 wastewater treatment facilities throughout the U.S., with a total service population of over 17 million people. Since these data are from measurements of nitrogen loading to the POTW, the nitrogen loading rate includes all sources (residential, commercial, and industrial) for the service communities represented. All of the nitrogen loading rate values are summarized in Table 1. The literature review results and table of survey data are included again for your reference in Attachments A and B, respectively.

Table 1. Summary of nitrogen loading values to POTWs.

Reference	Nitrogen Loading Rate (g N/capita-day)
EPA *Draft Inventory* – Domestic Sources	19.9
EPA *Draft Inventory* – Domestic, Industrial, and Commercial Sources	24.9
Metcalf & Eddy – "Industry Standard"	15
Literature Review – Range of Reported Values	6-22.7
Literature Review – Average of Reported Values	13.3
NACWA Data	15.1

[2] Tchobanoglous, G., F.L. Burton, and H.D. Stensel, *Wastewater Engineering: Treatment and Reuse, Metcalf & Eddy, Inc.* 4th Edition, McGraw-Hill, New York, 2003.

The nitrogen loading values found in the literature review average 13.3 g N/capita-day, which is even less than the value 15 g N/capita-day reported by Metcalf & Eddy. The average nitrogen loading value found in the NACWA survey of POTWs was 15.1 g N/capita-day, which agrees almost exactly with the Metcalf & Eddy value. The value used in the *Draft Inventory* of 19.9 g N/capita-day for domestic sources only falls within the upper part of two ranges found in the literature review, while the derived value of 24.9 g N/capita-day for all sources is above all of the published values and is also above the highest value found in the NACWA survey of POTWs. EPA's own references cite values of 11.2, 12, 6-17, and 8.16-22.7 g N/capita-day, which are all lower than the nitrogen loading rate for all sources used in the *Draft Inventory*. NACWA believes that the value used in the *Inventory* should be closer to the average nitrogen loading value from the available literature, rather than in the very upper part of a range of values.

If the *Inventory* methodology is used to convert only the per capita protein consumption into per capita nitrogen loading, without the additional factors to account for non-consumed protein and non-domestic sources, the result is:

$$(32.2 \text{ kg protein/capita-year}) \times (0.16 \text{ kg N/kg Protein}) \times (1{,}000 \text{ g/kg}) \div (365.25 \text{ days/yr}) = 14.1 \text{ g N/capita-day}$$

This value is extremely close to the value found in the NACWA data and to the average value from the literature survey. EPA makes two assumptions to convert this value of protein consumption (expressed as N) into the nitrogen contribution from domestic sources:

1. All of the protein consumed is excreted; and
2. The protein consumed is multiplied by the 1.4 factor for non-consumed protein to represent other sources of nitrogen in domestic wastewater.

The first assumption, that all protein consumed is excreted, is not clearly stated in the *Draft Inventory*, but it appears to be made based on the equations and values reported. EPA should clarify whether or not this assumption is made. If the assumption is not made, then the fraction of consumed protein that is excreted should be reported in the *Inventory*.

The result of these two assumptions translates into a loading rate of 19.9 g N/capita-day from domestic sources. While protein consumption may be a reasonable "starting point" for the estimation of per capita nitrogen loading, the factors used to convert per capita protein consumption to per capita nitrogen loading may be overly conservative. The actual per capita POTW influent total nitrogen value may instead be:

1. A fraction of the reported per capita protein consumption (expressed as N), due to less protein being excreted than is consumed, with some additional nitrogen from non-consumed protein;
2. Accurately predicted by the per capita protein consumption and the factor of 1.4 is too high for the addition of non-consumed protein to the wastewater; or
3. A combination of the two scenarios above.

Modifying the nitrogen loading rates used in the *Draft Inventory* to account for these scenarios may result in more agreement between the calculated rates and the rates cited in the literature and verified with the NACWA survey.

Recommendations for Modifying EPA's Estimation Methodology
While it may be reasonable to use per capita protein consumption as an index of potential changes in POTW influent per capita nitrogen values over the years, the factors used to convert per capita protein consumption data into per capita POTW influent nitrogen values should be adjusted to reflect real-world data. EPA has agreed in the current *Draft Inventory* that "obtaining data on the changes in average influent N concentrations to centralized treatment systems over the time series would improve the estimate of total N entering the system, which would reduce or eliminate the need for other factors for non-consumed protein or industrial flow." NACWA urges EPA to work to obtain the appropriate data to justify changes to the *Inventory*, either to adjust the factors applied to convert protein consumption to influent nitrogen values, or to change the calculation to a purely data-based approach.

EPA noted in the current *Draft Inventory* that "the dataset previously provided by NACWA was reviewed to determine if it was representative of the larger population of centralized treatment plants for potential inclusion into the inventory." However, EPA concluded that "this limited dataset did not represent the number of systems by state and the service populations served in the United States." NACWA disagrees with this conclusion. The literature review documented peer-reviewed nitrogen loading values that are widely used and accepted by the wastewater sector. NACWA conducted the survey of measured nitrogen loading rates at POTWs to determine if the values published in the literature continue to be appropriate. The agreement between the measured values and the literature shows that the literature values are valid. NACWA believes that the literature – including EPA's own publications – provides sufficient information to allow changes to be made to the *Inventory* emissions calculations methods.

If EPA judges the peer-reviewed literature values to be insufficient proof for changing the *Inventory*, NACWA suggests that the information submitted provides EPA with a strong argument to conduct its own study of nitrogen loading rates to centralized treatment plants. EPA should have enough data available through its National Pollution Discharge Elimination System (NPDES) permitting program to determine an appropriate and justifiable nitrogen loading rate. The NPDES permitting program is nation-wide in scope and long-term in its nature, which would allow changes to be made in emissions estimates over the time series represented in the *Inventory*. Since EPA believes that further data of a broader and more representative scope are required before changing the *Inventory*, the NPDES database would certainly suffice as it represents every central POTW in the U.S. We urge EPA to conduct this analysis if it believes that further evaluation is needed to justify the standard, well-accepted nitrogen loading values documented in the literature.

NACWA believes that using the literature nitrogen loading values or EPA-collected values from U.S. POTWs would better reflect the actual emissions from POTWs in the U.S. than the current methods based on the *IPCC Guidelines*. The *IPCC Guidelines* do not necessarily reflect actual conditions at POTWs throughout the U.S. This is illustrated by the emission factor ("EF_1") of 3.2 g N_2O/person-year for plants with no intentional denitrification, used in the *Draft Inventory* and in the *IPCC Guidelines* to calculate nitrous oxide emissions from centralized wastewater treatment plants. This value was obtained from a single study of a very small wastewater treatment plant (1.06 million gallons per day, or MGD) in a small university town in New Hampshire. The population of this town is 12,500 during the school year, but drops to 6,200 in the summer months, during which most of the measurements for this study were made. If the IPCC can use this single study to define an emission factor that is used for centralized treatment facilities all over the world, certainly EPA can justify changing the nitrogen loading rate for facilities in the U.S. based on multiple literature values and data that it can collect from POTWs across the nation.

Recommendations for Revisions to the Emissions Equations

NACWA recommends that several changes be made to the equations on page 8-13 used to calculate the nitrous oxide emissions from domestic wastewater and to the definitions of the factors used in these equations on page 8-14:

1. In the $N_2O_{WOUT\ NIT/DENIT}$ equation (line 44, page 8-13), the $F_{IND\text{-}COM}$ factor should be moved outside of the square brackets. This is a typographical error rather than an error that affects the calculations.
2. In the $N_2O_{EFFLUENT}$ equation (line 45, page 8-13), the US_{POP} factor should be multiplied by the WWTP factor, as it is in the $N_2O_{WOUT\ NIT/DENIT}$ equation, since septic system users should not be included in the amount of effluent discharged to aquatic environments. NACWA recommends that any nitrous oxide contributions from septic systems be calculated in a separate equation if they are even included in the *Inventory*.
3. The units provided in the definitions of N_2O_{TOTAL}, N_2O_{PLANT}, $N_2O_{NIT/DENIT}$, and $N_2O_{WOUT\ NIT/DENIT}$ (lines 2-7, page 8-14) should be Gg, not kg, since conversions are made to Gg in the equations used to calculate these values.
4. The value of 269 Tg N for N_{SLUDGE} (line 37, page 8-14) appears to be an error, resulting in a negative value for $N_2O_{EFFLUENT}$. The value of 141 Gg N found in the Annex in Table A-193 (page A-231) is a more appropriate magnitude. However, even substituting this 141 Gg N value for N_{SLUDGE} does not result in a N_{TOTAL} value that agrees with the value of 15.9 Gg N_2O in Table 8-7. EPA should review the equation for $N_2O_{EFFLUENT}$ and all of the values used in it for accuracy.

Thank you for consideration of our comments on the *Draft Inventory*. Please contact me at 202/296-9836 or *cfinley@nacwa.org* if you have any questions about NACWA's comments.

Sincerely,

Cynthia A. Finley
Director, Regulatory Affairs

Attachments

Attachment A

References in literature for nitrogen per capita loading rates.

Reference	Value (g N/ capita-day)	Comments
U.S. EPA, *Manual: Nitrogen Control*, EPA/625/R-93/010 Office of Research and Development, Office of Water, Washington DC 20460, September 1993.	12	Residential contribution.
U.S. EPA, *Manual: Nitrogen Control*, EPA/625/R-93/010 Office of Research and Development, Office of Water, Washington DC 20460, September 1993.	8.16-22.7	Based on raw influent wastewater characteristics of per capita pollutant generation rates of 0.18-0.25 lb/capita/day (BOD). The pollutant relationship between BOD and TKN was defined as 0.1-0.2 TKN/BOD. (Table 2-2, p. 26)
U.S. EPA, *Systems Manual: Onsite Wastewater Treatment*, EPA/625/R-00/008 Office of Research and Development, Office of Water, Washington DC 20460, February 2002.	6-17	Total nitrogen loading value from Table 3-7, Constituent Mass Loadings and Concentrations in Typical Residential Wastewater. This applies to typical residential households with standard water-using fixtures and appliances.
U.S. EPA, *Systems Manual: Onsite Wastewater Treatment*, EPA/625/R-00/008 Office of Research and Development, Office of Water, Washington DC 20460, February 2002.	11.2	Total nitrogen loading value contributions by source in Table 3-8. Estimates 0.6 g/person/day from the garbage disposal, 8.7 g from toilets, and 1.9 g from bathing, sinks, and appliances for the total of 11.2 g/person/day of nitrogen.
Metcalf & Eddy, Inc., *Wastewater Engineering: Treatment, Disposal, Reuse*, 2nd Edition, McGraw-Hill Book Company, NY, 1979.	15	"Normal domestic wastewater." Range of 10-18 g N/capita-day, with complete grinding of food waste.
Metcalf & Eddy, Inc., *Wastewater Engineering: Treatment, Disposal, Reuse*, 3rd Edition, McGraw-Hill Book Company, NY, 1991.	12	"Normal domestic wastewater" without contribution from ground kitchen waste. Range of 9 to 14 g N/capita-day.
Metcalf & Eddy, Inc., *Wastewater Engineering: Treatment, Disposal, Reuse*, 4th Edition, McGraw-Hill Book Company, NY, 2003.	9-22	Value for the United States was obtained from Table 3-14, p. 184 of typical wastewater constituent data for various countries.

Henze, M. and A. Ledin, "Types, Characteristics and Quantities of Classic, Combined Domestic Wastewaters," in *Decentralized Sanitation and Reuse: Concepts, Systems and Implementation*, Lens, P., G. Zeeman, and G. Lettinga Ed, IWA Publishing, London, 2001.	14	Values for Denmark and USA reported to be similar to range from 14 to 19 g N/capita-day.
Matsui, S., M. Henze, G. Ho, and R. Otterpohl, "Emerging Paradigms in Water Supply and Sanitation," in *Frontiers in Urban Water Management: Deadlock or Hope*, Maksimović, C and J. A. Tejada-Guibet Ed., IWA Publishing, 2001.	13	Household wastewater.
Average Value	**13.3**	
Low Value	**6**	
High Value	**22.7**	

Attachment B

Nitrogen loading data from wastewater treatment facilities in the U.S. (The names, cities, and other information about the treatment facilities are not included in this table, but this information can be provided by NACWA if needed.)

State	Service Population (End of Data Period)	Nitrogen Loading (g/person-day)	Period of Data Record
CA	95,000	15.2	1995-2000
CA	80,000	11.0	1995
CA	102,000	16.6	1985-1986
CA	25,800	13.3	1993
CA	200,000	14.4	1988
CA	60,000	16.3	1994
CA	360,000	9.1	1983
CA	35,900	11.4	1995
CA	965,185	15.0	2007
CA	1,337,912	17.0	2007
CA	127,658	13.0	2006
CA	156,759	17.0	2006
CT	18,585	16.8	1998-2005
CT	5,400	20	
CT	12,980	14.1	1999-2001
CT	17,650	16.8	
CT	49,815	13.2	2002-2003
FL	187,320	15.6	1990-1999
IA	-	19.07	
IL	67,500	10.6	1999
MA	2,060,000	15	1986-1987
MA	89,589	15.4	2000
MA	6,986	11.8	2001-2006
MA	9,000	14.1	1997-2000
MN	52,150	7.0	1998
MT	139,200	14.53	2000-2005

MT	31,700	10.44	2003
MT	33,000	9.99	2004
MT	35,700	11.80	2005
NC	800,000	14.53	2007
NE	3,350	16.80	Dec. 2007
NH	17,000	20.0	2005
NJ	192,089	15.9	1999-2001
NM	-	16.8	2002-present
NV	600,000	16.80	2007
NY	26,622	22.7	1997-1999
NY	26,000	16.5	Jan. 2004- July 2007
OR	2000	19.5	2000-2004
OR	2000	15.9	1994-2000
OR	60,000	20.43	2005-2006
PA	900,000	9.7	2005
RI	139,000	19.1	1997-1998
TX	875,355	13.2	1996-2005
VA	300,818	15.9	2007
VA	273,356	15.9	July 2005 – June 2006
VA	361,582	14.5	FY 1990-2007
VA	115,000	19.1	2004-2006
VA	412,700	11.53	2001-2003
VA	82,000	18.16	2003-2006
WA	96,500	16.3	April-Oct. 2007
Average Value		**15.1**	
Low Value		**9.1**	
High Value		**22.7**	

Appendix F

Received 29 August 2008
Revised 5 September 2008
Accepted 21 October 2008

Lifetime-leveraging

An approach to achieving international agreement and effective climate protection using mitigation of short-lived greenhouse gases

Frances C. Moore
Yale School of Forestry and Environmental Studies, New Haven, Connecticut, USA, and
Michael C. MacCracken
Climate Institute, Washington, DC, USA

Abstract

Purpose – The purpose of this paper is to suggest an approach to post-Kyoto climate negotiations that could provide a way out of the apparent deadlock between developed and developing countries. This is an urgent issue as the world already appears to be close to a level of climate change that could be considered "dangerous".

Design/methodology/approach – The paper explores the potential that control of short-lived greenhouse gases such as methane, tropospheric ozone, and soot could have, in addition to steep cutbacks in industrialized nations, to both mitigate global warming and overcome political stalemate in the international climate negotiations.

Findings – Although rarely mentioned in climate discourse, reducing emissions of short-lived greenhouse gases offers a cost-effective way of actually reducing the radiative forcing in the atmosphere, while at the same time producing substantial subsidiary benefits such as improved urban air quality. The paper suggests leveraging this potential in the post-Kyoto treaty in order to "buy time" to address the arguably more difficult problem of essentially eliminating fossil-fuel related CO_2 emissions, which will ultimately be required to truly bring climate change under control. While high-income countries work on steep cutbacks of all greenhouse gas emissions, middle-income nations could make significant additional contributions by undertaking commitments to control only short-lived greenhouse gases until they reached a threshold level of per-capita GDP, at which point they would cap and begin reducing all greenhouse gas emissions.

Originality/value – This paper recognizes that political tradeoffs will have to be made in negotiating the next climate treaty, and offers a way of approaching these tradeoffs that could minimize resulting environmental damage.

Keywords Climatology, Global warming, International cooperation, Environmental politics

Paper type Research paper

International Journal of Climate Change Strategies and Management
Vol. 1 No. 1, 2009
pp. 42-62

1756-8692
DOI 10.1108/17568690910934390

The views expressed in this paper represent the views of the authors and not necessarily of any institutions with which they have been or are affiliated.

Thanks to Steve Smith and Navin Ramankutty for providing emissions data used for modeling. Thanks also to Nina Rinnerberger, Ivan Valencia, Bhuwan Thapa, Takanobu Terada, Claudia Vinay, and Lars Christiansen for valuable suggestions on the policy aspects of this proposal and for their comments on the draft.

Introduction

The UN Framework Convention on Climate Change (UNFCCC), negotiated in 1992, sets as its objective the stabilization of greenhouse gas concentrations at a level that would avoid "dangerous anthropogenic interference with the climate" (Article 2). The Kyoto Protocol, negotiated under the auspices of the UNFCCC, expires in 2012 and is widely regarded as a necessary but incomplete first step on the path toward achieving this objective. It put in place an international cap-and-trade framework that can be built on in future negotiations, but it restricted the emissions of relatively few countries and did not set long-term emissions targets. Global emissions have risen 23 per cent since the treaty was negotiated in 1997 (Marland *et al.*, 2007; BP, 2007).

Coincident with the accelerating rise in emissions and global temperature over the past decade have been scientific studies of the impacts on vegetation, wildlife, and the world's glaciers and ice sheets to climate change. These indicate that even relatively small increases in the global average temperature can lead to significant changes in the climate (Intergovernmental Panel on Climate Change – IPCC, 2007a), and it seems increasingly clear that impacts on society are likely to be more immediate and serious than previously indicated (IPCC, 2007b). As a result, it is now reasonably clear that global emissions need to peak and begin declining no later than 2020 to give a reasonable probability of avoiding the most serious climatic consequences (Meinshausen, 2006). The successor agreement to the Kyoto Protocol will therefore be critical in determining whether the world will avoid a dangerous level of climatic change.

The post-Kyoto treaty must possess two key characteristics: it must be stringent enough to avoid dangerous climate change and it must be structured in a way that provides incentives for participation of the world's major emitters. It is unclear which of these requirements will be the most difficult to achieve. Increasing scientific evidence of positive feedback mechanisms and of the Earth's sensitivity to past climatic changes has suggested that dangerous and irreversible climate change can be expected at a warming between 2 and 2.5°C above pre-industrial temperatures[1]. The atmosphere already contains enough long-lived greenhouse gases to raise global temperature by over 2°C[2]. Of that, 0.8°C of warming has already been realized, 0.6°C will be realized as the climate system comes to equilibrium, and the remainder is being offset by the cooling effect of (relatively short-lived) sulfate aerosols (IPCC, 2007a). Clearly, the Earth is already flirting with a dangerous level of climate change and steep and deep emissions cuts will be necessary if the threshold is to be avoided.

Despite the urgency of the threat, summoning the international political will to agree and enforce these strict limits could prove even more difficult than making the cuts themselves. The USA, the world's largest emitter over the twentieth century, has declined to ratify the Kyoto Protocol on the basis that it does not restrict emissions from developing countries that are also big emitters. Conversely, these developing countries, particularly China and India, have given little indication that they would accept any limit to their CO_2 emissions. Russia, the world's third largest emitter, recently announced that it would not undertake any future limits to emissions under a post-Kyoto agreement.

In this difficult political environment, it is inevitable that compromises will have to be made. Creative approaches to crafting the new international agreement will ensure that necessary political tradeoffs are made in a manner that minimizes damage to the environmental effectiveness of the agreement. The following sections describe the current deadlock in the negotiations process and the part that short-lived greenhouse gases play in the global warming problem. Then an approach is outlined through which mitigation of these short-lived gases could be incorporated into a future agreement and the equity, cost-effectiveness, and climatic effectiveness of such an agreement are examined in turn.

