Summary of Public Comments and Responses: Draft *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015*

April 2017

U.S. Environmental Protection Agency,
Office of Atmospheric Programs, Washington, D.C.

Responses to Comments Received during the Public Review Period on the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015*

Preface

EPA thanks all commenters for their interest and feedback on the annual *Inventory of U.S. Greenhouse Gas Emissions and Sinks*. Per Federal Register Notice FRL–9959–29–OAR published on February 15, 2017 the Environmental Protection Agency (EPA) announced document availability and request for comments on the draft "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015" report. The EPA requested recommendations for improving the overall quality of the inventory report to be finalized in April 2017 and submitted to the United Nations Framework Convention on Climate Change (UNFCCC), as well as subsequent inventory reports.

During the 30-day public comment period, EPA received 47 unique comments in response to the notice. This document provides EPA's responses to technical comments on methods and data used in developing the annual greenhouse gas inventory. The verbatim text of each comment extracted from the original comment letters is included in this document, arranged by commenter. EPA's responses to comments are provided immediately following each comment excerpt.

Commenter: 3M Electronics Materials Solutions Division

Kurt Werner

***Comment*:** *Suggested Revisions to Table A-146: Fire Extinguishing Market Transition Assumptions*. 3M's assumptions with regard to market share transition from halons to HFCs and Non ODP/GWP alternatives are very different than what is reflected in Table A-146, especially the assumption that the market for HFC-227ea in the mid to late 1990s is only 18% of the original halon market. 3M fully recognizes that, due to cessation of discharge testing and pricing of substitute agents, the clean agent market was substantially smaller after the phase-out of halon. The assumptions in A-146, however, do not appear to consider the technology boom of the late 1990s or the fact that substantially more HFC is necessary per protected space than halon. Appendix I includes the original Table A-146 and a second Table A-146 with 3M recommended edits.

As you consider updating the U.S. inventory of GHG emissions, please consider these comments related to the fire suppression sector. The market dynamics impacting the evolution and uptake of halon alternatives has meaningfully changed since the original assumptions were established. Please also note that some of the original assumptions with regard to the size of halon replacement may need to be considered. Contrary to voluntary industry reporting, measured atmospheric concentration suggest that emissions of HFCs from the fire suppression continue to rise and this should not be surprising given the increasing installed base of HFC fire suppression systems. Future HFC emission rate estimates from the fire suppression sector should also consider that the secondary market for HFCs in fire suppression is saturated and there is essentially no market for recovered HFC-227ea.

Response: **As new fire suppressants enter the market, the U.S. EPA's Vintaging Model does account for the relative quantity of fire suppressant used in fire protection systems by using replacement ratios, with 1 kilogram of halon as the basis. These replacement ratios are chemical-specific, constant, and are based on NFPA 2001: Standard on Clean Agent Fire Extinguishing Systems and industry estimates. EPA will consider adopting the suggested market penetration revisions (shared separately by 3M) to Table A-146.**

EPA looks forward to working with the commenter during the peer review of the Vintaging Model to understand the following: data sources informing the proposed market transition assumptions; information supporting the suggestion that all HFC-227ea will be emitted (rather than incinerated or recycled) as systems are decommissioned in a saturated secondary market where there is no market for recovered HFC-227ea; and how the global atmospheric concentration of HFC-227ea estimated by Laube et al. (2010) can quantitatively inform historical and projected emissions from the total flooding protection sector in the United States.

Commenter: American Fisheries Society

Robert M. Hughes

Comment: I agree with the importance of forests and grasslands as C sinks. And I agree that wood harvested for energy production should be treated as a C emission. I agree with using the FIA estimates of wood volume to arrive at national estimates of forest C, as well as the NRCS estimates of soil C for estimating grassland C. I also agree with the need to obtain accurate estimates of soil C status and

trends for Alaska grasslands & wetlands. I believe there are large stores of C in those systems, and as they dry and warm they will release C.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Comment: I am unclear and concerned about the accuracy of the CH4 estimates from the oil and gas industry. Unlike the USDA, industry reports suffer from both real and potential conflicts of interest. I am particularly concerned with unreported CH4 leakage from fracked wells, rock, and water sources. In addition, I am concerned about inaccurate well counts, inaccurate well locations, and incomplete/faulty sealing of abandoned and inactive wells.