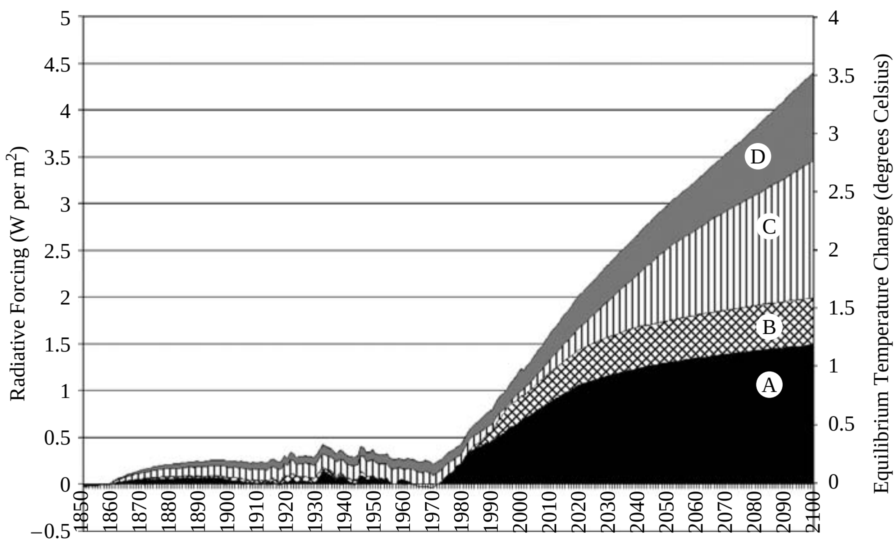
The first mover problem and the current climate impasse

All discussions of international climate agreements raise ethical issues regarding responsibility for past and future warming and the equity of the cost distribution of proposed solutions. As shown in Figure 1, the pattern of regional contributions to global warming over time shows that accumulated emissions from the OECD and former Soviet Union, with 20 per cent of the world's population, currently account for roughly 75 per cent of the warming problem. Per-capita emissions show an even greater disparity, with an American's carbon footprint currently five times the global average and 200 times that of someone living in one of the poorest countries. Indeed, the UN estimates that the average air conditioning unit in Florida is responsible for more CO_2 in a year than a Cambodian is in a lifetime, and that use of an average dishwasher in Europe results in emission of as much CO_2 in a year as three Ethiopians (UNDP, 2007).

These huge differences in per-capita emissions are significant because they are a product of economic development in high-income countries that has been powered by use of inexpensive fossil fuels. Developing countries ask why, when global warming ranks relatively low on a long list of humanitarian and economic priorities, and when greenhouse gas emissions are today closely correlated with the energy consumption that drives economic growth and welfare improvement, they should not do the same.

However, Figure 1 shows that even under a relatively modest emissions growth scenario, non-OECD countries will account for about 70 per cent of the climate forcing in 2100, and an even larger part of the growth in emissions over the next 100 years. Over the twenty-first century, with no internationally-agreed constraint, the developing countries will emit four to five times the amount of carbon dioxide emitted by the developed economies over the last century and a half. Clearly, even were it politically feasible to do so, high-income nations will be unable to solve the climate change problem alone: even were the OECD countries to completely cease emissions in 2013 after the expiry of the Kyoto Protocol, a "dangerous" level of greenhouse gas concentrations would be reached before 2050.

Much of the recent debate on achieving a stabilization of greenhouse gas concentrations has focused on how emissions reductions should be shared between developed and developing nations, particularly the large, rapidly growing developing countries (Posner and Sunstein, 2008; Baer and Athanasiou, 2007; Sugiyama and Deshun, 2004). Given their high per-capita emissions, greater wealth and greater responsibility for greenhouse gases currently accumulated in the atmosphere, the developed countries clearly bear the ethical burden of moving first to reduce greenhouse gas emissions, as reflected in the provisions of the UNFCCC and the Kyoto Protocol.



Notes: Ⓐ– OECD, Ⓑ– former Soviet Union, Ⓒ– Asia, Ⓓ– Africa, Latin America and the Middle East. The B2 scenario from the 2000 Special Report on Emissions Scenarios (IPCC, 2000) was chosen as a 'baseline' scenario for analysis because it is a mid-range scenario. Recent evidence, however, suggests that since 2000, emissions have grown faster than the high-end A1FI scenario, suggesting that the B2 scenario might be, at best, a lower-bound on future emissions (Canadell *et al.* (2007). Note also that the net radiative forcing is plotted, in which the negative forcing from sulfate aerosols is subtracted from the positive forcing from greenhouse gas emissions, occasionally more than canceling the warming responsibility from some regions. A conversion factor of 0.8°C per Wm^{-2} (about 3˚C for a doubling of CO_2) is used. See endnote 5 for a definition of radiative forcing. Includes effect of carbon dioxide, methane, nitrous oxide and sulfate aerosols. This and subsequent graphs were created using emissions from WRI (2007), Houghton (2003), Ramankutty and Foley (1999), Stern and Kaufman (1998), Olivier and Berdowski (1998) and Smith *et al.* (2004), with projected emissions from IPCC (2000) and lifetime and forcing equations from Hansen (2007), IPCC (2001), and IPCC (1997)

Figure 1.
Responsibility for warming commitment by region for the IPCC B2 scenario

However, reducing emissions in developed nations will require a substantial and expensive restructuring of the energy infrastructure, a program that governments are understandably reluctant to undertake without a meaningful commitment from the big emitters among developing nations that they will join in the effort to keep global warming constrained to some agreed level. To effectively prevent dangerous climate change, the next climate agreement must cover all major emitters and so must effectively broker a compromise between the interests and responsibilities of developed and developing nations.

Greenhouse warming: a multi-gas problem

Adequately addressing climate change will require confronting all aspects of the problem. International attention has so far focused primarily on CO_2 emissions from fossil fuels because CO_2 is the single most important greenhouse gas, one of the longest-lived, and is most closely linked with economic development and so is seen to pose the most intractable problem. Large reserves of fossil carbon (particularly coal), which will likely be used to support future economic development in the absence of emissions caps, mean that a large part of the projected increment in greenhouse warming between 2000 and 2100 results from energy-related CO_2 emissions.

These reasons justify early and strong control of CO_2 emissions, but nevertheless, CO_2 accounts for only around half of the current positive forcing from greenhouse gases[3] (IPCC, 2007a), and at least a fifth of this CO_2 forcing is attributable to land-use change and deforestation rather than fossil fuel burning. Other important greenhouse gases include methane, nitrous oxide, the halocarbons, soot, and tropospheric ozone.

As can be seen from Table I, radiative forcing from anthropogenic emissions of methane amounts to more than half the forcing from CO_2 emissions. Similarly, the warming influence of black carbon (soot) emissions appears to be large, especially if the albedo effect of soot deposition on snow, glaciers and ice is accounted for. Models used by the IPCC estimate warming from soot at 0.44 Wm^{-2} (IPCC, 2007a), but a more recent review by Ramanathan and Carmichael (2008) that includes observational evidence suggests that it could be as high as 0.9 Wm^{-2}. Tropospheric ozone, a product of the emission of several of the gases in Table I, also has a significant positive influence on radiative forcing. Half of the forcing attributable to CO and volatile organic compound (VOC) emissions, and almost a quarter of the warming from methane emissions comes from the effect these gases have of increasing tropospheric ozone concentration. Under baseline scenarios this effect is likely to persist in coming decades – one study found that changing levels of short-lived, radiatively active particles would likely account for 20 per cent of the globally-averaged warming in 2050 (CCSP, 2008).

Crucially, as indicated in Table I, several of these greenhouse gases (i.e. methane, soot, and tropospheric ozone) have relatively short atmospheric lifetimes. Unlike carbon dioxide, which once in the atmosphere creates a radiative perturbation that will

Agent emitted	Net change in radiative forcing in 2005 due to emissions 1750-2005 (Wm^{-2})	Persistence (lifetime) of perturbation	Primary sources
CO_2	1.56	Centuries-millennia	Fossil fuel burning, deforestation and land use change, cement production
CH_4	0.86	12 years	Landfills, natural gas leakage, agriculture
N_2O	0.14	114 years	Fertilizer use, livestock sector, fossil fuel combustion
CFC/HCFC	0.28	100-1,000 years	Aerosols, cleaning products and refrigerants
CO/VOC (O_3precursors)	0.27	CO – months; VOC – hours; (O_3 – days)	CO – incomplete fossil fuel combustion; VOCs – petroleum production and consumption, solvents
Black carbon	0.44-0.9	One week	Fossil fuel combustion, biomass burning

Note: VOC – volatile organic compounds
Sources: IPCC (2007a, p. 33, 207) and new results from Ramanathan and Carmichael (2008)

Table I.
Change in radiative forcing from 1750 to 2005 due to emission of various agents

persist for centuries, these pollutants are removed far more rapidly. This means that reducing these emissions will have a near-immediate effect on the atmospheric concentration of these gases, and so, by extension, on climate forcing. This characteristic can be utilized in planning a successful climate stabilization strategy.

Figure 2 shows the breakdown, by gas and period of emission, of radiative forcing at various points in the twenty-first under the B2 emissions scenario. The green bars show the forcing effects from gases that have yet to be emitted – in other words, the portion of forcing that can be altered by emission reduction strategies put in place in the near future. Because of its relatively short lifetime, strict control of methane emissions between 2000 and 2050 could, in theory, entirely eliminate the warming effect of this gas. Soot and ozone are not shown in Figure 2, but control of the contributing emissions would result in a similarly rapid decrease in forcing. Carbon dioxide, on the other hand has a far longer atmospheric lifetime, so a similar degree of control would result in a reduction in radiative forcing of only 38 per cent by 2050.

Problematically, reducing emissions of CO_2 today will only slow or halt the rate of increase in concentration over the next few decades and so offers little opportunity to actually reduce the amount of committed warming. Since the world already has a level of greenhouse gas concentrations that take it perilously close to the 2-2.5°C threshold likely to lead to dangerous climate change, and in that the world community shows little sign of reining in the growth in fossil fuel emissions, concentrating some near-term attention specifically on the short-lived pollutants can provide a valuable climatic "breathing space" while nations work to develop and deploy technologies that will bring fossil-fuel CO_2 emissions to near zero, as must happen over the next century if climate is to be stabilized.

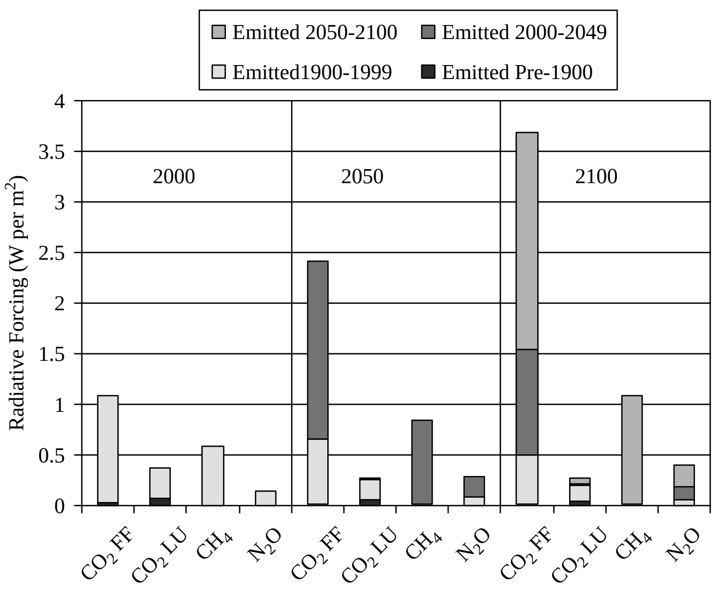


Figure 2. Radiative forcing under the B2 emissions scenario from carbon dioxide from fossil fuel burning (CO_2 FF) and land use change (CO_2 LU), methane (CH_4), and nitrous oxide (N_2O). Colors correspond to the date of emission

Proposed architecture for the post-2012 agreement

The fundamental objective of the next agreement should be to limit the maximum commitment to future warming to no more than 2-2.5°C above pre-industrial temperature. This upper limit represents the recent crystallization of scientific understanding around the idea that a warming above this level would likely cause large areas of the Greenland ice sheet to melt, would put the West Antarctic ice sheet at substantial risk, and would cause widespread disruption to global ecosystems and the hydrologic cycle (SEG, 2007; IPCC, 2007b; MacCracken, 2008a).

The 2-2.5°C limit corresponds to a net radiative forcing in the atmosphere of between 2.5 and 3.1 $\mathrm{Wm^{-2}}$ above pre-industrial, although uncertainty over the climate sensitivity parameter means this value could be somewhat higher or lower[4]. This compares to a current net forcing of 1.6 $\mathrm{Wm^{-2}}$ above pre-industrial, a combination of a positive forcing of 3.2 $\mathrm{Wm^{-2}}$ from increased greenhouse gas concentrations, and a negative forcing of 1.6 $\mathrm{Wm^{-2}}$ from the estimated cooling influence of sulfate aerosols (IPCC, 2007a)[5]. It will be important that temperature and forcing limits of acceptable climate change are defined in a future climate agreement in order to provide direction to the process of negotiating long-term, global emissions limits.

The architecture proposed in this paper for the needed post-Kyoto agreement is based on the existing cap-and-trade framework, with expanded membership, deeper emissions cuts, and a longer commitment term. As in the Kyoto framework, national responsibilities for emissions reduction are differentiated based on per-capita GDP, but cuts in the emissions of short-lifetime pollutants are leveraged to take advantage of the timely and cost-effective mitigation options offered by control of these greenhouse gases, and to catalyze the participation of key middle-income countries in a way that, we suggest, should be acceptable to both middle- and high-income nations (see MacCracken, 2008b for a succinct summary of proposal commitments).

Nations would be grouped into three categories, replacing the present system of Annex 1 (generally referred to as developed nations) and Annex II (generally referred to as developing nations). This reflects the large variation in economic development that exists in the Annex II group. The following threshold values are suggested as category definitions, roughly following World Bank (2008) groupings of low- and lower-middle-income, upper-middle-income, and high-income nations:

(1) high-income nations, having a per capita GDP of more than $10,000 in 2005;

(2) middle-income nations, having a per capita GDP of between $3,000 and 10,000; and

(3) low-income nations, having a per capita income of less than $3,000.

Graduation between groups would be based on both these economic thresholds, and on additional per-capita emissions thresholds that could be defined as part of the negotiations.

The responsibilities for emissions limitations[6] would vary by category and time, such that:

(1) High-income nations, because of their historic contribution to the present level of greenhouse gas concentration, their generally high per-capita emissions, and their greater economic capacity, would assume responsibility for the largest emission reductions in the near-term, committing to steep cuts in emissions of all

greenhouse gases. Net emissions (so allowing credit for documented biologic or geologic sequestration) need to be roughly 80 per cent below year 2000 emissions by 2050, a level consistent with the recommendation of the Stern (2007) report. While a fraction of these cutbacks could be accomplished by financing emissions reductions in middle and low-income nations, part of the burden of high-income nations is to demonstrate that a high-income society can function with a very low level of emissions; otherwise, there is no practical or moral basis for expecting action by others. Because of this, purchasing of emissions credits from low- and middle-income countries should be capped at perhaps 10-15 per cent of emission reduction commitment. Beyond 2050, it is likely that further emissions cuts on the order of 50 per cent will be required to keep warming below the threshold level, but this time frame will likely be beyond the scope of the post-Kyoto agreement.

(2) Middle-income nations, including major emitters such as China, India, Indonesia, and Brazil, that are presently responsible for the rapid growth in annual global emissions, will be critical to the success of the climate-stabilization effort. These nations would have a two-part commitment:

- The first part would be binding commitments to sharp reductions (on the order of 80 per cent by 2050) in emissions of CH_4, soot, and the pollutants that contribute to formation of tropospheric ozone. These commitments are key to the lifetime-leveraging strategy, as they will cause early and substantial reductions in radiative forcing but can be done at relatively low cost and will have substantial benefits beyond climate mitigation (Ramanathan and Carmichael, 2008; CCSP, 2008; Tol *et al.*, 2003). For example, many cities in the developing world suffer from air pollution problems that could be partially alleviated by reducing soot and ozone concentrations. Such measures would be consistent with Millennium Development Goals and could be politically acceptable to governments and people in middle-income countries. Other actions such as capturing methane from landfills or pipelines, and improving combustion efficiency to reduce soot emissions are efficiency measures that can have a relatively short payback time. Action on these "low-hanging fruit" commitments, which nevertheless have substantial climate benefits, would help to persuade hesitant high-income countries that the key middle-income nations are serious about participating in the global fight against climate change.
- The second part of the commitment would be sectoral intensity targets for fossil fuel emissions, in place of an absolute cap. Nations in this category would agree to adopt targets that would steadily improve the carbon-intensity of energy-intensive industries such as aluminum, paper, cement, steel, petrochemicals, and glass, ultimately aiming toward the highest industry standards. These improvements will likely have positive impacts on competitiveness, especially if global energy prices continue to increase, and several governments, notably China, already have energy-intensity targets in place (Pew Center on Global Climate Change, 2007).

(3) Low-income nations would have the least restrictive commitments. They would have no absolute cap on emissions but would adopt aspirational targets consistent with sustainable development and the Millennium Development Goals. These could include reducing soot from burning traditional biofuels

(generating substantial public health improvements) as well as targets for avoided deforestation. Nations that join the agreement by setting and working toward such targets would benefit from participation in the global carbon market through a certified emissions reduction program similar to the current clean development mechanism (CDM).

As countries develop economically, they would, over time, "graduate" into the stricter emission-reduction regimes. For example, a low-income country under this proposal would agree to cap and reduce short-lifetime emissions (at a moderate rate of approximately 1 per cent per year) once it passed the threshold per-capita GDP definition of a middle-income nation. Similarly, middle-income countries would agree to reduce their long-lived greenhouse gas emissions at a comparable rate once their per-capita GDP was high enough to qualify.

In order to incentivize low-carbon development and to improve the equity of the proposal, we suggest that there be double graduation thresholds: one based on per-capita GDP and one on per-capita emissions. A country would have to pass both before entering the more restrictive regime. This would provide some incentive for a country to follow a low-carbon development path because such a low-emission country would be able to delay increased regulation beyond the per-capita GDP threshold.

Maintaining equity while reducing greenhouse gas emissions

At the heart of the current climate impasse is a recognition that, since the start of the Industrial Revolution, the developed nations have used the abundant and inexpensive energy from fossil fuels to power their economic development, and in doing so have caused the lion's share of the current climate problem. At the same time, a scenario in which the rest of the world achieved the OECD-level of current per-capita emissions (Marland *et al.*, 2007) before reducing them would be disastrous for the climate, resulting in a temperature increase far in excess of the 2-2.5°C threshold of dangerous climate change. In this context, any agreement that effectively prevents climate change by restricting the emissions of middle- and low-income countries might be considered "unfair" to the developing world because it will impose a constraint on development, for a global good, that richer nations did not face. To responsibly address this concern, it is important that equity considerations are at the heart of the post-Kyoto agreement. Having an architecture that is widely regarded as "fair" (i.e. one that is consistent with certain fundamental and widely-held equity principles) is not simply desirable, it is a basic prerequisite if the agreement stands any chance of being agreed to by the governments and public of negotiating countries.

The most commonly cited principles of equity in discussions of climate mitigation include the responsibility to mitigate (those with largest emissions mitigate the most) and the capacity to mitigate (those with the most resources mitigate the most) (Lange *et al.*, 2007). Because of the historic link between fossil-fuel use and economic growth, these two measures are somewhat correlated (richer countries tend to have higher per-capita emissions) but this link is not absolute. By linking the graduation thresholds that separate countries with increasingly-restrictive emission-reduction requirements to both per-capita emissions (a measure of responsibility) and per-capita GDP (a measure of capacity), these two equity considerations are explicitly incorporated into this proposal. Even though countries in each class are not further differentiated on the basis of responsibility or capacity (each member has to reduce the same proportion of emissions), the transparency of this basic system is preferable to a more complex emission-reduction formula that would be liable to manipulation and dilution.

Additional equity in this proposed agreement comes from assigning primary responsibility for the early reductions in long-lived greenhouse gas emissions, particularly fossil-fuel CO_2 emissions to the high-income nations. The dominance of energy-related CO_2 emissions in policy discussion reflects an acknowledgement that this issue is both critical to limiting long-term climate change and is the most difficult to solve. This proposal would shift the burden for early reductions in these emissions (which do need to happen if climate change is to be contained to an acceptable level) as much as possible onto the high-income nations. These countries would be responsible for the basic development and deployment of low-carbon energy sources and would bear the burden of demonstrating how economically-developed societies could exist with very low per-capita carbon emissions.

In contrast, middle-income countries would initially participate in the global climate agreement by controlling only the short-lived greenhouse gases, reductions of which tend to have ancillary benefits, and to be more cost-effective. Additionally, most of these emission-reductions can be achieved using technology that already exists. These nations would only tackle more challenging CO_2 reductions later on, once the technology is better established and, presumably, less expensive.

Promoting cost effectiveness

In combination with equity, cost effectiveness will be a crucial test for evaluating a climate agreement architecture. While it is perfectly possible that a non-cost-effective architecture could be negotiated, effective implementation and compliance, already a problem with the Kyoto Protocol, will be even more unlikely if costs are significantly higher than they could be. Including mechanisms to improve the cost effectiveness of the agreement will also likely improve the chances of the agreement being attractive to the governments of high-income nations, which will bear a large fraction of the initial costs of climate mitigation.

True cost effectiveness requires that the marginal cost of emissions abatement be equalized across all countries, industries, and gases. This can be achieved either through a wide-reaching cap and trade system, or by implementing a universal carbon tax. Cost effectiveness also requires that abatement of different greenhouse gases be interchangeable, achieved in the current agreement by comparing regulated gases through conversion to CO_2-equivalents using the 100-year global warming potential (GWP).

In this proposed lifetime-leveraging architecture, however, reductions in emissions of short-lived gases are explicitly specified as a way of actually reducing radiative forcing. The short atmospheric lifetime of some of these pollutants (particularly soot and tropospheric ozone) as well as their complex chemistry means that they are fundamentally different from, and so not readily exchangeable with, the long-lived greenhouse gases such as CO_2.

To the extent that there will not be a single, universal abatement price, the approach suggested here will not be absolutely cost-effective. However, good evidence already exists that reducing soot and ozone concentrations will be some of the least expensive ways of limiting global warming. Both of these are air pollutants and are already regulated in developed countries because of their impacts on human health and natural systems. The technology to reduce concentrations of these pollutants already exists and has been deployed in rich countries, so transfer to other parts of the world should be relatively inexpensive. Additional benefits from reducing mortality and morbidity from air pollution make it likely that these measures would have a negative net cost. For example, Ramanathan and Carmichael (2008) estimate that simply replacing biofuel cooking in South and East Asia with clean technologies would reduce black carbon heating in the regions by 75 and 30 per cent, respectively, and would dramatically reduce the hundreds of thousands of annual deaths and respiratory illness from indoor air pollution.

Because of the importance of this issue, two key aspects of cost-effectiveness, emissions trading and clean development are discussed more fully in the following sections.

Emissions trading

Under the Kyoto Protocol, all regulated gases can be traded interchangeably by conversion to CO_2-equivalents using the 100-year GWP (UNFCCC Decision 18, COP 7). The CO_2-equivalent of a given gas takes into account both the degree to which different molecules intensify the greenhouse effect, and the relative lifetimes of each gas. For example, out to 20 years after emission, a unit mass of atmospheric CH_4 is 72 times as effective at trapping heat as a comparable mass of CO_2; however, because the injected CH_4 is removed much more rapidly than the CO_2, the equivalency drops to only 25 when considering the cumulative effects over 100 years (IPCC, 2007a).

Several studies (Reilly *et al.*, 1999; Manne and Richels, 2000) have documented the limitations of comparing gases using only the CO_2-equivalent metric, noting that it particularly tends to undervalue the contribution of methane over the timescales of interest. For example, Reilly *et al.* (1999) compared two scenarios in which emissions were reduced by the same amount of CO_2-equivalents, in one case using only CO_2 and in the other using the cost-effective mix of Kyoto gases. When emissions cuts were substantial, they found the multi-gas approach produced a temperature rise in 2100 less than half of the supposedly-equivalent, CO_2-only approach.

Essentially, equating gases based on the 100-year GWP significantly reduces the value of reductions in the emissions of methane because its atmospheric lifetime is only 12 years (IPCC, 2007a). However, because this rapid removal means cuts in emissions can lead to an early decrease in the global warming influence, we suggest that methane-reduction is in fact more valuable than indicated by the CO_2-equivalent (100-year GWP) calculation, precisely because of its relatively short lifetime.

Applying this principal generally, it is clear that emission reductions of short- and long-lived greenhouse gases (or aerosols) are not truly interchangeable; control of the former reduces the stock of gas in the atmosphere, while control of the latter prevents an increase in the stock over the timescales of interest. In a world where preventing dangerous climate change looks set to become increasingly urgent and increasingly difficult, this difference cannot be overlooked.

The authors propose that emissions trading be limited to the greenhouse gases with lifetimes of centuries or longer (CO_2, HFCs, N_2O etc) for which the CO_2-equivalent metric produces a good approximation of the relative warming influences over the timescales of policy interest. In the interests of cost-effectiveness, we suggest that methane could also be traded with longer-lived gases but conversion should be based on the 20-year GWP, which better captures the value of the rapid reduction in radiative forcing that methane emission reduction produces. The complicated chemistry, localized distribution, and difficulty of ensuring a permanent reduction of the very short-lived pollutants (specifically tropospheric ozone and soot) means that they are generally unsuited to an international trading program[7].

While it is true that international trading of permits can lead to more cost-effective outcomes, limits do need to be imposed on the extent of trading. The authors propose that emission reduction requirements for countries in a given income category be traded freely between other countries in that group, but that there be a limit of 15 per cent of the reduction requirements that can be met using certified emission reduction credits from countries with less strict regulation (equivalent to the CDM under the current regime). This is because it is essential that there be a strong push from high-income nations to develop the technologies that will allow them, and eventually all nations, to sharply reduce their emissions over the next few decades, and also because of the problems with additionality that have been identified with the CDM as it currently stands.

Supporting clean development

Because this proposed framework encourages the participation of low- and middle-income countries by not imposing caps on the long-lived greenhouse gas emissions in the near-term, the mechanisms to support clean development will need to be particularly strong and effective. CDM financing will need to increase substantially, which will to some degree occur naturally as the carbon market expands and the accreditation process is streamlined. In addition, given the importance of robust certification measures of emission reductions, particularly for the large, rapidly-developing middle-income countries, the CDM process for these nations should be reformed so as to remove current perverse incentives for the countries and industries that stand to profit from it, and to provide real baselines, rather than the current hypothetical, and hence ultimately unverifiable baselines.

The CDM for middle-income countries would be reformed to move away from the project-by-project approach and toward national accounting measures for these middle-income countries. Participating countries would agree on a national baseline for business-as-usual emissions for any greenhouse gases that are not capped under the agreement. Reductions below this baseline would be credited and could be sold to regulated countries to satisfy their emission-reduction goals, or could be banked by developing countries themselves against future reduction requirements once they pass the threshold level of per-capita GDP and per-capita emissions. This system, where credits are issued based on relation to a hypothetical but given baseline would ensure the credits represent a real and quantifiable reduction in emissions.

Negotiating the business-as-usual baseline will undoubtedly be difficult: the baseline will need to be at once high enough to persuade developing countries to aim for an emissions pathway below that level, and yet low enough that global emissions collectively do not exceed 2.5°C of warming. Critically, however, this baseline could be used to incentivize the participation of important middle-income countries: a baseline higher than the projected business-as-usual essentially amounts to giving away valuable carbon-credits. While clearly not ideal environmentally, this tool could theoretically be used to encourage participation of certain large-emitters whose non-participation would threaten the entire agreement process.

This modified CDM could provide some financial incentive for a country to follow a lower-carbon development pathway, but other mechanisms could help to facilitate this. CDM trading should be closely tied to technology transfer, so that the process results not just in the development of carbon credits, but in increased capacity in the host country that could generate further reductions. One way of doing this is to have a premium on those carbon credits that are tied to verified capacity building and technology transfer in the receiving country. Credit value would be generated not only for the emissions they help reduce, but for also the positive domino effect of technology transfer in further emission reductions.

In addition, improvements in sectoral efficiency for energy-intensive industries will be an important part of the middle-income countries' climate commitment. This should improve the environmental effectiveness and substantially lower the overall cost of the agreement by avoiding a widescale deployment of inefficient technology that would have to be removed and replaced once CO_2 emissions begin to be regulated. Many of the key middle-income countries already have domestic policies that mandate just such efficiency improvements. The Chinese Government, for example, in its 11th five-year plan (2006-2010), has set a national target for improving energy intensity by 20 per cent by 2010 (Pew Center on Global Climate Change, 2007). In India, the Bureau of Energy Efficiency (2008) was established in March 2002 as a statutory body under the Indian Ministry of Power to coordinate energy efficiency measures and reduce the energy intensity of India's economy.

While the existing CDM does have several problems, the advantage of a project-based approach is that it does not rely on the central government for inventorying emissions or for the implementation of national emissions-control policy. Since many of the LDCs lack the institutional capacity to comprehensively monitor and control emissions, the traditional, project-based CDM could be continued in the low-income countries that become party to the post-Kyoto agreement. This would allow these nations access to the carbon-trading mechanism but would likely only have a limited adverse climatic effect relative to the national baseline approach; to date only 280 out of 3,250 CDM projects have taken place in the least-developed countries (UNEP, 2008).

Incentives for participation and compliance

Mechanisms for encouraging participation (countries to sign the agreement) and compliance (countries to implement what they agree to under the agreement once signed) are major weaknesses of many proposed climate agreements (Aldy *et al.*, 2003). This is at least partly because the agreement will be between sovereign nation states and so these methods are inherently limited. To some degree, participation and compliance will need to be motivated by the desire to limit climate change. But, as many have noted, this is unlikely to be enough incentive for major middle-income emitters to join an ambitions climate agreement, and might not be enough to keep countries sticking to difficult and costly emission-reduction measures, even though committed to under and international agreement.

Part of the advantage of the lifetime-leveraging strategy is the fact that the early commitments from middle-income countries are related to measures that would likely be undertaken anyway as part of a development strategy. These include reducing air pollution, and improving combustion efficiency. This should ideally make participation more attractive to middle-income nations and, to a limited degree, reduce the extent of specific participation incentives needed to bring these key countries on board.

The most important specific measure in the proposed agreement that would encourage participation by low- and middle-income countries is the certified emissions reduction program. With the carbon market expected to grow to $3.1 trillion by 2020 (Point Carbon, 2008), and potentially substantially larger under a stronger post-2012 agreement, revenues from the CDM-type program will probably be substantial, even if it is responsible for a maximum of 10-15 per cent of emissions reductions. As suggested above, national baselines for key middle-income nations could be negotiated on a country-by-country basis as a way of incentivizing participation. In addition, any adaptation funding, either from specific pledges from OECD countries, or from a tax on traded emissions, could be made contingent on participation in the international agreement.

Encouraging compliance could be even more difficult than encouraging participation. Countries should have short-term (five years or so) targets to meet, which could steepen over the course of the agreement, in order to ensure they are on their way to achieving the long-term emissions reduction plan set out in the agreement. These targets could be used to evaluate whether or not a country is in compliance. Countries consistently out of compliance could become vulnerable to tariffs (scaled based on carbon-intensity) on energy-intensive imports, at the discretion of in-compliance, signatory countries. The authors believe that trade measures, which are now widely discussed as one of the only ways of imposing climate externalities beyond national borders and which were incorporated into the Lieberman-Warner Climate Security Act, are better used to address compliance issues rather than participation issues. Used this way, they stand a better likelihood of being WTO-compliant (Tarasofsky, 2008; World Bank, 2007) and of being generally perceived as fair.

Can lifetime-leveraging prevent dangerous climate change?

Preliminary analysis indicates that with ambitious (but very likely achievable) reductions in emissions, the lifetime-leveraging architecture described above can limit the increase in radiative forcing enough to prevent warming of more than 2-2.5°C. In carrying out this evaluation, we developed a relatively simple pulse-response model to calculate the time history of radiative forcing under various emissions scenarios based on the lifetime-leveraging approach[8].

For example, total warming commitment could be constrained to less than 2.5°C if the OECD countries undertook an ambitious target of reducing all greenhouse gas emissions 80 per cent by 2050 and a further 50 per cent by 2100, and middle-income countries undertook the same targets for the short-lived greenhouse gases. If these middle-income countries develop relatively efficiently under the intermediate B2 growth path (IPCC, 2000) and begin reducing long-lived greenhouse gas emissions by 1 per cent per year once they reach $10,000 per-capita GDP then, assuming an intermediate climate sensitivity of 0.8°C/Wm^{-2} (close to 3°C for a doubling of CO_2), warming should peak at less than 2.5°C above pre-industrial temperatures[9].

Figure 3 shows the fossil-fuel-related carbon emission pathway, per-capita emission pathway, and annual emission reductions below baseline for the four modeled world regions under this scenario. Although the developing regions of Asia, Africa and Latin America are responsible for the largest below-baseline reductions (Figure 3(c)), these do not begin until fairly late in the twenty-first century, and are therefore likely to be less costly than the earlier reductions undertaken by the OECD. Asia (as an average region) does not begin reducing CO_2 emissions until almost 2050, and the other developing regions until 2065. These regions will thus likely benefit from the technologies and experience developed by the OECD countries during their earlier emissions reduction. Per-capita emissions for all regions are converging toward equal values by 2100 (Figure 3(b)), and could be stabilized at the same amount in the early part of the twenty-second century.

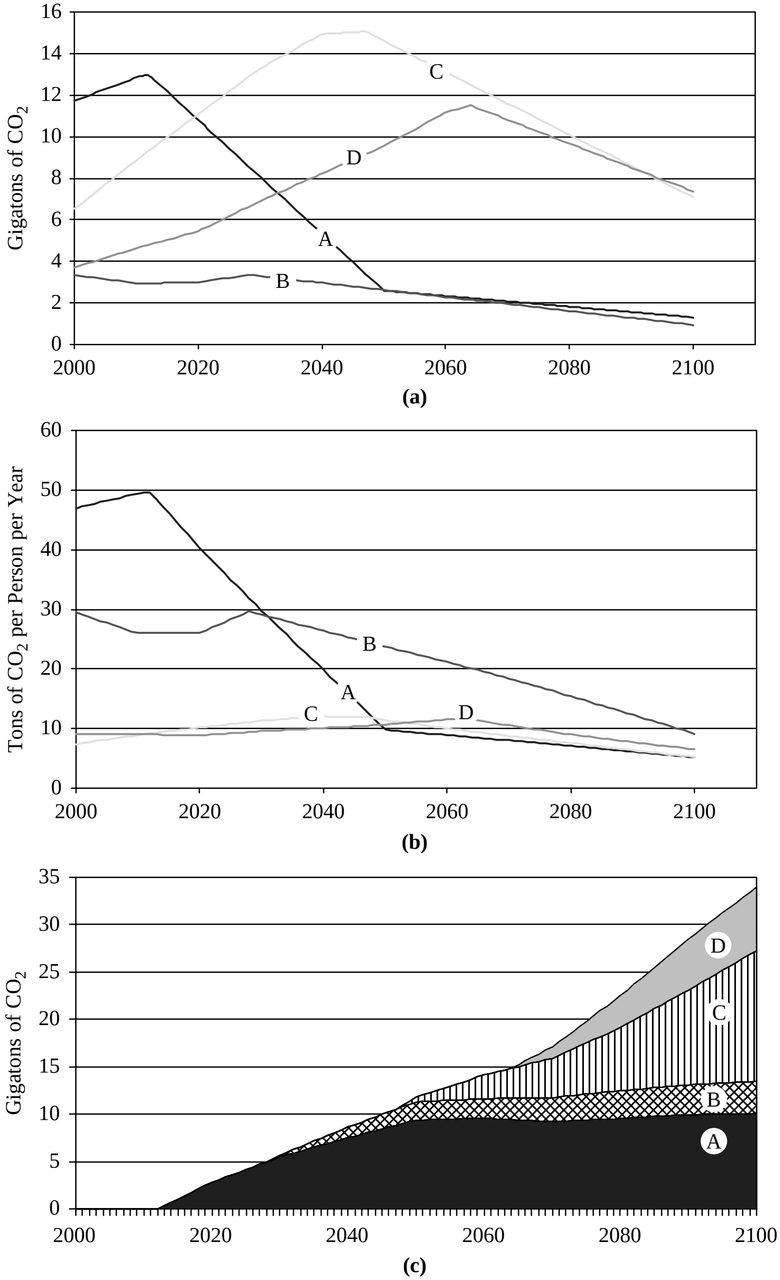
This modeling result admittedly does not take into account the effects of emissions leakage, whereby fossil-fuel intensive industries move from a regulated region to a non-regulated region to avoid the cost of compliance. A recent study of the effects of existing energy efficiency and emission-reduction measures on energy-intensive industries found that evidence for emissions leakage to date is equivocal at best (World Bank, 2007). Nevertheless, emissions-control regulations have so far been fairly lenient compared to what they will likely have to be in the future, and it could still be that emissions leakage would substantially reduce the efficacy of any agreement that did not impose caps on the emissions of all countries.

The structure of the proposed agreement, however, in which emissions reduction requirements are tied to GDP thresholds, could provide a negative feedback that would limit the impact of emissions leakage. The relocation of energy-intensive industry to developing countries constitutes economic development that will raise the GDP of the host nation, meaning that the threshold income level at which fossil-fuel emission regulation begins will be reached sooner than in the baseline scenario. A simple spreadsheet model used to estimate the strength of this feedback effect suggests that even if up to 50 per cent of "cut" emissions were to leak to non-regulated regions, cumulative emissions over the twenty-first century would increase by only 7 per cent. Since the climatic effect of emissions depends most strongly on the cumulative amount, rather than the timing of emissions (Matthews and Caldeira, 2008), it is unlikely that including the effect of emissions leakage would substantially reduce the climate-stabilizing benefits of the lifetime-leveraging architecture.

Summary and conclusion

Over the last decade, as the rate of climate change has accelerated, many natural systems, including the Arctic sea ice, the Antarctic ice shelves, and the Greenland ice sheet, have surprised scientists with the speed of their response to warming. The effects of climate change have been detected in ecosystems on every continent (Rosenzweig, 2008) and, given the inertia in the system and the possibility of substantial carbon-cycle feedbacks, it is becoming increasingly difficult to argue that the world is not already close to a degree of climate change that could generally be considered dangerous, if not catastrophic (SEG, 2007).

Given this context, the post-Kyoto climate agreement will be critical in determining the climatic burden that we place on future generations. The lifetime-leveraging architecture proposed in this paper has the double benefit of using the



Notes: Ⓐ– OECD, Ⓑ– former Soviet Union, Ⓒ– Asia, Ⓓ– Africa, Latin America and Middle East
Source: Baseline emissions from IPCC (2000)

Figure 3.
(a) Annual emissions of CO_2 from fossil fuel burning for four world regions under the proposed emissions reduction scenario; (b) per-capita emissions of CO_2 from fossil fuel burning for four world regions under the proposed emissions reduction scenario; (c) below-baseline (B2) reductions in CO_2 emissions from fossil fuel burning for four world regions under the proposed emissions reduction scenario

often-overlooked, short-lived greenhouse gases to both substantially decrease radiative-forcing ("buying time" to fully get to grips with more intractable CO_2 emissions), and to overcome the negotiations deadlock between high- and middle-income countries.

Reductions in the atmospheric burdens of tropospheric ozone, methane and soot represent an opportunity to significantly reduce the human-induced radiative forcing that is causing global warming. Moreover, much of the reduction in these emissions can be done at little cost, and in a way that is consistent with the broad development strategy of middle-income nations. In fact, the benefits of reducing soot and ozone concentration in term of improved public health will likely be larger than the benefits of mitigated climate change. This targeting of short-lived pollutants, combined with aggressive cuts in emissions from high-income countries, aspirational goals and CDM-participation from low-income countries, and improvements in energy intensity to slow the growth of energy-related CO_2 emissions in middle-income countries, should be enough limit peak temperature increase to less than 2-2.5°C above pre-industrial temperatures. If this can be done, and the radiative forcing then be gradually reduced from the peak levels in following decades, the objective of the UNFCCC, namely to avoid "dangerous anthropogenic interference with the climate", may be achieved.

Notes

1. All temperature increases in this proposal are given as the warming above the preindustrial baseline, even if this is not mentioned each time.
2. Calculated using radiative forcing given by the IPCC (2007a, p. 204) and assuming a climate sensitivity of 0.8°C/Wm^{-2} (approximately 3°C for a doubling of CO_2).
3. Radiative forcing is a useful measure for directly comparing diverse factors that affect the Earth's climate. Measured in Watts per meter squared (Wm^{-2}), the value describes the equivalent change in net solar irradiance at the tropopause (top of the troposphere) caused by a given climate driver (for example, an increase in greenhouse gas concentration or a change in albedo).
4. Note that, because it takes several decades for the global temperature to equilibrate with a change in radiative forcing, breaching the forcing threshold will not immediately lead to breaching of the temperature threshold. Rather the threshold is a stabilization target, indicating that the value should not be exceeded for a substantial length of time (more than a decade or so).
5. In the longer-term, the world should aim for stabilization at a maximum (and ideally well below) 3.1 Wm^{-2} of positive forcing (rather than net forcing), which would likely require the removal of some long-lived greenhouse gases from the atmosphere. Exceeding the forcing threshold with long-lived greenhouse gases and then relying on the cooling effect of short-lived sulfates places an indefinite burden on future generations, requiring them to either continue emissions of sulfates that might otherwise be controlled to improve public health, or to launch a geoengineering project to otherwise sustain their cooling effect.
6. Because emissions of halocarbons are covered under the Montreal Protocol and subsequent conventions, their limitation is not considered here. It is instead assumed that limitations in halocarbon emissions will be aggressively pursued under that agreement (Velders *et al.*, 2007).
7. For example, ozone is not emitted directly, but is formed from the reaction of NO_x and volatile organic compounds. Soot is distributed extremely heterogeneously in the atmosphere and the effect of emissions reductions on atmospheric warming depends

partly on the ambient black carbon concentration and on the underlying surface albedo, hence differs from region to region, making international trading of emissions reductions problematic.