Response: **The Inventory uses a variety of data sources to calculate emissions of CH_4 from oil and gas, and conducts QA/QC and Verification activities on the data. Please see the QA/QC and Verification section in 3.5 Petroleum Systems and 3.6 Natural Gas Systems. Methane emissions from hydraulically fractured completions and workovers are included in the production segment emission for both petroleum and natural gas systems. The Inventory has been revised to use updated well count data; see the Recalculations Discussion section in 3.5 Petroleum Systems and 3.6 Natural Gas Systems. Emissions from abandoned wells are discussed in the Planned Improvements section of both 3.5 Petroleum Systems and 3.6 Natural Gas Systems. Well location information is not used in the calculation of the Inventory.**

Commenter: American Petroleum Institute

Karen Ritter

Comment: *Specific Correction for Petroleum Systems Data***.** *In Tables 3-36 and 3-37, the numbers presented do not sum to the total for Production Field Operations. In the previous national inventory, EPA included a line item for miscellaneous venting and flaring to include the sum of all other sources not listed. This line should be added to both tables for the final report.*

Response: **The table has been updated in the final Inventory. Please see 3.5 Petroleum Systems.**

Comment: *Transparency***.** The Annex Tables 3.5 and 3.6 provide the emission factors, activity data, and resulting CH4 emissions for every source across the full time series (1990-2015). This level of detail has not been provided previously. API supports these tables as an addition to the information previously provided in the inventory annex sections for petroleum systems and natural gas systems. Specifically, API requests that EPA maintain the detail provided in the annexes from previous GHGI reports in addition to the new tables.

API also requests that numeric tables be provided to stakeholders in Excel format. Annex Tables 3.5 and 3.6 also provide considerable abbreviated descriptions of the data sources for the emission factors and activity data. More detail is needed for some sources to fully understand how EPA developed the final data that is used for the emissions calculations. For example, the Petroleum Systems annex notes that counts of storage tanks in the Production segment for 2011-2015 are based on 2015 GHGRP Subpart W data. However, there is neither discussion of how these counts were extrapolated from the Subpart W reports to a national level nor any discussion of how the 2015 data were used to apply to the years

2011-2014. API requests additional transparency for emission sources where multiple steps are used to derive either the activity data or the emission factor.

Response: **For the final Inventory, EPA has provided the annex tables reported in previous Inventory reports, the additional level of detail provided in the Public Review draft, and an expanded data discussion, in Excel format. Please see https://www.epa.gov/ghgemissions/natural-gas-and-petroleum-systems-ghg-inventory-additional-information-1990-2015-ghg.**

Comment: *Well Counts***.** API has addressed EPA's update to well counts in its letter of 1/27/2017 as part of the expert review of EPA's proposed methodology updates for Natural Gas and Petroleum Systems Production emissions. API continues to support the proposed revised methodology and has indicated that the well counts described in the agency's memo result in EPA's revised well count aligning with, and becoming far more comparable to, other data sources (such as Energy Information Administration, World Oil, Independent Petroleum Association of America, and API's queries of DI Desktop). API welcomes EPA's indication that it received feedback where other stakeholders generally support the revised well counts and agree that it introduces more consistency with recently published well count estimates. API is looking forward to the results of EPA's further comparison of current estimates with stakeholders' well counts also derived from DrillingInfo, investigation of differences, and establishing revised well counts in the final Inventory. API understands that this may potentially result in additional changes to calculated emissions from sources that rely on oil well counts for activity data (e.g., pneumatic controllers, equipment leaks, and storage tanks). A large number of the national equipment counts used in both petroleum systems and natural gas systems production are based on scaling well counts from the GHGRP. Based on API's review of the public review draft of the GHGI, it appears that EPA derives the GHGRP 2015 well counts from the major equipment count reported for Equipment Leaks (file EF_W_EQUIP_LEAKS_ONSHORE). However, API notes that these counts differ from the well data reported under 98.236(aa) (File EF_W_INTRODUCTION_SUMM), as shown in Table 1 below. EPA needs to resolve the differences between these two numbers reported through the GHGRP. API contends that the well counts reported under the sector summary information are more reliable.