8. The model used is a simple four region Excel model that accounts for emissions of CO_2 from fossil fuel burning and deforestation, CH_4, N_2O, and the direct and indirect effects of sulfate. Past emissions are assembled with datasets from WRI (2007), Houghton (2003), Ramankutty and Foley (1999), Stern and Kaufman (1998), Olivier and Berdowski (2001) and Smith *et al.* (2004), with projected emissions from IPCC (2000) and lifetime and forcing equations from Hansen *et al.* (2007) and IPCC (2001, 1997). The complicated chemistry and spatial heterogeneity of tropospheric ozone and soot make them too difficult to include in such a simple model so reductions in radiative forcing will in fact be larger than suggested above under the proposed scenario; for an indication of the likely magnitude of these effects, see CCSP (2008).
9. Although the B2 scenario is intermediate in the suite of SRES storylines, the growth in emissions since 2000 has exceeded the high-end A1FI scenario (Canadell *et al.*, 2007). However, the B2 storyline might be roughly consistent with developing countries undertaking commitments to improve energy efficiency, as proposed above.

References

Aldy, J.E., Barrett, S. and Stavins, R.N. (2003), "Thirteen plus one: a comparison of global climate policy architectures", FEEM working paper, Vol. 64, July.

Baer, P. and Athanasiou, T. (2007), "Frameworks and proposals: a brief, adequacy and equity-based evaluation of some prominent climate policy frameworks and proposals", *Global Issues Papers*, Vol. 30.

BP (2007), *Statistical Review of World Energy 2007*, British Petroleum – BP, London.

Bureau of Energy Efficiency (2008), *About Us*, Bureau of Energy Efficiency, New Delhi, available at: www.bee-india.nic.in (accessed 21 June 2008).

Canadell, J.G., Pataki, D. and Pitelka, L. (2007), "Contributions to accelerating atmospheric CO_2 growth from economic activity, carbon intensity, and efficiency of natural sinks", *Proceedings of the National Academy of Sciences*, Vol. 104 No. 47, pp. 18866-70.

CCSP (2008), "Climate projections based on emissions scenarios for long-lived and short-lived radiatively active gases and aerosols", in Levy, H. II, Shindell, D.T., Gilliland, A., Schwarzkopf, M.D. and Horowitz, L.W. (Eds), *A Report by the US Climate Change Science Program and the Subcommittee on Global Change Research*, Department of Commerce, NOAA's National Climatic Data Center, Washington, DC.

Hansen, J., Sato, M., Ruedy, R., Kharecha, P., Lacis, A. and Miller, R. (2007), "Dangerous human-made interference with climate – a GISS modelE study", *Atmospheric Chemistry and Physics*, Vol. 7, pp. 2287-312.

Houghton, R.A. (2003), "Revised estimates of the annual net flux of carbon to the atmosphere from changes in land use and land management 1850-2000", *Tellus B*, Vol. 2, pp. 378-90.

IPCC (1997), in Houghton, J.T., Kram, A., Makarov, B., Sorensen, B., Yokobori, K. and Zhou, F. (Eds), *Technical Paper II: An Introduction to Simple Climate Models Used in the IPCC Second Assessment Report*, Intergovernmental Panel on Climate Change – IPCC, pp. 41-2.

IPCC (2000), in Nakićenović, N. and Swart, R. (Eds), *Special Report on Emissions Scenarios (SRES)*, Intergovernmental Panel on Climate Change – IPCC, Cambridge University Press, Cambridge.

IPCC (2001), in Houghton, J.T., Ding, Y., Griggs, D., Noguer, M., van der Linden, P. and Xiaosu, D. (Eds), *Climate Change 2001: The Scientific Basis*, Intergovernmental Panel on Climate Change – IPCC, Cambridge University Press, Cambridge, pp. 800-23.

IPCC (2007a), in Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M. and Miller, H.L. (Eds), *Climate Change 2007: The Physical Science Basis*, Intergovernmental Panel on Climate Change – IPCC, Cambridge University Press, Cambridge.

IPCC (2007b), in Parry, M., Canziani, O.F. and Palutikof, J.P. (Eds), *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Intergovernmental Panel on Climate Change – IPCC, Cambridge University Press, Cambridge.

Lange, A., Vogt, C. and Ziegler, A. (2007), "On the importance of equity in international climate policy: an empirical analysis", *Energy Economics*, Vol. 29 No. 3, pp. 545-62.

MacCracken, M.C. (2008a), "Prospects for future climate change and the reasons for early action", *Journal of the Air and Waste Management Association*, Vol. 58, pp. 735-86.

MacCracken, M.C. (2008b), "Prospects for future climate change and the reasons for early action: a summary of the 2008 critical review", *The Magazine for Environmental Management*, June.

Manne, A.S. and Richels, R.G. (2000), "A multi-gas approach to climate policy – with and without GWPs", FEEM Working Paper, No. 44.

Marland, G., Boden, T.A. and Andres, R.J. (2007), "Global, regional, and national fossil fuel CO_2 emissions", *Trends: A Compendium of Data on Global Change*, Oak Ridge National Laboratory, Information Analysis Center, Oak Ridge, TN.

Matthews, H.D. and Caldeira, K. (2008), "Stabilizing climate requires near-zero emissions", *Geophysical Research Letters*, Vol. 35, L04705.

Meinshausen, M. (2006), "What does a 2°C target mean for greenhouse gas concentrations? A brief analysis based on multi-gas emission pathways and several climate sensitivity uncertainty estimates", in Schellnhuber, J.S., Cramer, W., Nakicenovic, N., Wigley, T.M.L. and Yohe, G. (Eds), *Avoiding Dangerous Climate*, Cambridge University Press, New York, NY, pp. 265-79.

Olivier, J.G.J. and Berdowski, J.J.M. (2001), "Global emissions sources and sinks", in Berdowski, J., Guichert, R. and Heij, B.J. (Eds), *The Climate System*, A.A. Balkema and Swets & Zeitlinger Publishers, Lisse, pp. 33-78.

Pew Center on Global Climate Change (2007), "Climate change mitigation measures in the People's Republic of China", available at: www.pewclimate.org

Point Carbon (2008), "Carbon market transactions in 2020: dominated by financials?", *Carbon Market Analyst*, 21 May.

Posner, E.A. and Sunstein, C.R. (2008), "Justice and climate change", Harvard Project on International Climate Agreements, Discussion Paper 08-04.

Ramanathan, V. and Carmichael, G. (2008), "Global and regional changes due to black carbon", *Nature Geoscience*, Vol. 1, pp. 221-7.

Ramankutty, N. and Foley, J. (1999), "Estimating historical changes in global land cover: croplands 1700-1992", *Global Biogeochemical Cycles*, Vol. 13, pp. 997-1027.

Reilly, J., Prinn, R., Harnisch, J., Fitzmaurice, H., Jacoby, H., Kicklighter, D. and Melillo, J. (1999), "Multi-gas assessment of the Kyoto Protocol", *Nature*, Vol. 407, pp. 549-55.

Rosenzweig, C. (2008), "Attributing physical and biological impacts to anthropogenic climate change", *Nature*, Vol. 453, pp. 353-7.

SEG (2007), "Confronting climate change: avoiding the unmanageable and managing the unavoidable", in Bierbaum, R.M., Holdren, J.P., MacCracken, M.C., Moss, R.H. and Raven, P.H. (Eds), *Scientific Expert Group on Climate Change – SEG*, prepared for the United Nations Commission on Sustainable Development by Sigma Xi, Research Triangle Park, NC, and the United Nations Foundation, Washington, DC.

Smith, S.J., Andres, R., Conception, E. and Lurz, J. (2004), "Sulfur dioxide emissions: 1850-2000", JGCRI Report, Pacific Northwest National Laboratories-14537.

Stern, D. and Kaufman, R. (1998), "Annual emissions of global anthropogenic methane: 1860-1994", *Trends Online: A Compendium of Data on Global Change*, CDIAC Oak Ridge National Laboratory, Oak Ridge, TN.

Stern, N. (2007), *The Economics of Climate Change: The Stern Review*, Cambridge University Press, Cambridge.

Sugiyama, T. and Deshun, L. (2004), "Must developing countries commit quantified targets? Time flexibility and equity in climate change mitigations", *Energy Policy*, Vol. 32, pp. 697-704.

Tarasofsky, R.G. (2008), "Heating up international trade law: challenges and opportunities posed by efforts to combat climate change", *Climate Change Law Review*, Vol. 1, pp. 7-17.

Tol, R.S.J., Heintz, R.J. and Lammers, P.E.M. (2003), "Methane emission reduction: an application of FUND", *Climatic Change*, Vol. 57, pp. 71-98.

UNDP (2007), *Human Development Report 2007/2008: Fighting Climate Change*, United Nations Development Programme – UNDP, New York, NY.

UNEP (2008), *CDM Pipeline*, United Nations Environment Programme, New York, NY, available at: cdmpipeline.org/cdm-projects-region.htm#1 (accessed 1 May 2008).

Velders, G.J.M., Andersen, S.O., Daniel, J.S., Fahey, D.W. and McFarland, M. (2007), "The importance of the Montreal Protocol in protecting climate", *Proceedings of the National Academy of Sciences*, Vol. 104, pp. 4814-19.

World Bank (2007), *International Trade and Climate Change: Economic, Legal and Institutional Perspectives*, World Bank, Washington, DC.

World Bank (2008), *World Bank List of Economies*, World Bank, Washington, DC, available at: http://go.worldbank.org/K2CKM78CC0 (accessed 17 October 2008).

WRI (2007), *Carbon Analysis Indicator Tool, Version 3.0*, World Resources Institute – WRI, Washington, DC, available at: cait.wri.org

Further reading

Stephens, B.B., Gurney, K.R. and Tans, P.P. (2007), "Weak northern and strong tropical land carbon uptake from vertical profiles of atmospheric CO_2", *Science*, Vol. 316, pp. 1732-5.

Wigley, T.M.L. (2005), "The climate change commitment", *Science*, Vol. 307, pp. 1766-9.

About the authors

Frances C. Moore is currently a student at the Yale School of Forestry and Environmental Studies, where she is studying the international climate negotiation process. Prior to coming to Yale, Frances worked as a Research Assistant at the Earth Policy Institute and at the Climate Institute, where she researched and wrote about climate change issues. She is co-editor of *Sudden and Disruptive Climate Change: Estimating the Real Risks and How We Can Avoid Them* and holds a BA, *summa cum laude*, in Earth and Planetary Science from Harvard University. Frances C. Moore is the corresponding author and can be contacted at: frances.moore@yale.edu

Michael C. MacCracken is Chief Scientist for Climate Change Programs with the Climate Institute in Washington, DC. He received a BS in Engineering from Princeton University in 1964 and PhD. in Applied Science from the University of California Davis/Livermore in 1968. From 1968-1993, Mike conducted research on climate change and air pollution with the University of California's Lawrence Livermore National Laboratory. From 1993-2002, Mike was detailed as senior global change scientist to the interagency Office of the US Global Change Research Program, serving as the first executive director of the Office from and then as executive director of the USGCRP's National Assessment Coordination Office from 1997-2001. Since 2002, Mike has also served on the synthesis team for the Arctic Climate Impact Assessment (2002-2004), review editor for the North America chapter of the Fourth Assessment Report of IPCC (2005-2007), president (2003-2007) of the International Association of Meteorology and Atmospheric Sciences (IAMAS), and a coordinating lead author on the recent report/Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable/prepared at the request of the UN Commission on Sustainable Development.

Appendix G

CENTER FOR A COMPETITIVE WASTE INDUSTRY
313 PRICE PLACE
MADISON, WI 53705
(608) 231-1100

April 14, 2010

Mr. Leif Hockstad
U.S. Environmental Protection Agency
Climate Change Division (6207J)
1200 Pennsylvania Ave., NW
Washington, DC 20460

Re: 2010 Draft U.S. Greenhouse Gas Inventory Report
Comments by the Center for a Competitive Waste Industry

Dear Mr. Hoskstad:

Thank you for the opportunity to provide comments by the Center for a Competitive Waste Industry on the U.S. Environmental Protection Agency's (EPA) 2010 Draft U.S. Greenhouse Gas Inventory Report (Draft). As someone formerly retained by EPA to review its landfill gas protocols, and someone independent of the landfill industry, we hope that you find the recommendations useful.

In summary, we recommend that the Draft be changed as follows:

(1) *Global warming potential.* Include in the table showing each sector's responsibility for anthropogenic greenhouse gas emissions the applicable value when current instead of obsolete Global Warming Potential multipliers are used.

(2) *Short-term strategies.* Employ a two-pronged strategy that includes a short-term along with the long-term approach in reported inventory values.

(3) *First Order Decay Model.* Replace the First Order Decay Model, which fails to account for internal moisture levels critical for gas generation, with a revised model that does.

Some of the recommendations can be accommodated within the Intergovernmental Panel on Climate Changes' (IPCC) Guidelines,[1] and others may not. For those that may not, nothing in the Guidelines precludes an Annex I signatory to the United Nations Framework Convention on Climate Change (UNFCCC) treaty from providing supplemental information as part of the formal inventory. For the future, inasmuch as EPA's views have guided the development of the IPCC's 1996 and 2006 support documents for landfills, and to the extent that the facts presented are correct and its policies, constructive, the agency can pursue their inclusion in future updates of the Guidelines.

[1] IPCC, *2006 Guidelines for National Greenhouse Gas Inventories* (2006).

I. GENERIC COMMENTS

A. Global Warming Potential

The reported anthropogenic warming impacts from the different greenhouse gases (GHGs) are converted into a common carbon dioxide (CO_2) equivalent basis by the use of Global Warming Potential (GWP) multipliers, which is a set of factors for each GHG. Of import, these factors are not immutable, but rather are periodically updated to comport with the current state of knowledge about such complex factors as indirect effects.

However, even though the Draft tracks Guidelines, it uses GWP factors that were actually published in 1996 (but, in fact, actually estimated several years prior to that publication date), and ignores the last 15 or more years of updated values that reflect what is now known.

According to the Draft, obsolete data was relied upon because:

> "The UNFCCC reporting guidelines for national inventories were updated in 2006, but continue to require the use of GWPs from the IPCC Second Assessment Report (SAR) (IPCC 1996). This requirement ensures that current estimates of aggregate greenhouse gas emissions for 1990 to 2008 are consistent with estimates developed prior to the publication of the IPCC Third Assessment Report (TAR) and the IPCC Fourth Assessment Report (AR4)."[2]

There may be value in having a consistent time series, but there is an even greater value in providing an inventory for 2010 that reflects the current state of knowledge. Otherwise, if a consistent time series were the only consideration reflected in the inventory, decision-makers, who use the inventory to triage priorities for government action, will be presented with obsolete information about the different GHG gases that does not reflect what we now know about how those gases' impact climate.

As a salient example, the GWP for methane is assumed to be 21 times CO_2, which is what was known in the years prior to 1996, almost 20 years ago.

Since then, in AR4 (published in 2007), methane's GWP (on a 100 year basis) was 25 times CO_2,[3] and the most recent information from the National Aeronautics and Space Administration (NASA) is that methane has 34 times the long-term warming impact of CO_2.[4] The reason why this value changes is due to the growing knowledge about the *indirect* impacts of methane on radiative forcing, first in terms of stratospheric water vapor, then tropospheric ozone, and, most recently, mixing with aerosols.

---

2 Draft, at p. ES-3.

3 IPCC, *Fourth Assessment Report*: Chapter 2: Changes in Atmospheric Constituents and in Radiative Forcing (2007), at p. 212. That value, in turn, was several years out of date when FAR was finally published in 2007, and, as indicated next, has now been supplanted.

4 Drew Shindell, "Improved Attribution of Climate Forcing Emissions," 326 SCIENCE 716 (2009).

To use a GWP for methane in 2010 of 21, when the most reliable value today is *62% greater*, has the effect of grossly undercounting the impacts of sources of anthropogenic methane emissions compared to sources of other greenhouse gases. That cannot but gravely distort society's response to a much more serious threat and result in a misapplication of resources to avert climate change, especially in the context of near-term impacts described next.

Therefore, we recommend that the final inventory include the existing table that shows a consistent time series from 1990 to 20008 (as modified by the other comments that follow below) to comport with the Guidelines. But, then the table should include an additional right-hand column showing the 2008 data converted to the current data on GWPs. Nothing in the Guidelines precludes or discourages more accurate supplementation.

There is an enormous value in incorporating the most reliable data into decision-making, and the Draft fails to accord this need its due. If the definition of "authoritative" were somehow to be twisted to mean "hopelessly out-of-date," the practical utility of the entire exercise would be called into in question and resemble nothing so much as "fiddling while the world burns." The difference between 1996's very preliminary state of knowledge then, which was largely ignorant of methane's indirect effects, and today, more than 15 years later, is simply too great to ignore on the grounds of nothing more substantive than bureaucratic inertia.

B. <u>Short Term Climate Impacts</u>

Each GHG has a different residence time in the atmosphere before they decay or are absorbed, from 0.38 years for methylene chloride to 50,000 years for PFC-14, with 12 years for methane.[5] In order to equate each GHG to CO_2, the same residency must be assumed to perform the calculation, even though, in fact, the gases remain airborne for vastly different periods. The current convention for that common denominator is 100 years, which initially was the proxy for CO_2's duration in the atmosphere.[6]

However, global warming does not proceed linearly over time, but rather, accelerated by positive feedback loops, changes in climate can ramp up rapidly and irreversibly in the near term as tipping points are crossed.[7] In response to this implacable reality, a growing body of scientific opinion has more recently urged a two-pronged strategy to address those points of no return. This is not to suggest either ignoring or demoting the long-term consequences. Rather, the recommendation is only to recognize that, in order to sustain the viability of human institutions until that far-off day arrives, we must first insure that quick action is taken to avert crossing key tipping points, after which further remedial action is no longer possible:

> "Policy must evolve and incorporate the emerging science in order to be effective. There is a growing need to create a two-pronged framework capable of

---

5 See NOTE 3, *supra*.

6 *Id*.

7 Timothy M. Lenton, et al., "Tipping elements in the Earth's climate system," 105 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES 6, at pp. 1786-1793.

> not only mitigating long-term climate change but also managing the magnitude and rate of change of near-term R[adiative] F[orcing]. Short-lived pollutants (black carbon and tropospheric ozone) and medium-lived pollutants (methane) account for more than half of the positive RF generated in years 1 to 20."[8]

Once the need for such a two-pronged strategy is understood, then attention quickly turns to methane as the most important GHG for that approach, as Dr. Jackson alludes to in his above statement. According to climate scientists at the National Aeronautics and Space Administration (NASA), the combination of methane's warming potency, and its short lifetime in the atmosphere, plays an especially critical role in the near term when we confront those critical tipping points. Methane's residency is 12 years, and, when measured in the next 20 instead of 100 years, is 105 times as powerful as CO_2:[9]

> "[F]easible reversal of the growth of atmospheric [methane] and other trace gases would provide a vital contribution toward averting dangerous anthropogenic interference with global climate...[Methane] deserves special attention in efforts to stem global warming...Given the difficulty of halting near-term CO_2 growth, the only practical way to avoid [dangerous interference] with climate may be simultaneous efforts to reverse the growth of [methane].[10]

Similarly, Robert Watkins, the co-chair of the IPCC's Third Assessment, recently wrote in the disappointing aftermath of Copenhagen:

> "This month's Copenhagen talks focused on the leading climate change culprit: CO_2. But reversing global temperature increases by reducing carbon emissions will take many decades, if not centuries. Even if the largest cuts in CO_2 contemplated in Copenhagen are implemented, it simply will not reverse the melting of ice already occurring ...The most obvious strategy is to make an all-out effort to reduce emissions of methane. Methane's short life makes it especially interesting in the short run, given the pace of climate change. If we need to suppress temperature quickly in order to preserve glaciers, reducing methane can make an immediate impact. Compared to the massive requirements necessary to reduce CO_2, cutting methane requires only modest investment. Where we stop methane emissions, cooling follows within a decade, not centuries. That could make the difference for many fragile systems on the brink."[11]

---

8 Stacy C. Jackson, "Parallel Pursuit of Near-Term and Long-Term Climate Mitigation," 326 SCIENCE 526 (2009), excerpted from 526-527. See, also, Alissa Kendall, et al., "Accounting for Time-Dependent Effects of Biofuel Life Cycle Greenhouse Gas Emissions Calculations," *Environ. Sci. Techn*. (August 14, 2009), p. 6907.

9 See note 3, supra.

10 James Hansen, "Greenhouse gas growth rates", 101 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES 46 (November 16, 2004), p. 161094.

11 Robert Watson and Mahamed El-Ashry, "A Fast, Cheap Way to Cool the Planet," *The Wall Street Journal* (December 29, 2009).

Indeed, EPA, itself, has long observed methane's critical importance for addressing short term climate impacts:

> "This relatively short lifetime makes methane an excellent candidate for mitigating the impacts of global warming because emission reductions could lead to stabilization or reduction in methane concentrations within 10-20 years."[12]

For these reasons, we strongly urge the Draft to include an additional chapter on short-term impacts (i.e. the next twenty years), along with the 100-year inventory values, and the GWP factors that are applicable to that time frame, along with reference to the greenhouse gases most important to short term climate action plans. In the case of methane, as noted, that would be a multiplier of 105 times CO_2's warming potential when using the latest data, and 72 times CO_2's, when using the data from AR4. This would enable decision-makers to assess where their short-term climate action plans should be most effectively directed.

This additional supplementation also comports fully with the IPCC protocols. The Second Assessment stated that while the UN Framework held there should be one set of consistent 100 year based GWP values across reporting nation's inventories, it also specifically provided that "[p]arties may also use other time horizons."[13]

II. LANDFILLS

As discussed in Chapter 8 of the Draft, along with Annex 3.1, landfills are among the significant sources of GHGs associated with climate change, because organic discards, which are half or more of total discards, if not separated at the source, are most often buried. In the oxygen-starved environment of a sealed landfill, food scraps, soiled paper, grass clippings, leaves, brush and other organic matter decompose anaerobically under the influence of methanogenic microbes. These thrive in the absence of oxygen, and create methane as a byproduct of decomposition.

Because modern lined landfills can extend for hundreds of acres in extent and rise hundreds of feet above grade, gas generated inside the waste body flows out into the atmosphere through myriad routes that defy measurement. This includes not only through cracks, tears and broken seams at the surface and along the sides and top, but also conveyed along the bottom of a facility following leachate collection gravel trenches and piping, wherever there is a path of least resistence.[14]

---

12 EPA, *U.S. Methane Emissions 1990 – 2020: Inventories, Projections, and Opportunities for Reductions* (EPA430-R-99-013, 1999), at p. 1-2.

13 EPA, *Greenhouse Gases and Global Warming Potential Warming Values* (April 2002), at p. 9.

14 George Tchobanoglous, *Integrated Solid Waste Management* (McGraw Hill, 1993), at p. 394. Memorandum to Brian Guzzone, EPA, from Chad Leatherwood, Eastern Research Group, Inc., dated November 18, 2002, re: Review of Available Data and Industry Contacts Regarding Landfill Gas Collection Efficiency (Leatherwood Memo), at p. 2.

In an attempt to overcome this lack of data, the process underlying the Annex's description purports to use the following mass balance equation that is calculated for each year:

$$Gas\ released = Gas\ generated - Gas\ captured - Gas\ oxidized \quad (1)$$

As discussed below, the problems with this attempt to represent reality are:

(1) ***Incorrect Modeling.*** Only one of the three terms to the right, Gas Captured, is known. Two are only modeled, not observed, values, namely Gas Generation and Gas Oxidized.[15] To estimate the unknown Gas Generation in order to then estimate Gas Released, a model is used which is inapplicable to the particular and unique conditions of a lined landfill and fails to include a coefficient for the most critical independent variable involved in decomposition of buried wastes, the level and distribution of essential moisture. Moreover, many of the landfill input data appears to be incorrect.

(2) ***Incomplete Landfill Phases.*** Gas generation from wastes interred today continue for decades into the future at a rate that varies with five different phases in a landfill's life that affects the level and distribution of essential moisture, all of which is ignored by the Draft's methodology.

(3) ***Oxidation Misapplied.*** The studies used to estimate oxidation are inapplicable to lined landfills.

Most of the controverted modeling turns on the equation used in the Draft to estimate Gas Generated, which is explained first.

A. <u>Modeling</u>

EPA first estimates the amount of annual Gas Generated based upon modeling by using a First Order Decay (FOD) equation, which in its simplified form is expressed:[16]

$$Methane = \sum_{i=1}^{n} M \times L_o \times k \times e^{-k \times t_i} \quad (2)$$

---

15 Gas Oxidized refers to the extent to which escaping methane is oxidized in a soil layer on top of the landfill.

16 Debra Reinhart, *First Order Kinetic Gas Generation Model Parameters for Wet Landfills* (EPA-600/R-05/072, June 2005), at Part 2-6, which describes 12 different variations on the same form. The variants primarily modify the manner in which time is accounted for (e.g. delaying the onset of gas generation for a lag phase, using decimal time instead of annual time intervals, etc.), rather than making the model more robust by accounting for more factors. Current default values recommended by EPA, which were reached by trial and error, are L_o = 100 m^3/Mg and k= 0.04/yr. EPA, *AP-42: Municipal Solid Waste Landfills*, Vol. 1, , at p. 2.4-4.

Where: M is remaining mass, L_o is lifetime gas potential, k is annual decay rate

Unfortunately, this simplified model, and all of its variants, was derived from, and is only applicable to, a continuous decay phenomena acting upon a declining mass, where the decay rate is independent of the availability of limiting pre-conditions that otherwise would impede particle disintegration. An example would be the radioactive decay of a uranium isotope that is represented by a constant decay rate multiplied by the mass, which declines each year as the original mass is reduced by the prior year's decay.

Moisture pre-condition. Anaerobic decomposition in a landfill suffers far too many complications for such a simplified model to be valid. In particular, first, as discussed in this section, the model does not account for whether the distribution and quantity of essential moisture is adequate to sustain the near optimal levels of decomposition assumed by the model. Yet, inexplicably, the Draft's list of relevant factors for methane formation ignores the necessity for their being very high moisture levels.[17]

Along with heat, microbes and pH, which generally are not limiting conditions, decomposition in a landfill cannot comprehensively proceed as the model predicts unless there is a continuing adequate supply of moisture greater than 50%. However, the entrained moisture in the incoming wastes is less than 25%,[18] and the very act of collecting gas from a landfill quickly dehydrates a covered site in a few years because half of the gas removed (by weight) is water vapor.[19]

In addition, the liquids need to be evenly distributed. Unfortunately, moisture is not dispersed throughout landfills. Municipal solid waste is exceedingly heterogeneous, heavily compacted in a landfill to about eight times its original volume, interspersed over each day's lift with daily cover, and often confined in splayed open plastic bags, all of which creates highly preferential paths of flow. Earlier estimates from the 1990s are that liquids only reach 23% to 34% of the mass,[20] and, with in-place densities more than 50% greater today, the dispersion of moisture is presumably significantly less now.

Typically, then, and at best, only limited volumes of gas is actually generated at an operating landfill, before it is closed tight. Even for that short period, decomposition is essentially restricted to isolated pockets where there are aggregations of food scraps and grass clippings that transport their own moisture with them, as well as at the bottom where hydraulic heads accumulate above clogged leachate lines and gravel beds. Differences in cover and operational

---

17 Draft, at p. 2, lines 21-25.

18 George Tchobanoglous, *Integrated Solid Waste Management: Engineering Principles and Management Issues* (McGraw-Hill, 1993), at pp. 72-73 and 393.

19 Rapid dehydration can be seen by the fact that, at 100% saturation and 40° C (104°F) temperature, the condensate is 51% by weight of the weight of the gas, according to standard Humidity Tables, and landfill gas weighs 0.0834 lbs./cf., according to standard conversions.

20 Debra Reinhart, *Prediction and Measurement of Leachate Head on Landfill Liners,* Florida Center for Solid and Hazardous Waste Management (Report #98-3) (1998), at p. viii.

practices implicate whether there is any replenishment or supplementation of moisture levels in situ that, in some cases, increases gas generation. After closure, and for as long as the cover seal maintains its integrity, gas generation rapidly tapers off as the site, for a time, takes on the intended characteristics of a "dry tomb." After the cover eventually fails, gas generation resumes until the residual carbon is exhausted and the site is biologically stabilized.

None of this wide moisture related variation in the rate of decomposition, and gas generation, is accounted for by FOD modeling, which represents a continuous function and that divergence underlies the irrational outputs the model generates.

Anomalous outputs. The extreme inexplicable and anomalous variability of the results the FOD model produces, which is widely reported in the literature, undermines its credibility at the outset. Even the EPA AP-42 background paper acknowledged that in its analysis:

> "The recommended defaults k and Lo for conventional landfills, based upon the best fit to 40 different landfills, yielded predicted CH4 emissions that ranged from ~30 to 400% of measured values and had a relative standard deviation of 0.73."[21]

The most recent survey by Thompson of the results of FOD modeling in landfills concluded that:

> "Landfill gas models continue to receive criticism due to their poor accuracy and insufficient validation: most model results have not been evaluated against methane recovery data. A few studies have compared methane recovery data to estimates of methane generation from models, but only for a few landfills. This limited approach is inadequate to validate the model for a wide, rather than site-specific application."[22]

Similar:

---

21 EPA, *Background Information Document for Updating AP42 Section 2.4 for Estimating Emissions from Municipal Solid Waste Landfills* (EPA/600/R-08-116) (September 2008), at p. 9.

22 Shirley Thompson, et al., "Building a better methane generation model: Validating models with methane recovery rates from 35 Canadian landfills," *Waste Management* 29 (2009), 2085, at 2086. Thus, to illustrate Dr. Thompson's point, the oft- cited French study, K. Spokas, et al., "Methane mass balance at three landfill sites: What is the efficiency of capture by gas collection systems," *Waste Management* 26 (2006) 516, which was based on a study of only three landfills, was rejected by EPA's own consultant, who found:

> "The results of this study on two landfills reported LFG collection efficiencies of 94 percent and 98 percent. However, at the French facility that reported 94 percent LFG collection efficiency, this efficiency was based on the lowest of three predicted LFG generation levels for that facility. When the highest estimate of LFG generation is used, then the LFG collection efficiency drops to 84 percent. This raises the issue again that a major difficulty in determining LFG collection efficiencies is accurately estimating LFG generation levels." Memorandum to Brian Guzzone, US EPA, from Chad Leatherwood, Eastern Re search Group, Inc., dated November 18, 2002, re: Review of Available Data and Industry Contacts Re: Landfill Gas Collection Efficiency, at p. 2.

"Results of this study suggest that the first order model cannot always be applied to full-scale landfill gas collection data with statistical significance."[23]

Another published paper that performed a random verification of related modeling of California landfills found a dispersion of 25 major landfills of predicted compared to actual values for gas collection efficiency, which ranged from 7% to 100%.[24]

A more recent unpublished survey of 46 California landfills by the California Air Resources Board reproduced in Table 1 found implied gas collection efficiency from gas generation estimated with LandGEM first order equations ranging from 6% to 225% gas captured, which is an exceedingly impressive engineering feat. California Air Resources Board, Staff Spreadsheet Titled Landfill Survey Data Public (2010), released in response to a Public Records request by Californians Against Waste. Similarly, the Wisconsin Department of Natural Resources did a comparison of actual gas collected to estimate gas generation in the State's landfills and found a wide and physically impossible outputs like those found in California's study. See on-line at http://dnr.wi.gov/org/aw/wm/solid/gas/gas.htm#art6.

---

23 Debra Reinhart, "Landfill Gas to Energy: Incentives and Benefits," University of Central Florida (Report #08-32026)(February 2010), at p. vi.

24 Nickolas Themelis and Prisilla Ulloa, "Methane generation in landfills," *Renewable Energy* 32 (2007), 1243, at 1250.

Landfill Survey Response Data			Survey CH4 Captured/Model CH4 Generation (%)						
Landfill	2006 WIP (%)	Avg. CH4 (%)	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*
1	9.4%	35%	109%	120%	107%	108%	112%	140%	140%
2	3.7%	46%	87%	108%	114%	109%	107%	135%	130%
3	3.2%	52%	61%	63%	73%	68%	52%	51%	83%
4	3.0%	39%	63%	73%	66%	79%	76%	90%	87%
5	2.7%	36%	91%	91%	91%	91%	84%	98%	92%
6	2.3%	34%	121%	121%	121%	121%	121%	121%	121%
7	2.2%	42%	99%	105%	109%	111%	105%	107%	104%
8	2.2%	14%	6%	5%	4%	6%	5%	6%	6%
9	1.9%	16%	66%	65%	65%	57%	59%	76%	76%
10	1.8%	25%	125%	113%	100%	97%	112%	124%	124%
11	1.8%	50%	64%	69%	71%	69%	66%	63%	63%
12	1.8%	42%	127%	127%	127%	127%	127%	146%	117%
13	1.4%	32%	121%	137%	128%	123%	119%	126%	126%
14	1.3%	49%	124%	119%	105%	102%	102%	76%	72%
15	1.3%	50%	59%	51%	41%	54%	54%	54%	54%
16	1.3%	43%	351%	261%	231%	226%	172%	166%	165%
17	1.2%	40%	45%	45%	45%	45%	53%	46%	44%
18	1.1%	39%	118%	118%	118%	118%	133%	118%	109%
19	1.1%	47%	78%	54%	96%	103%	90%	90%	116%
20	1.1%	44%	64%	63%	65%	40%	51%	39%	37%
21	0.8%	51%	89%	90%	103%	82%	81%	83%	108%
22	0.7%	50%	74%	73%	76%	88%	75%	94%	121%
23	0.6%	48%	152%	180%	140%	109%	104%	96%	91%
24	0.5%	48%	28%	35%	42%	50%	62%	70%	64%
25	0.4%	59%	57%	57%	57%	57%	57%	57%	57%
26	0.4%	29%	22%	22%	20%	21%	21%	25%	21%
27	0.4%	48%	23%	23%	23%	23%	15%	21%	34%
28	0.3%	38%	20%	26%	23%	21%	19%	14%	16%
29	0.3%	40%	111%	111%	116%	102%	114%	99%	98%
30	0.3%	43%	104%	104%	104%	104%	104%	93%	114%
31	0.3%	37%	29%	29%	29%	30%	33%	28%	25%
32	0.2%	42%	31%	31%	31%	31%	31%	28%	34%
33	0.2%	41%	22%	22%	19%	20%	21%	24%	30%
34	0.2%	48%	103%	85%	80%	91%	124%	123%	135%
35	0.2%	17%	6%	6%	5%	6%	6%	6%	6%
36	0.1%	48%	78%	78%	78%	102%	74%	66%	79%
37	0.1%	32%	35%	40%	38%	54%	62%	62%	50%
38	0.1%	33%	38%	17%	20%	16%	17%	27%	23%
39	0.1%	38%	257%	257%	341%	234%	234%	216%	257%
40	0.1%	37%	44%	38%	33%	18%	33%	33%	33%
41	0.0%	45%	76%	76%	76%	85%	78%	65%	76%
42	0.0%	37%	69%	66%	63%	59%	56%	52%	49%
43	0.0%	30%	46%	41%	37%	32%	27%	23%	19%
44	0.0%	27%	165%	161%	157%	138%	137%	138%	126%
45	0.0%	31%	38%	38%	38%	38%	38%	22%	47%
46	0.0%	30%	18%	17%	14%	14%	14%	14%	10%

Statistical validation failed. Initially, attempts to support the validity of FOD models was based upon a putative statistical test using regression equations of a sample that purported to show its predictions were a good fit.

The regression analysis prepared for EPA by Peer was intended to validate the FOD model's applicability to the approximately 2,000 MSW landfills in the United States,[25] but it failed to do so. The Peer study used too small a sample of only 21 landfills, or only 1% of the population, which is too few degrees of freedom for statistical significance. Also, none of those selected for the sample were chosen randomly, which removes the normal distribution essential for regression equations to estimate a population.

Furthermore, not only was the selection process not random, it was also chosen with a specific bias that has the effect of significantly skewing results to appear to show high capture rates. This was done by limiting the sample to landfills with energy recovery. These facilities typically recirculate leachate, which accelerates decomposition and gas generation,[26] in order to boost the profitability of electricity sales. That has been shown to increase near term gas generation very significantly, while only moderately increasing the volume of gas captured.[27] Since the model is blind to the fact that gas generation was augmented, the uptick in gas collected makes it seem appear that capture rates have significantly improved, even though they most probably have significantly declined.

Moreover, in addition to all those limitations, circular reasoning was used in performing the model's attempt at a statistical validation. In an attempt to assess the reasonableness of the model's estimates of Gas Generation, Eq. (3) is used to provide a putative independent estimate:[28]

$$\left| \text{Gas captured} = \text{Gas generated} \times \text{Gas capture rate} \right| \quad \textbf{(3)}$$

Solving Eq. (3) for Gas Generated is shown in Eq. (4):

---

25 R. L. Peer, et al., "A comparison of methods for estimating global methane emissions from landfills," 26 CHEMOSPHERE 387 (1993).

26 Debra Reinhart, *First Order Kinetic Gas Generation Model Parameters for Wet Landfills* (EPA-600/R-05/072)(June 2005), at p. 2-2.

27 Contrast: Pat Sullivan and Alexander Stege, "An Evaluation of Air and Greenhouse Gas Emissions and Methane-Recovery Potential from Bioreactor Landfills," *MSW Management* (Sept./Oct. 2000), at p. 78, states that bioreactor landfills increase near term gas capture per ton of waste-in-place by 76%; with 67 FEDERAL REGISTER 36463 and 36465 (May 22, 2002), which states that bioreactors increase gas generation in the near term by 2 to 10 times.

28 Debra Reinhart, "Landfill Gas to Energy: Incentives and Benefits," University of Central Florida (Report #08-32026)(February 2010), at p. 4.

$$Gas\ generated = \frac{Gas\ captured}{Gas\ capture\ rate} \quad (4)$$

But, since only one of the two independent variables is known, this exercise rests on a house of cards. For the Gas Capture Rate is also unknown and an unsupported guesstimate is used, defeating the attempt to provide a solid foundation for the calculation. Thus, to solve the equation for Gas Generation, the study just *assumed* that Gas Capture Rate was 75% at all times during a landfill's life. Recalling that one of the purposes of the entire exercise was to establish a factual basis for assuming 75% capture rates in the first place, this led to a circular exercise with no statistical value. As a tautological statement, it establishes nothing about Gas Capture Rates anymore than it does about Gas Generation.

Moreover, the problem is not just that the provenance of the 75% assumption is neither an observed value nor, in view of its definition as the best systems during the limited period of their peak performance, even a reasonable assumption. In addition, in order to perform the Pearson calculations, the analysis assumed that every single landfill in the study (i) exhibited identical performance, even though operating practices significantly affecting collection efficiency vary widely among landfills, as well as (ii) achieved that same high capture rate during all phases of each sites' biologically active or latent life, including the challenging times when there is no installed or functioning gas collection system. However, US EPA has never asserted that its 75% assumption was intended to apply for each landfill at all times. Rather, to the contrary, it only purported that 75% was intended to be an average value when considered across peak times and among all landfills.[29]

Finally, in view of the fact that moisture, which is a limiting condition for decomposition landfill decay behavior obviously reflects complex interactions, which are especially difficult to model in a heterogeneous waste mass that goes through multiple phases some of which when prerequisite moisture levels are absent. The reason given to justify the paucity of other explanatory variables in the model to explain that complex environment, such as critical internal moisture levels, is that the excluded variables had statistically insignificant estimated coefficients in earlier versions of the regressions.

But, the problem of statistically insignificant coefficient estimates arises for many reasons other than the authors' claimed lack of importance. One of the reasons for insignificant coefficients is a small sample size that leads to limited degrees of freedom, which is evident in the study. Other problems include poorly formulated equations, data measurement errors, and inappropriate error term distribution specifications and related estimation procedures. Each of these problem s exist.

---

29 Debra Reinhart, *First Order Kinetic Gas Generation Model Parameters for Wet Landfills* (EPA-600/R-05/072, June 2005), at p. 3-2 and 5-2. US EPA, *Background Information Document for Updating AP42 Section 2.4 for Estimating Emissions from Municipal Solid Waste Landfills* (EPA/600/R-08-116) (September 2008), at p. 7-8.

This points towards an unreliable and questionable estimation process known as data mining or fishing, and not to the lack of importance of things, such as moisture, needed for a valid model. With these fishing procedures, various fuller models are formulated and discarded, not because they are not well formed or include inappropriate variables, but because the analysts did not want to confront the substantial complexities or consequences that more complete modeling would entail.

The exclusion of variables merely on the basis of low levels of estimated coefficient significance is not statistically justified, as dramatically shown by the irrational scattergun outputs it produces. For, if the excluded data are truly relevant, their exclusion leads to estimation bias and unreliable results. Coefficient significance is not an appropriate means for deleting variables from a regression model. Various appropriate tests exist for testing overall significance of a set of variables – in particular maximum likelihood ratio tests. The Peer paper does not show that these forms of significance testing were performed.