Table 1. Comparison of Well Counts

GHGRP File Name	Oil Wells	Gas Wells
EF_W_EQUIP_LEAKS_ONSHORE	Wellheads for crude oil production equipment = 219,433	Wellheads for Natural Gas Production Equipment = 307,737
EF-W_INTRODUCTION_SUMM	Well producing for Oil formations = 213,890	Wells producing for Gas formations = 277,327
	Wells Acquired for Oil formations = 4,510	Wells Acquired for Gas formations = 11,633
	Wells Divested for Oil formations = 3,230	Wells Divested for Gas formations = 6,525
	Wells completed for Oil formations = 10,432	Wells completed for Gas formations = 4,911
	Wells removed from service for Oil formations = 4,523	Wells removed from service for Gas formations = 2,326

Response: **In the current Inventory, EPA has included updated well counts natural gas and petroleum systems. See the Recalculations Discussion sections in 3.5 Petroleum Systems and 3.6 Natural Gas Systems. EPA will update the next Inventory with resubmitted data, which may result in minor changes in equipment counts per well for 2015.**

Comment: *Data Quality***.** API reiterates that the EPA should carefully analyze and screen Subpart W reported data in order to improve the validity of data used in the national GHGI. EPA should have an established procedure for identifying obvious data errors and/or outliers, and for correcting or excluding those outliers to prevent disproportionately impacting the derivation of emission factors (EFs) or extrapolation of potentially erroneous information for inclusion in the national GHGI.

In addition, as EPA is evaluating data available from new studies, it is important to understand the applicability of these studies for a national inventory. API reiterates the need to vet new studies and data through a multi-stakeholder group prior to updating the GHGI. API proposes that such a working group be convened following the completion of the 2017 GHGI to provide a structured framework, and agreed upon timeline, for consultation and review of GHGI updates. An early start (April 2017) and frequent meetings (every 1-2 months) would provide sufficient time to review and consolidate "developing" information in an informed process for updating the 2018 GHGI and beyond.

Response: **EPA has a multi-step data verification process for GHGRP data, including automatic checks during data entry, statistical analyses on completed reports, and staff review of the reported data. Based on the results of the verification process, EPA follows up with facilities to resolve mistakes that may have occurred.[1] See the QA/QC and Verification discussion in 3.5 Petroleum Systems and 3.6 Natural Gas Systems. Information on EPA's stakeholder process for the 2018 Inventory is available at https://www.epa.gov/ghgemissions/natural-gas-and-petroleum-systems.**

Comment: *Associated Gas Venting and Flaring***.** Significant changes have been made to estimating emissions from associated gas venting and flaring in the RY 2015 inventory compared to previous years which addressed only stripper wells. This is an area that requires further study because operational practices that result in either venting or flaring are linked to the availability of appropriate infrastructure to capture and use associated gas, rather than vent or flare it. This is a dynamic situation that varies from year to year and from region to region, and requires further analysis of information available through the GHGRP.