Due to all of the deficiencies discussed above, the results of the regression analyses cannot be relied upon to provide credible annual methane production quantities, anymore than the putative validation of the FOD model can corroborate that the model conforms to statistical norms. In addition to all of the problems discussed above, the low levels of R^2s in the Peer study (one measure of the explanatory power of estimated regression equations) do not support a conclusion that the regression analyses provide reliable results.

The reason why the FOD model's outputs are anomalous is that its coefficients, variables and structure are incomplete and its input variables are wrong.

The most recent attempt by Thompson to validate FOD models through modifying its architecture is similarly flawed.[30] Thompson searches for the best FOD model to validate for estimating gas generation in order to solve the mass balance equation. It uses the Pearson correlation to compare the modeled estimates of gas generation to what it construes to be observed values among six variants of the FOD model at 35 non-randomly selected Canadian landfills with alternative assumptions about one of the factors, namely the assimilated organic fraction in the landfill, and adjustments to the values for L_o and k that are irrelevant to gas generation.

The problems with this attempt are, first, that this so-called calibration approach is more akin to correlation fishing with a torn net. The study does not present a rational conceptual solution to errors that it identified in past modeling practices. Instead, by trial and error, it iteratively examines for each landfill the modeled gas generation estimates from each of the six variations on the same core equation, along with alternative input values, until it finds a best fitting Pearson correlations among historic landfill data.

However, the Pearson correlation does not show causality, but only a correlation that might be due to chance – a possible explanation whose probability increases markedly as the number of different values for variables and model permutations multiply, which more accurately

30 Shirley Thompson, et al., "Building a better methane generation model: Validating models with methane recovery rates from 35 Canadian landfills," *Waste Management* 29 (2009), at p. 2085.

resembles shooting fish in a barrel for correlates. In addition, the Pearson correlation is a process that says nothing about whether all critical explanatory variables, such as critical moisture levels, have been included in the model. As such, the Study's procedures are not a valid statistically appropriate procedure to derive reasonable estimates useful for future predictions of gas behavior among the population of municipal solid waste landfills.

Second, like Peer, the Thompson study is also circular. Pearson's correlation looks for linear associations between observed values and the parallel modeled estimates, here of gas generation. However, there are no observed values of gas generation to search for correlations with modeled generation outputs. In the three-term simplified mass balance equation above, only gas captured was known. In order to perform the Pearson analysis, the study resorts, at p. 2088, to the use of Eq. 4 to model further what is intended to be observed gas generation.

But, again, this equation with three terms, which is used in an effort to provide an observed value for gas generation, also has two unknowns. To produce a value for the desired observation for gas generation, the study is forced to make another assumption, which is not based upon any observations, about the gas capture rate. In this study, collection efficiency is *assumed* to be the average of 75%, which is the oft-cited US EPA assumption based upon the questionable decision to focus on the best systems at the limited time of their peak performance, and 85%, which is the claimed, but disputed, *Spokas* assumption,[31] or 80%. However, the EPA view is based upon a literature review that simply ignored low reported values in the published literature. As regards *Spokas*' claimed 85% value, as noted previously, it was even rejected by EPA and also by *Thompson*.

Again, too, like Peer there is the further problem that, in order to perform the Pearson calculations, the analysis assumed that every single landfill in the study (i) exhibited identical performance during all phases of each sites' life, which is something that EPA never claimed for the assumption.

By way of comparison, incidently, the Intergovernmental Panel on Climate Change (IPCC) states that the average lifetime capture rate equivalent to EPA's best instantaneous rate is actually as low as 20%.[32]

Thus, when the *Thompson* study rejected several scenarios because they seemed to "consistently produce[] much higher estimates than the [observed] methane generation rates," the calculated large standard errors it thought the analysis found were actually due to its arbitrary assumption about high capture rates rather than a real statistical deviation. Had the study used the lower IPCC assumption, the findings about which model showed the best fit would probably have been reversed.

As to the intention to improve upon the L_o and *k* values by localizing them to the conditions in the Province in which the landfill is located, those only create the illusion, but not

[31] , Kurt Spokas, et al., "Methane mass balance at three landfill sites: What is the efficiency of capture by gas collection systems," *Waste Management* 26 (2006), at p. 516.

[32] IPCC, *Fourth Assessment Report:* Chapter 10:Waste Management (2007), at p. 600.

the substance, of refinement. Using Provincial waste audits to derive L_o is a meaningless gesture because audits are just visual inspections with very wide and unknown bands of uncertainty no better than the three-fold dispersion, from 100 to 310 m^3/Mg., currently in the literature.[33]

Similarly, the attempts to refine the k value by more closely correlating it to the Province's annual precipitation is also meaningless because the relevant criteria is moisture *inside* the landfills at different points in a landfill's life, not rainfall *outside* the facility. Directly intervening between surface and interior conditions at any given time are the permeability of any cover, any re-injection of leachate or outside liquids, in-situ compaction ratios, waste composition, the functionality of the leachate collection system, site geometry and surface grading practices. At times, in fact, after the final cover is installed and for as long as it is maintained, the waste mass will go bone dry and therefore generate very little gas (hence the moniker, "dry tomb landfills"), even if there is a monsoon raging at the surface.

But, most important for the model's structure, those factors affecting interior moisture levels vary over time. To illustrate, there is no low permeable cover until 5 to 15 years after first waste emplacement (when significant gas is generated), and then a barrier to infiltration installed and remains for as long as the cover is maintained (when very little gas is generated), after which its performance will decline and rain will re-infiltrate the site (when gas generation resumes). Therefore, the operative decay rate is not the same in those three different phases.

If the model is to reflect the critical limiting conditions for decomposition to occur, such as internal moisture levels, then the value for *k* also must be appropriate, and different, for those distinct time periods. That would be higher in the first and the last phase and much lower in the middle phase of a landfill's biologically active or latent life. Slightly modifying the value for *k* by site location, rather than by the landfill's phase, and as a constant value under all of these conditions, fails to rectify the fundamental flaw in the first order decay model as it is presently constructed. The use of a constant k value, more closely tied to a largely irrelevant factor, fails to correct the flaws in FOD models current contemplation of *k*.

Data Problems. The underlying data for the analysis is not transparent, but, we continue to believe that the data inputs used for Gas Captured and Methane Destroyed, systematically understate not only Gas Generation for the reasons described above, but also Gas Captured and destroyed.

From past experience, we believe that the aggregated data for Gas Captured continues to be grossly inflated. In the past when we last consulted for EPA, the landfill owners and vendors refused to provide actual data on gas collected at each landfill for the purpose of compiling a national data base, even though this data is typically available buried in the files of state regulators. In lieu of actual data, the nameplate capacity of the permitted flares were multiplied by the number of hours. This fails to account for subpar performance, maintenance and unexpected downtime. States should be queried to compile actual data, or if that is not possible, a statistical sample of landfills should be selected and state records reviewed to estimate the deviation from manufacturers' claimed values for the different equipment.

---

33 Debra `, *First Order Kinetic Gas Generation Model Parameters for Wet Landfills* (EPA-600/R-05/072, June 2005), at p. 3-2.

On a related note, while the high methane destruction values used are appropriate for flares, state enforcement officials report seeing performance for internal combustion engines below 95%. Field data should be compiled from actual state reports to improve the reliability of long-held assumptions. It is unfortunate that AP-42 continues to fail to provide any of the data that it collected in a form from which more reliable estimates might be developed.

B. <u>First Three Phases.</u> As noted, decomposition, and gas generation, are not a continuous function but rather are moisture dependent. In turn, the level, and distribution, of moisture depends primarily upon when the final cover is installed, and whether leachate is recirculated (and/or outside liquids added), as well as waste composition, in-situ compaction ratios, precipitation and transpiration, the presence of active gas collection wells, and surface grading

Typically, after first waste emplacement, the gas collection system is not installed for five years in large landfills (though not in smaller ones), but it does not function to its design standards until the final cover is installed soon thereafter that creates a necessary seal for the system's vacuum forces to work properly and to prevent oxygen infiltration from the surface when it fully draws. Before the cover is installed, moisture is brought to the landfill entrained in food discards, grass clippings and left over liquids at the bottom of containers, which is supplemented by infiltrating rainfall while the top remains open while the cell fills up. Following capping, the residual moisture is quickly dehydrated by the gas systems, because half of the extracted gas by weigh is water vapor.

In wet cell landfills, discussed later, leachate is recirculated soon after first waste emplacement in order to accelerate decomposition, and often the final cover is delayed for several more years to extend the time when infiltrating rainfall can replenish moisture levels.

Thus, through the period of time that the cover is maintained, which may be approximately 30 years following closure, the landfill proceeds through three phases:

- 1 Pre-installation of the gas collection system
- 2 Post-gas collection installation but pre-installation of the final cover
- 3 Post-installation of the gas system and final cover but prior to the end of post-closure maintenance

This is not controversial. These different phases are accepted by EPA, and, indeed, the structure is reflected in the GHG Reporting Rule, and by the landfill industry.[34] These phases directly implicate how a landfill GHG inventory needs to be calculated. For, each of these phases evinces very different characteristics for the gas generation and gas collection, that varies significantly what is assumed in the First Order Decay model used in the draft inventory:

---

[34] 40 C.F.R. §98.340 Subpart HH. US EPA, *Background Information Document for Updating AP42 Section 2.4 for Estimating Emissions from Municipal Solid Waste Landfills* (EPA/600/R-08-116) (September 2008), at p. 7-9; SCS Engineers (SCS), *Current MSW Industry Position and State-of-the-Practice on LFG Collection Efficiency, Methane Oxidation, and Carbon Sequestration in Landfills* (July 2007), at p. 10.

Three Phases of Landfill Life Actual Landfill Characteristics Compared to First Order Decay Model		
	Gas Generation	**Gas Collection**
Pre Gas Collection **Dry Tomb** **Wet Cell**	 Same Higher	 Lower Lower
Post Gas/Pre Cover **Dry Tomb** **Wet Cell**	 Same Higher	 Lower Lower
Post Cover-Pre Maintenance Ends	Lower	Higher

Comparing the second to the third column shows the point that Prof. Hans Oonk made to the draft version of AR4. It convinced the IPCC that the average lifetime capture rate that was equivalent to EPA's 75% assumption of what the best systems might achieve at the point of their peak performance is as low as 20%.

While the EPA and landfill industry have recognized the fact of these three phases of a landfill's life, they do not seem to appreciate the paradox that Oonk first raised, namely gas capture is only good when there is scant gas production, and when most gas is generated, there is little or no gas collection.

The draft inventory, however, recognizes neither, not the existence nor the phases or the paradox that they create. Indeed, by performing the first order decay model on total estimated landfill tonnages in each prior year, instead of on each individual landfill as a function of which phase it is in that year, the calculation ignores all of these very significant distinctions. In aggregate, the effect, again, is to grossly understate landfill GHG emissions.

C. Second Wave

To further complicate matters, there is a critical *fourth* time period in a landfill's life-cycle that is critical to include in the GHG inventory, yet is currently ignored in both the draft inventory and the GHG Reporting Rule. That is the second wave of gas generation, after postclosure maintenance ends, when the majority of a landfill's lifetime gases are generated, and, with the site abandoned, are released unabated.

Moisture restrictions. The second wave occurs because of three factors. First, as noted, the organic material in solid waste require 60% or more moisture to decompose, while incoming wastes contains less than 25% moisture. Absent additional liquids, decomposition will be minimized.

Distribution limited. Second, moisture is not evenly distributed in landfills. Solid waste is highly heterogeneous, heavily compacted to eight times its original density, inter-leafed with daily cover, and often confined in partially splayed open plastic bags, all of which combine to create highly constricted preferred paths of flow. Field studies, undertaken in the late 1990s when waste densities were only two-thirds of their current ultra-high compaction levels, show that entrained and infiltrating liquids only reach 23% to 34% of the mass.[35] With in-place densities today 50% to 66% greater than when the study was done, dispersion of liquids will tend to be significantly less.

Essentially, prior to the site closing and being covered with a low permeable liner, decomposition is confined to a few areas. It only occurs where there is moisture entrained with the incoming food scraps and grass clippings and leaking out the bottom of bottles containing fluids, as well as where rain travels through cracks and fissures and then pools in pockets where food is decomposing and in voids between large particles.[36]

After installation of the final cover, however, infiltration largely ceases and any residual moisture is quickly extracted with the gas, half of which is condensate (by weight) in the collection system, rapidly dehydrating the waste mass.[37] From the data, probably more than half of the original carbon content in the organic discards remains upon closure.[38]

Cover ultimately fails. Third, the final cover has a finite life. After closure, at best financial assurance regulations only provide funds for routine maintenance and for only 30 years.[39] As EPA repeatedly stated during the 1980's leading up to the promulgation of Subtitle D in 1991, even composite liners "will ultimately fail" within decades after the agency's post-closure care requirements have expired,[40] "and when they do, "leachate will migrate out of the facility."[41] Yet,

---

35 Debra Reinhart, *Prediction and Measurement of Leachate Head on Landfill Liners,* Florida Center for Solid and Hazardous Waste Management (Report #98-3) (1998), at p. viii.

36 STI Engineering, *LFG Recovery* (Typescript, 2001).

37 Rapid dehydration can be understand by the fact that, at 100% saturation and 40° C (104°F) temperature, the condensate is 51% by weight of the weight of the gas, according to standard Humidity Tables, and landfill gas weighs 0.0834 lbs./cf., according to standard conversions. Simplified gas generation rates are.10 cf per pound of MSW, declining 2%-3% per year. EPA, *Turning a Liability Into an Asset* (EPA 430-B-96-0004)(September 1996), at p. 2-5. At that rate, the landfill will become bone dry in approximately 3 years after new infiltration is blocked by the installation of a final cover and continuing through the time the cover is maintained.

38 The best data, as we have repeatedly requested EPA to undertake, would be statistical bore samples after closure to measure unsequestered carbon content. However, this has never been done, notwithstanding the enormous importance the answer holds for the long term safety of landfills. For current financial assurances are only required for 30 years after closure.

39 40 C.F.R. §258.72.

40 53 FEDERAL REGISTER. 168, at pp. 33344-33345 (August 30, 1988).

41 46 FEDERAL REGISTER 11128-11129 (February 5, 1981). Similar: "A liner is a barrier technology that prevents or greatly restricts migration of liquids into the ground. No liner, however, can keep all liquids out of the ground for all time. Eventually liners will either degrade, tear, or crack and will allow liquids to migrate out of the unit. Some have argued that liners are devices that provide a perpetual seal against any migration from a waste management unit. EPA has concluded that the more reasonable assumption, based on what is known about the pressures placed on liners over time, is that any liner will begin to leak eventually." FEDERAL REGISTER (July 26, 1982), at pp. 32284-32285.

the EPA recognized, the duration of a landfill's hazardous loadings that needs to be isolated may be "many thousands of years,"[42] long after the time when discharges will occur.

The early warnings from EPA were more recently reinforced from an investigation and field study conducted by the agency's Inspector General –

> "EPA officials have stated that based on current data and scientific prediction, the release of contaminants may eventually occur, even with the application of best available land disposal technology. There is concern that *these barriers will merely postpone the inevitable release of contaminants until after the 30-year liability has expired*. As previously stated, some sites contain materials which are highly resistant to decomposition or which remain toxic forever. There have been several studies to determine the expected life span of landfill liners, and opinions on this issue vary widely. The bottom line is that not even the manufacturers claim that their liners will last forever."[43]

Why, then, did the EPA proceed to adopt liner-based regulations in 1991, when they were fully informed that engineered barriers will eventually fail? That question was answered by the EPA Inspector General a decade later in 2001. Extensive interviews with the agency's staff established that *the reason was political*, not technical–

"Landfill design requirements and post-closure maintenance for both Subtitle C and Subtitle D facilities are expected to prevent leakage in the short term; however, their long-term effectiveness in controlling releases of contaminants is unknown. EPA and others have stated that it is likely that some disposal facilities will leak at some period after they close. ... "However, some who commented were concerned that an extended time frame would place an economic burden on smaller businesses. Therefore, EPA officials *acknowledge the lack of criteria or scientific basis* for establishing the 30-year post-closure time frame. ... EPA made the decision to establish the time frame at 30 years, seemingly *based on a compromise of these competing interests*. EPA officials we spoke to agreed that the 30-year time frame was *not based on specific scientific criteria or research studies*."[44]

State environmental agencies reached the same conclusion about the fact that the covers would eventually fail and lead to a second wave of gas generation after maintenance ends at closed landfills. The California Integrated Waste Management Board stated:

---

42 46 FEDERAL REGISTER 28314-28328 (May 26, 1981). *See, also*, Commission of the European Community*, Management and Composition of Leachate from Landfills: Final Report* (1994), at p. 7, TABLE 1.2. H. Belevi and P. Baccini, "Long Term Behavior of Municipal Solid Waste Landfills," *Waste Management and Research* (1989), at p. 43. Peter Flyhammar, *The Release of Heavy Metals in Stabilized MSW by Oxidation* (Swedish Department of Water Resources, Nov '99), at p. 20 TABLE 10.

43 Office of the Inspector General, *RCRA Financial Assurance for Closure and Post-Closure* (2001-P-007) (Mar. 30, 2001), at pp. 33. On-line at: http://www.epa.gov/oigearth/audit/list301/finalreport330.pdf. (Emphasis added.)

44 U.S. Environmental Protection Agency Inspector General, *RCRA: RCRA Financial Assurance for Closure and Post-Closure* (No. 2001-P-007) (March 28, 2001), at p. 31 (emphasis added).

"However, the initial term of 30 years for P[ost] C[losure] M[aintenance] is unlikely to resolve all the environmental issues related to a closed landfill in California. Since Subtitle D was promulgated, research shows that certain wastes in some landfills stabilize in a short period of time and that, at those landfills, the potential to impact the environment may only last for a short portion of the conventional 30-year PCM period. On the other hand, some landfills may remain a threat to the environment for longer than 30 years. For example, stakeholders have reported to Board staff that landfill gas control systems have had to be installed at landfills that had not operated for up to 60 years. Dry tomb landfills (favored by Subtitle D and 27 CCR) indefinitely suspend and/or retard the decomposition process such that a breach in containment (e.g. extreme climate or earthquake event or inappropriate land use, or simply failure of equipment or containment barriers) could trigger uncontrolled production and release of landfill gas and leachate, and public contact with waste. *The state of the science thus indicates that municipal solid waste landfills will in many cases pose a significant threat to the environment well beyond the conventional 30-year PCM period*."[45] (See accompanying FIGURE showing a second wave of gas generation denoted as "containment failure.")

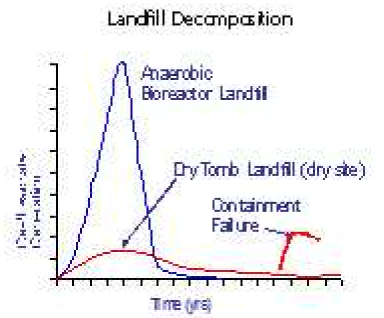


FIGURE 1

Similarly, Washington state's Department of Ecology has stated:

"The extent to which today's landfills adequately protect human health and the environment is a subject of debate, however. Requirements that govern siting, operation, closure, and post-closure are stringent and extensive. While the newest landfills are state-of-the-art facilities, they are far from benign in their impacts. Landfills may still affect the air, land, and water but to a significantly lesser degree than before today's standards went into effect. As waste decomposes in landfills, methane and other hazardous gases are generated. Methane is a greenhouse gas concern because its impact is twenty-three times that of carbon dioxide (EIA). Leachate from decomposing matter in landfills can contain hazardous constituents. If landfill liners and/or leachate collections systems fail, then groundwater and surface-water pollution can occur. No liners are engineered to be 100 percent impenetrable or to last forever without some sort of failure. In fact, US EPA officials have stated that problems can occur more than thirty years after closure of

45 CIWMB, Discussion Paper Regarding Postclosure Maintenance Beyond the Initial 30 Years and Financial Assurance Demonstrations (December 6, 2004) (emphasis added).

a landfill, pointing out that 'even the best liner and leachate collection system will ultimately fail due to natural deterioration.'"[46]

In addition, the Wisconsin Department of Natural Resources has also pointed to the same inherent flaw in dry tomb designs for landfills:

> "The problem with dry tomb landfills is that the organic wastes in them remain largely undecomposed. They represent a continuing and large potential source of methane gas, as well as a potential source of groundwater pollutants. The essentially perpetual management of these problems represents a long-term financial liability to the waste management industry, and potentially to the state, if public monies have to be used to clean up future problems."[47]

Furthermore, in the last three years, many in the landfill industry have conceded these basic facts, as well. The Executive Director of the Solid Waste Association of North America (SWANA), John Skinner previously headed EPA's Office of Solid Waste where he had a major role in drafting Subtitle D. Dr. Skinner has recently written:

> "The problem with the dry-tomb approach to landfill design is that it leaves the waste in an active state for a very long period of time. If in the future there is a breach in the cap or a break in the liner and liquids enter the landfill, degradation would start and leachate and gas would be generated. Therefore, dry-tomb landfills need to be monitored and maintained for very long periods of time (some say perpetually), and someone needs to be responsible for stepping in and taking corrective action when a problem is detected. The federal Subtitle D rules require only 30 years of post-closure monitoring by the landfill operator, however, and do not require the operator to set aside funds for future corrective action. Given the many difficulties of ensuring and funding perpetual care by the landfill operator, the responsibility of responding to long-term problems at dry-tomb landfills will fall on future generations, and the funding requirements could quite likely fall on state and local governments."[48]

Dr. Skinner's predecessor at SWANA, Lanier Hickmanexpressed the same view more forcefully:

> "Currently many policymakers view F[inancial] A[ssurance] for landfills from the perspective, 'If it ain't broke, don't fix it.' However, *the question is not 'if' there will be future landfill problems, but 'when.'* Since FA requirements are the last

---

[46] Washington Department of Environmental Protection, *Background Information for Beyond Waste Document* (2004), at p. 3.

[47] Testimony of Suzanne Bangert, Director Wisconsin Department of Natural Resources Bureau of Waste Management Before the Assembly Committee on Natural Resources on Clearing House Rule 04-077 (April 27, 2005).

[48] John Skinner, "Composting and Bioreactors," *MSW Management* (July/August 2001), at p. 16 (emphasis added).

line of defense before the public winds up with the costs for corrective action, it is critical that an FA mechanism be able to guarantee coverage of expected landfill costs."[49]

Or from Peter While, an environmental scientist with Procter & Gamble –

"...The dry containment method of operating a landfill has been described as long-term storage of waste rather than waste treatment or waste disposal, and does have some significant drawbacks. There will always be pockets of moisture within waste, and *it is generally accepted that all lining and capping systems will eventually leak so rain and/or groundwater will eventually enter the site*. Thus, the decomposition of the organic fraction of the waste will eventually occur, with resulting emissions of landfill gas and leachate. Since pipes and pumps buried within the waste eventually clog up and fail, there will be less chance of collecting and treating these emissions if they occur in the distant future."[50]

Or from John Pacey, one of the premier landfill engineers –

"The containment provided by these landfills offers environmental protection initially; however, at some point *beyond the 30-year [postclosure] period, there may be partial failure(s)* of the containment lining system (underlying and overlying the waste). The primary environmental issue associated with partial containment system failure and moisture infiltration is the potential associated increase in gas and leachate production and the resulting impact of uncontrolled leachate and/or landfill gas releases to the environment. The nature and magnitude of the releases exiting the landfill and their resulting impacts are directly related to the amounts of organic waste not yet decomposed."[51]

Thus, a very substantial fraction and quite possibly a significant majority of the carbon in the incoming wastes remains when the landfill is closed due to insufficient and unevenly distributed moisture while open. Also, eventually the cover will fail after maintenance ends, reigniting a second wave of gas generation that will probably be larger than the first wave. At that time, there will be no gas collection and all of the future gases from the residual decomposables will escape into the atmosphere.

Not only is it vital that the fifth phase of a landfill's life be acknowledged, but also it is necessary to include the future emissions that will flow from today's discards in the annual GHG inventories. Yet, for the organic discards buried in the year for which the inventory is prepared, EPA's current practice purports to track each landfill's actual performance only in that annum.

---

49 Rob Arner, H. Lanier Hickman and Cristine Leavitt, "Dump Now, Pay Later?" *MSW Management* (Sept. 2000).

50 Peter White, *Integrated Solid Waste Management: A Lifecycle Inventory* (Aspen Pub. 1999), at p. 275.

51 John Pacey, *et. al.*, *The Bioreactor Landfill - An Innovation in Solid Waste Management*, Monograph (2001), at p. 2 (emphasis added).

However, in fact, we understand that the agency does not even recognize the fact that a not insignificant fraction of the gases generated that year are from open or not fully closed cells where there is either no gas collection or no low permeable cover. In those cells, the Gas Capture Rate is zero or a fraction of collection system's peak performance, while EPA's calculations presumes capture rates are a constant and optimal at all times, belying any claim that it is tracking each landfill's behavior in that year.

Even if the new four-phase protocols included in Table HH-3 of the GHG Mandatory Reporting Rule were followed in the inventory – which we do not believe it was – that would still ignore the fifth phase when, most likely, a majority of the gases are generated and, since none of those are captured, most of the fugitive emissions occur.

Accounting for future emissions. EPA has previously defended the inventory's omission of the vast majority of postponed GHGs that arising from the residual carbon in the wastes buried today. It has argued that the inventory only encompasses emissions estimated to occur in that year.

However, this view produces a result that ignores the majority of the delayed emissions associated with wastes deposited in that year, which, under EPA's protocols will *never* be counted for in the relevant future. This result is akin to assessing a person's dose absorption of a 24-hour time release pill in the first hour after its being swallowed, and ignoring the further uptake in the following 23 hours.

Moreover, EPA's opinion is fundamentally inconsistent with the IPCC principles that the agency has itself restated in its reports:

> "CH_4 emissions from landfills *are* counted [under the IPCC guidance in inventories of anthropogenic GHG emissions.] Even though the source of carbon is primarily biogenic, CH_4 would not be emitted were it not for the human activity of landfilling the waste, which creates anaerobic conditions conducive to CH_4 formation. Note that this approach *does not distinguish between the timing of CO_2 emissions,* provided that they occur in a reasonably short time scale relative to the speed of the processes that affect global climate change. In other words, as long as the biogenic carbon would eventually be released as CO_2, *it does not matter whether it is released virtually instantaneously (e.g., from combustion) or over a period of a few decades (e.g., decomposition on the forest floor).*"[52]

Finally, the refusal to acknowledge the future stream of methane emissions that inevitably will follow from the burial of organic discards today is also in fundamental conflict with other practices used elsewhere in the inventory. In order to compute the equivalent warming effects of other greenhouse gases to CO_2, each of which has different residence times, the accepted convention uses an assumed common 100-year period for the time each gas, released today, will remain in the atmosphere before it decays or is absorbed. Since methane actually only remains in

---

[52] EPA, *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks* (3rd Ed., 2006), at p. 12 (emphasis added).

the atmosphere for 12 of those 100 years, its actual impacts are diluted by being spread over 88 years when it is no longer present.[53]

In the event EPA's decision is to bar recognition for those delayed impacts, then, to be consistent, the protocols also must use a single-year basis for calculating the different gases' warming potential, something that would increase methane's carbon-equivalence by more than 100 times. But, the protocols cannot responsibly use a century long frame of reference in one chapter and an instantaneous snapshot in another and produce a coherent analysis in the conclusion.

As to the complaint that there is no nomenclature to properly account for the future stream of emissions in the inventory for the current year, there is a well-trod analogous mechanism to do this. Accounting routinely incorporates into the present a future stream of income flows that derive from an investment made today to best pick from various options. This directly resembles continuing gas emissions from decaying wastes discarded in that year. That technique is the net present value analysis, long used in economic planning and decision-making.

As to the complaint that present value type of calculations require making projections about future events that are not precisely known, that, too, is a red herring. For one thing, the current present-only analysis is already replete with made up assumptions without any factual basis, such as the gas capture rate. For another, ignoring future consequences that will follow from today's actions does not eliminate uncertainty. To the contrary, ignoring the future is a palpable decision that there will be no future decomposition activity from today's discards, which is a totally absurd result. Tomorrow's uncertainty cannot be eliminate by pretending it does not exist.

Of note, a present-value type of calculation attributing future emissions from wastes buried today to the current year is a practice that the IPCC has used elsewhere. The estimation technique of compressing into the present the future emissions from today's sources has more recently been specified as the appropriate methodology in the IPCC's Clean Development Mechanism program.[54]

E. <u>Oxidation</u>

The draft inventory continues the practice of continuing to assume that 10% of escaping methane is oxidized in the cover soil. Previously, EPA has effectively rested its case on the

53 IPCC, *Fourth Assessment Report*: Chapter 2: Changes in Atmospheric Constituents and in Radiative Forcing (2007), at p. 212, Table 2.14.

54 IPCC, Proposed New Methodology: Baseline (CDM-NMB) Version 02 (July 15, 2005). As other examples, *see, also*, German Ministry for the Environment, *Waste Sector's Contribution to Climate Protection* (Research Report 205-33-314)(2006), at p. 15.

Czepiel study, which found in field and laboratory studies during 1994 that 10% of the methane generated in a landfill was oxidized in the cover soil over the course of a year.[55]

When the gases that are emitted are diffused throughout the overlying soil blanket, as would have been the case with most landfills constructed before 1991, this study would be applicable. However, modern landfills gases are not diffused at the surface throughout that earthen layer, because, since 1991 a composite cap has been required under that soil blanket, including in practice a 60-mil (or $^{1}/_{16}$") high density polyethylene plastic membrane that effectively impedes the passage of gases from the waste into that cover soil.[56]

This is key. It means that instead of the methane diffusing throughout the topsoil for maximum oxidizing effect, the gases that are released above the landfill are concentrated in high fluxes at a handful of cracks and tears in the plastic sheet. Concentrated high flux emissions quickly overwhelm the capacity of the topsoil to oxidize the escaping methane through these hot spots.[57]

Czepiel expressly stated that not only was his study not done at a landfill with a synthetic geomembrane, but also, "[p]eriodic maintenance of the cover materials has minimized significant surface cracks" in the clay layer, as well.[58] That is to say, nothing in his study can be used to describe what happens to the methane that flashes through a small number of hot spots on the top face of the landfill.

He further reemphasized again in his conclusion that his findings did not apply when gases are released in high fluxes through narrow cracks:

> "Waste settlement, surface erosion and soil dessication often promote significant surface cracking, providing paths of minimal resistance to gas flow, effectively bypassing microbial influence. Our study generally lacked surface cracks, although his characteristic may not be representative of the entire spectrum of landfill surfaces."[59]

---

55 Czepiel, *supra,* at p. 16,721. There are two other studies listed in the draft paper. However, the one by J. Jensen et al., "CH4 Emissions from Solid Waste Disposal," *Background Papers-IPCC Expert Meetings on Good Practice Guidance* (IPCC, 2002), is not a study but a proposed protocol for estimating methane emissions from landfills. In any event, Jensen acknowledges that "[t]he oxidation effect is also highly dependent on the type and thickness of cover at the SWDS." *Id.,* at p. 429 The other by Mancinelli was withdrawn upon our inquiry. The Mancinelli study has been withdrawn because a copy of the paper cannot be located.

56 40 C.F.R. §258.60(a)(1). As noted previously (see NOTE 111 on page 74), technically, the rule only requires that the permeability of the cover not be less than the bottom liner, although in practice this is met with a composite system in the cover as well.

57 Czepiel, *supra*, at p. 16,727. Oxidation was observed to follow the Arrhenius relationship, or parabolic behavior, in which oxidation increases with greater inputs, but only to a distinct maximum, after which it rapidly declines.

58 Czepiel, *supra,* at p. 16,721.

59 Czepiel, *supra,* at p. 16,728.

Furthermore, a consultant for the U.K. Department on the Environmental conducted a comprehensive study involving 250 measurements at a landfill with a composite cover and found that there was no oxidation effect:

> "Methane oxidation is only observed where the diffusion gradient through the cap is very small, and therefore the methane oxidizing bacteria can cope with the rate of supply of gas. When higher fluxes predominate there is little evidence either for or against methane oxidation being a significant component of emission control."[60]

A similar field examination by researchers at a Swedish landfill corroborated the U.K. findings.

Other Technical Constraints on Oxidation

Even if, for the sake of argument, methane oxidation were able to occur landfills with plastic liners, there are many other limitations of Czepiel's findings when attempting to apply them without limitation to the typical landfill and across time.

For one thing, in northern climates, oxidation is improbable during cold winters. Also, in addition to the small cracks in the geomembrane, similar problems can afflict the clay liner as well. In the northern climatic zones, the freeze/thaw cycle is a constant source of cracking, and in hot, arid climates, clay is susceptible to cracking from dessication.[61] For another, remembering that landfill gas is heavier than air and seeks the path of least resistence, no one has yet been able to satisfactorily determine what proportion of landfill gases escape through the top of the landfill– where any oxidation that occurs would take place – and, through the bottom and even the sides of the site or through the leachate collection system – where it would not, as EPA has previously pointed out.[62] Then, too, there is the practical complications of maintaining optimized laboratory conditions for methanotrophs to oxidize methane over the long term at a real site.[63]

In any case, even if for the sake of argument it were considered appropriate to give the benefit of oxidation for the period of time prior to the installation of the final cover when there emissions might diffuse through any soil layer, EPA itself has stated that a concomitant reduction in collection efficiency would have to be registered to account for the lack of a seal necessary for efficient gas collection.[64]

---

60 AEA Technology, *Methane emissions from UK landfills* (UK Department of the Environment, Transport and the Regions, 1999), at p. 2-9.

61 P. Lechner, C. Heiss-Ziegler and M.H. Humer, "Reducing Greenhouse Gas Emissions: How Composting and Compost Can Optimize Landfilling," *BioCycle* (September 2002).

62 56 FEDERAL REGISTER 24492 (May 30, 1991).

63 Kightley, *supra*, at pp. 596 - 600.

64 Debra Reinhart, *First Order Kinetic Gas Generation Model Parameters for Wet Landfills* (EPA-600/R-05/072, June 2005), at p. 5-2.

●

For the foregoing reasons, it is no longer rational or responsible to continue conducting the waste section of the GHG inventory exactly as it has done so in the past only because it has always done it this way, regardless of the fact that its foundations have been vitiated by the EPA's reports.

With kinetics experts as part of a team, we stand ready to accept a commission to revise the present first order decay model to properly reflect the things that we know make its present formulation useless.

Sincerely,

CENTER for a COMPETITIVE WASTE INDUSTRY

Peter Anderson

By:__________________________________
PETER ANDERSON
Executive Director

Appendix H

CITY OF OAKLAND

250 Frank H. Ogawa Plaza, Suite 5301 OAKLAND, CALIFORNIA 94612-2034

Public Works Agency
Environmental Services Division

FAX (510) 238-7286
TDD (510) 238-3254

April 14, 2010

Mr. Leif Hockstad
Environmental Protection Agency
Climate Change Division (6207J)
1200 Pennsylvania Ave., NW
Washington, DC 20460

RE: City of Oakland Comments on the Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008 (March 2010)

Dear Mr. Hockstad:

The City of Oakland commends the U.S. EPA on continuing to track and report on U.S. greenhouse gas (GHG) emissions. We appreciate this opportunity to comment on the Draft Inventory of U.S. GHG Emissions and Sinks (Draft Inventory).

Recommendation: Include a "systems" or "consumption"-based perspective on GHG emissions within the Draft Inventory.

It is critical that we work together at all levels of government to track and report on GHG emissions in a manner that compels us to take action where we have opportunities for reduction. Framing GHG emissions in a "systems-based" or "consumption-based" view, in addition to the conventional "sector-based" view used in the current Draft Inventory, is important.

The EPA promoted this approach in its recent 2009 whitepaper "Opportunities to Reduce Greenhouse gas Emissions through Materials and Land Management Practices." The whitepaper, issued by the Office of Solid Waste and Emergency Response, presents an alternative "systems-based" perspective of GHG emissions that includes the upstream impacts of waste reduction and recycling. We find this framing equally compelling as the "sector-based" view. Each perspective has pros and cons, and each includes some data the other ignores when evaluating a nation (or community) in isolation. Most importantly, each also informs consideration of GHG reduction opportunities that the other is not set up to recognize or encourage.

We need to achieve dramatic reductions in GHG emissions, which requires that we unlock new ways of reducing our collective carbon footprint. How we tell the story of our nation's carbon footprint can help to educate and motivate the individuals, communities, and organizations that our nation comprises to act on their own opportunities to reduce GHG emissions.

Waste reduction and recycling create clear GHG reduction benefits up and down the product lifecycle chain. Our national GHG story, told through the Draft Inventory report, should be framed to cause reflection and motivate action on these GHG reduction opportunities.

Our own staff analysis has shown that GHG reductions associated with waste reduction and recycling opportunities are on the same order of magnitude as those associated with the transportation and building energy use sectors. It is important that we take action in all three of these areas. The fact that they can't all be added and depicted in one pie chart should not prevent us from telling the story of their respective importance.

The simplest solution is to include both the "sector-based" and "systems-based" perspectives in the national GHG inventory. We plan to show both perspectives in our own local GHG accounting and reporting, and are encouraging all communities to make this standard practice. This relatively small adjustment to our reporting can have a big impact in creating GHG reductions associated with lifecycle impacts of all the things we purchase, use and discard.

Please feel free to contact Garrett Fitzgerald, the City of Oakland's Sustainability Coordinator, at gfitzgerald@oaklandnet.com or (510) 238-6179 if you would like to further discuss any of these comments.

We look forward to working with you, the U.S. EPA, and other government agencies as we collaborate to reduce GHG emissions in a meaningful way.

Sincerely,

Susan Kattchee
Environmental Services Manager
City of Oakland

Appendix I

Appendix I

Main Office: 33 Central Ave, 3rd Floor, Albany, New York 12210
Phone: (518) 462-5527 ◆ Fax: (518) 465-8349 ◆ E-mail: *cectoxic@igc.org*

Websites: www.cectoxic.org ◆ www.ecothreatny.org ◆
www.toxicfreefuture.org

April 13, 2010

Mr. Leif Hockstad
Environmental Protection Agency
Climate Change Division (6207J)
1200 Pennsylvania Ave., NW
Washington, DC 20460
Also sent by email to hockstad.leif@epa.gov

Re: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008

Dear Mr. Hockstad,

We are writing to address some of the inadequacies of the national Greenhouse Gas Inventory and to make specific recommendations for more timely amendments to reflect better science and for improvements to better identify more sustainable options that achieve greenhouse gas reductions. We particularly focus on the inadequate accounting for waste and wasting in the inventory. We have actively engaged in New York's state level greenhouse gas inventory and are concerned that EPA's inventory will hurt our efforts to obtain better scientific treatment of waste issues.

- As currently structured the national inventory gathers rough estimates of end of the pipe emissions of greenhouse gas emissions.
- To a great extent the inventory looks at historical information.
- The national inventory uses conventions adopted for the 2nd IPCC assessment. As a result newer, better information since that time are not being incorporated into the national greenhouse gas inventory.
- The categories of emissions primarily relate to extremely large sectors of combustion sources-- power plants, mobile sources, heating of buildings, etc. The accuracy of these emissions estimates is limited by the methodology and the broad economy- wide focus.
- Despite such problems numerous entities, public and private are engaged in this data collection devoting significant time, energy and personnel resources to the effort.
- There is a massive task before us: achieving 80% reduction in greenhouse gas emissions by 2050 nationally and also globally. Unfortunately, the national inventory is so broad that it is really not useful in identifying the solutions we desperately need immediately.

We recommend amendments to the national inventory and that EPA:

1. Seek global agreement to update the methodology so that it reflects the best current scientific information.
2. Continue to use the agreed upon 2nd IPCC assessment guidance, but add a supplement to the inventory that reflects current understanding of better scientific information. This also will help identify additional opportunities for greenhouse gas reductions. For example, see our discussion of issues related to WASTE below.
3. Identify solutions and best practices which can be implemented immediately by state and local governments. All solutions and best practices should be sustainable, offering benefits in 3 spheres -economic, environmental and social-- with no damaging or detrimental drawbacks. Adopting sustainable solutions becomes easy, when multiple benefits, beyond GHG reductions, are within reach .
4. Do more analysis at the micro-level. What is the most efficient way to get food from the farm to household dinner tables? the most efficient way to deliver health care? How energy efficient can supermarkets be made? Hospitals? Sewage treatment plants? Schools? Various industries? Etc.
5. Strive to make all of the systems we use and rely on - sustainable. Until we do we will not be able to address climate change.
6. Immediately address WASTE and WASTING in a much more substantial way. Post World War II we have dramatically increased the amount of waste we generate. WASTE and WASTING are similar to energy losses, except that waste involves the loss or destruction of material resources as well as embedded energy.

Waste

Waste involves a huge sector of our economy that is not adequately captured in the greenhouse gas inventory. This was illustrated for us recently as we worked on NY Climate Action Plan. New Jersey calculated much greater lifecycle emissions vs. direct emissions for waste management. The failure to include upstream GHG emissions and embodied energy in materials serves to disadvantage the most sustainable solid waste options (recycling and composting) vs. the most unsustainable solid waste options (incineration). Doing so flies in the face of EPA's WARM model which finds recycling to save 4-5 times the energy an incinerator recovers from waste. Waste and Energy Loss have many things in common and as a result no inventory can be considered adequate that gives little attention to waste.