Response: **For the current Inventory, the associated gas venting and flaring estimates have been updated to use year-specific 2011 through 2015 GHGRP data for the years 2011 through 2015 in the Inventory, and an estimate based on 2011 GHGRP data and assumptions about flaring earlier in the times series for 1990 through 2010. EPA agrees that these practices can vary and continues to seek information on associated gas venting and flaring, in particular for earlier years of the time series; please see the Planned Improvements discussion in 3.5 Petroleum Systems.**

Comment: *Gas Processing Compressors***.** API's analysis for gas processing compressor's average emission factors was previously presented to EPA in a letter of 2/13/2017 (including attachments and technical memoranda). API recommends that emission factors be derived based on average GHGRP data from 2013 through 2015 to account for the variability in measured components and the use of controls. Furthermore, API recommends that going forward it may be appropriate to use the GHGRP data reported for compressor emissions each year, or on a rolling three-year average, depending on data variability in future years.

Response**: For the current Inventory, the gas processing compressors estimates were updated to use data from EPA's GHGRP, for the year 2015. EPA will consider refinements to these estimates, such as**

[1] https://www.epa.gov/sites/production/files/2015-07/documents/ghgrp_verification_factsheet.pdf

use of additional years of GHGRP data and/or using a rolling 3-year average of GHGRP data, for future Inventory reports. Please see the Planned Improvements section of 3.6 Natural Gas Systems.

Comment: *Abandoned Wells***.** EPA indicates that it is seeking emission factors and national activity data available to calculate emissions from abandoned wells. API contends that this is an area that requires further study and determining a national count of abandoned wells will be challenging. API cautions EPA that current studies (Townsend-Small et al. 2016 and Kang et al. 2016) are limited in scope and should not be extrapolated broadly.

Response**: EPA agrees that associated gas wells require further study. Please see the Planned Improvements section of 3.6 Natural Gas Systems and 3.5 Petroleum Systems.**

Comment: *Gas STAR Reductions***.** API agrees that many emissions sources in the GHGI are now calculated using net emissions approaches, with technology-specific activity data and emission factors, and annual data from the GHGRP. For these emission sources it may not be necessary to adjust for Natural Gas Star reductions, which may result in double-counting of reductions. Removing the Natural Gas Star reductions from these sources would improve transparency of the results and methods by relying on direct net emission calculations. However, where applicable, EPA should continue to apply the Natural Gas Star reductions for those specific sources for which only potential emission data is available.

Response: **We agree that Gas STAR reductions should be removed for sources which are calculated with net emissions approaches. In the Inventory, Gas STAR reductions have been removed from the petroleum production segment and the natural gas processing segments, which are now calculated using a net emissions approach. For the natural gas production segment, though many sources in production are now calculated with net factor approaches, several sources are calculated with potential emissions approaches, and therefore some of the Gas STAR reductions are subtracted from the production segment estimates. To address potential double-counting of reductions, a scaling factor is applied to the "other reductions" to reduce this reported amount based an estimate of the fraction of those reductions that occur in the sources that are now calculated using net emissions approaches. The fractions were recalculated in the current Inventory to take into account that tanks are now calculated with net emissions approaches, and to address minor errors in the previous calculation. Please see the Recalculations Discussion section of 3.5 Petroleum Systems and 3.6 Natural Gas Systems.**

Commenter: Applied Geosolutions and World Resources Institute

Stephen Hagen and Nancy Harris

Comment: *Area of forest land converted to grassland***.** Table 6-7 indicates that nearly 4.6 million hectares of forest land were converted to non-forest land each year over the last five years, 4 million hectares of which were converted to grassland. This number seems high, given that forest land to grassland conversion in the lower 48 states between 2006 and 2011 was approximate 1 million ha/yr on average, as estimated from NLCD data. While we recognize the mismatch in years of analysis (2006-2011) and that NRI rather than NLCD is the source of data used for estimating this conversion type in the lower 48 states, the rate of conversion of forest land to grassland estimated using NRI data is about four times higher than estimates derived from NLCD. The acknowledgement of this difference, as well as the inclusion of some language of clarification in the inventory, seems warranted.