We were also shocked to not see reference to EPA's recent report that put greenhouse gas emissions associated with non-food products and packaging at 37%, *EPA, Opportunities to Reduce Greenhouse Gas Emissions through Materials and Land Management Practices*, Sept. 2009. Joshuah Stolaroff, PhD worked on the EPA report and subsequently extended the analysis to include products produced abroad and consumed in the US. This Product Policy Institute white paper states total GHG emissions of non-food products and packaging is 44%. Both reports can be accessed at www.productpolicy.org Such information tells us that we are not appropriately accounting for the greenhouse gas impacts of waste. EPA's own WasteWise program has numerous examples of large corporations saving millions of dollars by reducing, reusing and recycling waste at their facilities. The dollars saved relate to less waste sent for disposal, less water use, less energy use, more efficient use of materials,etc. We have also included a factsheet we have prepared: *Waste Impacts Climate Change.*

Methane

Global Warming Potential for Methane is listed as 21. We don't know the reason for using the 2^{nd} IPCC assessment guidance for assembling the inventory rather than the 4^{th}. However, methane is pretty unique and needs to have special consideration. It has now been recognized that methane has a relatively short life span in the atmosphere compared to CO2. It also has much greater global warming potential. Because of its shorter life, its global warming potential should be considered over 10 or 20 years, rather than 100 years. The 4^{th} IPCC assessment puts the global warming potential at 72 over a 20 yr. period. A subsequent report from NASA puts the GWP at 34x CO2 for the long term and 105x in the near term because of its contribution to ozone formation.

> IPCC, *Fourth Assessment Report*: Chapter 2: Changes in Atmospheric Constituents and in Radiative Forcing (2007), at p. 212. Most recently, methane's warming potential has been more extensively investigated and NASA's scientists now consider methane to be 34x CO_2 in the long-term, and 105x in the near term, after factoring in indirect impacts on the formation of aerosols, which is another greenhouse gas. Drew Shindell, "Improved Attribution of Climate Forcing Emissions," 326 SCIENCE 716 (2009).

There are important reasons to consider a shorter time frame for climate change. If we can adequately tackle significant greenhouse gases in the short term we might be able to avoid or delay the tipping point for a runaway situation. Doing so would give us more time to institute other more complicated measures to control CO2. Methane can be key to these short term measures.

According to climate scientists at the National Aeronautics and Space Administration (NASA), the combination of methane's potency, and its short lifetime in the atmosphere, plays an especially critical role in the near term when we confront those critical tipping points:

> "[F]easible reversal of the growth of atmospheric [methane] and other trace gases would provide a vital contribution toward averting dangerous anthropogenic interference with global climate...[Methane] deserves special attention in efforts to stem global warming...Given the difficulty of halting near-term CO_2 growth, the only practical way to avoid [dangerous interference] with climate may be simultaneous efforts to reverse the growth of [methane].[11]

Similarly, Robert Watkins, the co-chair of the IPCC's Third Assessment, recently wrote in the disappointing aftermath of Copenhagen:

> "This month's Copenhagen talks focused on the leading climate change culprit: CO_2. But reversing global temperature increases by reducing carbon emissions will take many decades, if not centuries. Even if the largest cuts in CO_2 contemplated in Copenhagen are implemented, it simply will not reverse the melting of ice already occurring ...The most obvious strategy is to make an all-out effort to reduce emissions of methane. Methane's short life makes it especially interesting in the short run, given the pace of climate change. If we need to suppress temperature quickly in order to preserve glaciers, reducing methane can make an immediate impact. Compared to the massive requirements necessary to reduce CO_2, cutting methane requires only modest investment. Where we stop methane emissions, cooling follows within a decade, not centuries. That could make the difference for many fragile systems on the brink."[12]

11 James Hansen, "Greenhouse gas growth rates", 101 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES 46 (November 16, 2004), p. 161094.

12 Robert Watson and Mahamed El-Ashry, "A Fast, Cheap Way to Cool the Planet," *The Wall Street Journal* (December 29, 2009).

The Above References are from *Beyond Recycling: Composting*, by the Center for a Competitive Waste Industry, prepared for EPA, Region 9 by Peter Anderson, Gary Liss and Steve Sherman, p.9-10.

Landfills do not reach 75% gas collection efficiency.

We are attaching Peter Anderson's memo to these comments. He is a landfill expert and thoroughly reviews the issues around LF gas collection efficiency. Please read his memo in conjunction with this section.

In brief the issues are:

- Landfills are not properly enclosed with an impermeable cap until they are closed.
- The majority of a landfill's operating life (62%) occurs before this impermeable cap and LFG collection system are installed.
- EPA has no factual basis upon which it settled on 75%; it represents wishful thinking.
- There are no field measurements of efficiency of landfill gas collection systems.
- The best evidence of lifetime capture rates are closer to 20%.

Given the highly questionable assumptions related to LFG collection efficiency, we believe it is not possible to accept EPA's estimate of 52% of carbon being sequestered in landfills for purposes of the GHG inventory. We recommend a lower percentage.

For these and other reasons, Peter Anderson reaches the conclusion that diverting organics from landfills has 260 times the benefits of LFG to energy collection systems.

The most sustainable climate change strategy is to divert biodegradable organics including food scraps away from landfills to composting or anaerobic digestion. Food waste should first be prevented, then unused food should feed people, then animals. Remaining food scraps should be composted or anaerobically digested and returned to soils.

Returning these nutrients to soils increases soil nutrients, displaces artificial fertilizers, builds soil holding capacity, decreases run-off, increases water holding, fights plant diseases, increases plant growth and food nutrients, while building soil carbon. Building healthy soil from diversion of biodegradable organic materials is a key example of a sustainable system with lots of ancillary benefits for farmers, nursery businesses and the consuming public. Anaerobic digestion also produces methane, which is a renewable energy source that more reliably captures and uses methane than a leaky landfill ever could.

Unfortunately to date, EPA has not captured the multiple environmental benefits of composting in its WARM model. While EPA is attempting to update this model, even the update will not be capable of capturing all of the above benefits. We believe it is possible to capture the sustainable benefits of a system qualitatively first, before you have all of the numeric measurements to complete a quantitative analysis.

Biogenic Emissions

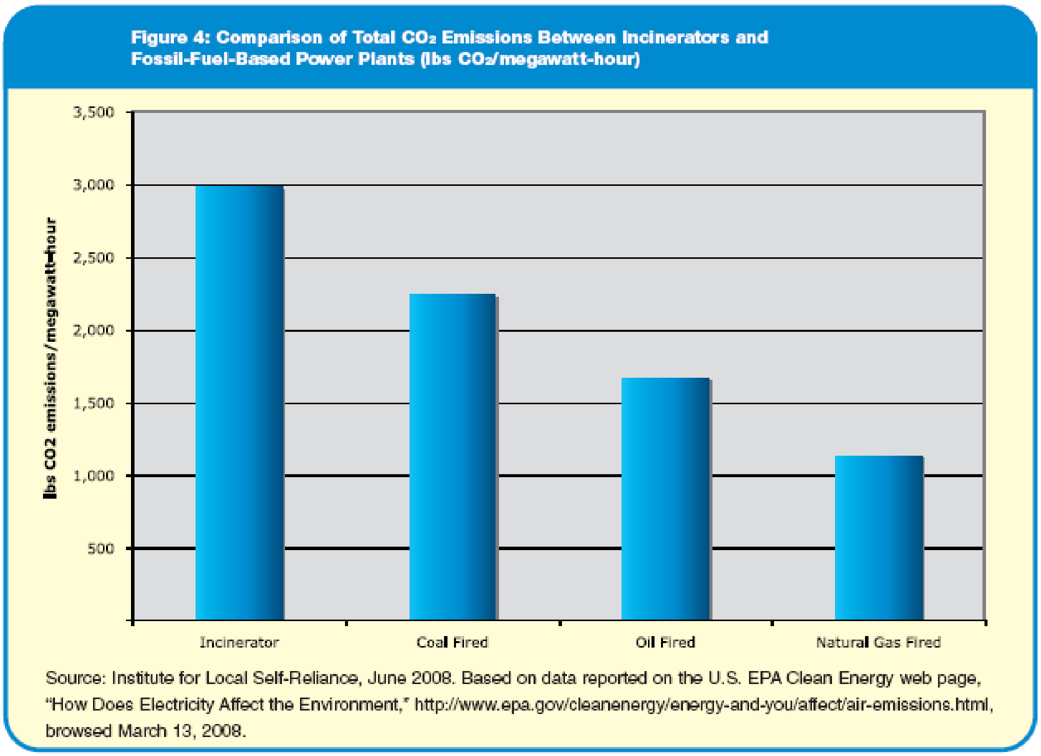
It is critical that biogenic emissions be addressed with a more critical eye. The current treatment of biogenic emissions provides a distinct advantage to incineration. MSW incinerators rely on an unsustainable waste system—a system that emphasizes disposal over waste reduction, reuse and recycling. Because incinerators destroy resources, those resources cannot be reused or recycled. Thus incinerators by destroying resources prevent their handling by more environmentally sound means that preserve resources and energy. The favorable treatment accorded biogenic emissions coupled with the failure to adequately count the benefits of composting serves to disadvantage the most sustainable option for handling organic waste materials.

In addition, there is a substantive difference between sustainably harvested biomass and the cutting down of irreplaceable rainforests. As currently handled the treatment of biogenic emissions is a one size fits all. As a result it is ripe for abuse.
Incinerators and other thermal treatments are the most problematic in this regard.

- All such equipment uses fossil fuel to operate, but this is often not quantified.
- What is burned is not just unprocessed biogenic material, but material that has had large energy inputs in the processing to a finished product. The modeling here does not include this embodied energy.

- Raw material resources are destroyed in thermal treatment. To get more paper, cardboard, etc. you have to cut down more trees.
- Green organic materials have a high water content and thermal treatments are using energy largely to remove water.
- There are higher and better uses for all materials to be burned in an incinerator and the processing costs are always less than thermal treatment.

This graph shows the total CO2 emissions of incinerators compared to fossil fuel plants.
Stop Trashing the Climate report



Below are some sections of the report *Stop Trashing the Climate* p. 39-40, which discuss the issue of biogenic emissions. www.stoptrashingtheclimate.org

The rationale for ignoring CO_2 emissions from biomass materials when comparing waste management and energy generation options often derives from the Intergovernmental Panel on Climate Change (IPCC) methodology recommended for accounting for national CO_2 emissions. In 2006, the IPCC wrote:

> "Consistent with the 1996 Guidelines (IPCC, 1997), only CO_2 emissions resulting from oxidation, during incineration and open burning of carbon in waste of fossil origin (e.g., plastics, certain textiles, rubber, liquid solvents, and waste oil) are considered net emissions and should be included in the national CO_2 emissions estimate. The CO_2emissions from combustion of biomass materials (e.g., paper, food, and wood waste) contained in the waste are biogenic emissions and should not be included in national total emission estimates. *However, if incineration of waste is used for energy purposes, both fossil and biogenic CO_2 emissions should be estimated. Only fossil CO_2 should be included in national emissions under Energy Sector while biogenic CO_2 should be reported as an information item also in the Energy Sector.* Moreover, if combustion, or any other factor, is causing long term decline in the total carbon embodied in living biomass (e.g., forests), this net release of carbon should be evident in the calculation of CO_2 emissions described in the Agriculture, Forestry and Other Land Use (AFOLU) Volume of the 2006 Guidelines."[127] *[emphasis added]*

There is no indication that the IPCC ever intended for its national inventory accounting protocols to be used as a rationale to ignore emissions from biomass materials when comparing energy or waste management options outside of a comprehensive greenhouse gas inventory. Rather, the guidelines state "…if incineration of waste is used for energy purposes both fossil and biogenic CO_2 emissions should be estimated."

The bottom line is that tremendous opportunities for greenhouse gas reductions are lost when a material is incinerated. When calculating the true climate impact of incineration as compared to other waste management and energy generation options, it is essential that models account for the emissions avoided when a given material is used for its highest and best use. This means, for instance, taking into account emissions that are avoided and carbon sequestered when materials are reused, recycled or composted as compared to incinerated. More climate-friendly alternatives to incinerating materials often include options such as source reduction, waste avoidance, reuse, recycling, and composting.

When wood and paper are recycled or source reduced, rather than incinerated, forests sequester more carbon. In other words, when we reduce the amount of materials made from trees, or when we reuse or recycle those materials, fewer trees are cut down to create new products. This leads to increased amounts of carbon stored in trees and soil rather than released to the atmosphere. As the EPA writes in its 2006 report *Solid Waste Management and Greenhouse Gases*, "… forest carbon sequestration increases as a result of source reduction or recycling of paper products because both source reduction and recycling cause annual tree harvests to drop below otherwise anticipated levels (resulting in additional accumulation of carbon in forests)."[128]

Thank you for your attention. We would appreciate being informed of future developments to improve the greenhouse gas inventory.

Sincerely,

Barbara J. Warren
Executive Director

encl: Factsheet- Waste Impacts Climate Change
Memo prepared by Peter Anderson

Waste Impacts Climate Change

- Wasting directly impacts climate change because it is directly linked to resource extraction, transportation, processing and manufacturing, all of which use energy and generate emissions. Two recent reports examined the greenhouse gas impacts of products and packaging, the first from EPA found 37% of GHGs associated with non-food products and packaging. The second report was a follow-up and included global trade, although food was still not included; it found 44% of GHGs associated with products and packaging. (Both reports available at www.productpolicy.org)

- For every bag of trash a household puts at the curb, 70 bags of trash were created upstream in the production process.

- Zero waste strategies-waste reduction, reuse, recycling, and composting-- are the fastest, cheapest and most effective strategies to protect the climate and the environment. All are associated with greenhouse gas reductions, in addition to many other benefits.

- Using zero waste strategies and significantly decreasing disposal in landfills and incinerators can reduce GHGs the equivalent of closing 1/5 of all US coal-fired power plants. (See www.stoptrashingtheclimate for this excellent report.)

- Waste reduction and material recovery strategies are ESSENTIAL to putting us on a path to stabilize the climate by 2050. Greenhouse gas reductions of 80% are needed and we cannot accomplish this goal without adequately addressing waste.

- Waste incineration and other thermal technologies* do not produce clean, renewable energy. It relies on destroying precious resources, is environmentally polluting and puts out 36% more CO_2 than coal-fired power plants. Recycling is renewable energy saving 4-5 times more energy than an incinerator recovers.

- Biodegradable materials like food and yard waste degrade in landfills and produce methane, a powerful greenhouse gas with 72 times the global warming potential of CO2 over a twenty year period. Adequate control of greenhouse gases is even more essential over the next twenty years, because of the possibility of a runaway situation for warming.

- Landfills even ones with good gas capture systems are able to collect only about 20% of the methane that is generated. (IPCC 4th Assessment, Working Group III, Mitigation of Climate Change, 10.4.2.)

- Composting of biodegradable material results in a valuable product that improves soil--increasing nutrients, water retention, and healthy plant growth while reducing plant diseases and the need for synthetic fertilizers. Increasing soil carbon is an added climate change benefit.

*Newer thermal technologies include gasification, pyrolysis, plasma arc and other creative descriptions. All are commercially unproven for mixed waste, but their claims sound wonderful.

Greenhouse gas emissions inventories often inappropriately deal with the issue of Biogenic Emissions.
Biogenic emissions are considered natural emissions from the carbon cycle. However burning waste should not be considered renewable because it relies on the destruction of resources rather than preservation. Often inventories do not count the biogenic emissions (CO_2 emissions generated by burning paper, wood, food and yard waste) from incinerators. This could arise from a misunderstanding of IPCC guidance. The IPCC states, " if incineration of waste is used for energy purposes, both fossil and biogenic CO_2 emissions should be estimated."

- All incinerators and thermal technologies use fossil fuel to operate, but this is often not quantified.
- What is burned is not just unprocessed biogenic material, but material that has had large energy inputs in the processing to a finished product. Incineration does not recover this embodied energy, but recycling does.
- Green organic materials have a high water content and thermal treatments are using energy largely to remove water.
- There are higher and better uses for all materials to be burned in an incinerator and any alternative processing costs for composting and recycling are always less than thermal treatment.
- Raw material resources are destroyed in thermal treatment. To get more paper, cardboard, etc. you have to cut down more trees. As EPA states, "forest carbon sequestration increases as a result of source reduction or recycling of paper products because both source reduction and recycling cause annual tree harvests to drop below otherwise anticipated levels (resulting in additional accumulation of carbon in forests). " *Solid Waste Management and Greenhouse Gases*, 2006 EPA Report.

EPA assumes landfills reach 75% gas collection efficiency. In reality:

- Landfills are not properly enclosed with an impermeable cap until they are closed.
- The majority of a landfill's operating life (62%) occurs before this impermeable cap and LFG collection system are installed.
- EPA has no factual basis upon which it settled on 75% collection efficiency; it represents wishful thinking.
- There are no field measurements of efficiency of landfill gas collection systems.
- The best evidence of lifetime capture rates are closer to 20%. (IPCC 4th Assessment, Working Group III, Mitigation of Climate Change, 10.4.2.)
- Significant carbon sequestration in landfills is thus highly questionable.

ZERO WASTE STRATEGIES can significantly reduce disposal and greenhouse gas emissions. ZW strategies provide cost savings, while also creating jobs and economic development. ZW strategies are good for New York and good for our climate.

For 2004, New York recycling reduced greenhouse gas emissions by 5,212,571 metric tons of carbon equivalents (MTCE) in a one year period. New York's recycling saved a total of 230,964,227 Million BTUs of energy. Recycling 811,057 tons of newspapers, phone books, office paper, textbooks, magazines and cardboard in 2004, New York resulting in forest carbon sequestration benefits equal to 54,885,090 tree seedlings grown for 10 years.(Northeast Recycling Council, NY 2004 factsheet.)

Prepared for NY Zero Waste Alliance, managed by Citizens' Environmental Coalition, 33 Central Ave. Albany, NY 12210, 518-462-5527. Contact Barbara Warren also at 845-754-7951 or warrenba@msn.com

Appendix J

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

APR 1 6 2010

REPLY TO THE ATTENTION OF:

L-8J

MEMORANDUM

SUBJECT: Comments on Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008 (March 2010)

FROM: Margaret M. Guerriero, Director
Land and Chemicals Division

TO: Leif Hockstad, OAR Climate Change Division
Brian B. Cook, OAR Climate Change Division

We appreciate the importance of updating the Inventory of U.S. Greenhouse Gas (GHG) Emissions and Sinks (Inventory) and the need to follow IPCC Guidelines and sector categories for consistency with UNFCCC reporting guidelines. We also appreciate your decision to re-allocate the emissions into more commonly used sector categories to improve the usefulness of the Inventory. We recommend that you consider including additional re-allocations, including those presented in Opportunities to Reduce Greenhouse Gas Emissions through Materials and Land Management Practices, USEPA OSWER, September 2009 (See chart on page 11, www.epa.gov/oswer/docs/ghg_land_and_materials_management.pdf).

Last year, EPA's Office of Solid Waste and Emergency Response completed a peer-reviewed analysis of the U.S. inventory that shows a systems-based view of emissions, "where each system represents and comprises all parts of the economy working to fulfill a particular need." While the current Inventory's sector-based view is helpful for identifying end-of-pipe strategies for reducing emissions within sectors, OSWER's systems-based view is helpful for identifying opportunities to reduce our GHG emissions through prevention-oriented mitigation strategies.

From our perspective, as a regional pollution prevention and sustainable materials management program, the systems view provides more insight to state and local governments, industry, and individuals looking for opportunities to reduce greenhouse gas emissions through policy options and behavior changes. While the draft Inventory acknowledges that the use of scrap material contributed to the decline in emissions from iron and steel production, the sector – based view of the data makes it difficult to identify other areas where material choices may impact emissions. OSWER's systems-based view estimates that 42 percent of the total U.S. GHG emissions are associated with materials management decisions. For a state or local government developing a climate action plan, knowing the relative emissions profiles of various systems (e.g., the provision of goods is responsible for 29 percent of emissions, relative to local passenger transport at 15 percent of emissions) is more helpful than the end-of-life emissions from materials as a result of landfilling, composting, and wastewater treatment provided in the current Inventory. In other words, the current Inventory does not reveal the total GHG emissions associated with goods and services across their life cycle. When viewed by systems, the impacts of consumption on our national GHG emissions are far more impressive, and highlight the importance of reducing both overall consumption and the emissions across the lifecycle of goods and materials.

We encourage you to revise the draft Inventory to include, at a minimum, a reference to this important and insightful EPA, peer-reviewed resource. Ideally, future versions of the Inventory will include both a sector-based and a systems-based view to present a more comprehensive picture of U.S. GHG emissions.

If you have any questions, please contact me, or your staff may contact Julie Gevrenov, of my staff, at (312) 886-6832.

cc: Brigid Lowery, Acting Director, OSWER Center for Program Analysis