Given the combination of data sources used in the inventory to represent the U.S. land base, it is also unclear in the inventory draft how much, if any, of this forest land to grassland conversion occurred in managed lands in Alaska, where NLCD is the data source used to determine transitions yet no NLCD data are currently available for years past 2011. The 2001 to 2011 NLCD product estimates that approximately 0.3 million ha/yr of forest land is converted to grassland in Alaska. Notwithstanding this fact, it is our experience that changes in land cover, as provided by the NLCD, are not always changes in land use. Specifically, a loss of tree cover associated with a clear cut harvest can appear in NLCD as a change from forest land to grassland, but if the land is intended to regrow into forest, the land use is to remain forest land. It is also our understanding that emissions associated with harvest are accounted for in the Forest Land Remaining Forest Land and Harvested Wood Pools section (pages 6-23, 6-24). While we have no evidence of double counting here, we want to note this possibility and request clarification.

***Response*: The amount of area classified as Forest Land Converted to non-Forest Land is the cumulative total over a 20-year period, and not the annual conversion. The *IPCC Guidelines* require that land converted to another land use remain in the land use conversion category for 20 years (e.g., *Forest Land Converted to Grassland*), and this is the reason for the 20-year cumulative total, instead of just the amount of land converted on an annual basis. In addition, the source of the Forest Land use conversion data is the Forest Inventory and Analysis (FIA) program data, and not the National Resources Inventory (NRI).**

There are tables with more detailed information about the land representation, including state totals, but these are not typically included in the Inventory report. EPA will consider including this more detailed information in the next Inventory report. There may be some areas in Alaska where the land has been subject to a clear cut operation, leading to a land cover classification as grassland, but the land is still managed as a forest. EPA will conduct additional analysis in the future in an attempt to capture some of these areas, but there will always be some limitations without a survey of the land owners/managers to understand the specific use of the land. EPA will also further investigate the possibility of double-counting the losses for forest land conversion in Alaska.

***Comment:** Carbon stock change factor for forest land converted to grassland*. An additional key factor in reporting carbon stock changes resulting from the Conversion of Forest Land to Grassland is the stock change factor and associated reporting assumptions applied. Forest lands typically have significantly higher above- and below- ground biomass densities than grasslands and thus conversion from forest land to grassland can result in high carbon losses. It is our understanding that the draft inventory makes use of measurements from FIA plots to estimate the forest land above ground forest carbon density and an IPCC Tier 1 default value for the post-change above ground grassland carbon density. This IPCC default, represented as an average value (+/- uncertainty) across a broad ecoregion type, may not be representative of the average measured carbon density in US grassland ecosystems. If IPCC defaults are substantially lower than measured C densities in US grasslands the result would be an overestimate of carbon loss from this transition. IPCC Guidelines encourage the use of Tier 2 country-specific factors where available. We encourage the inventory team to explore the use of a carbon density value of grasslands that accurately represents US grasslands to replace the IPCC default in the case of transition of forest land to grassland.

***Response:* The Inventory Team identified that the IPCC Tier 1 approach and default stock estimates used in the Public Review version of the Inventory may not accurately characterize the carbon stock transfers from Forest Land to Grasslands in the Great Plains and Western United States. The team**

undertook additional analyses during the Public Review period that included a more refined disaggregation of land use changes using Forest Inventory and Analysis data. These analyses included estimation of state-specific carbon stock estimates for grasslands where a fraction of the carbon stocks from forest land are transferred to the grassland land use category rather than assuming all carbon is lost to the atmosphere in the year of conversion. Please see the Land Converted to Grasslands section for details on the refined disaggregation of land use changes and the estimation of state-specific grassland carbon stocks, which resulted in changes in the estimates reported in the Public Review version of the Inventory. To learn more, review the Supplementary USFS Briefing Paper and Technical Summary available here:
https://www.epa.gov/sites/production/files/2017-04/documents/usfs_brief_techsummary.pdf

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Commenter: Center for Carbon Removal

Jason Funk

Comment: We noted significant changes to the estimates of the magnitude of the historical U.S. LULUCF sink in the Draft Inventory, compared to estimates from previous years. In some cases, these revisions changed previous estimates in a way that decreased the magnitude of the overall sink by more than 50 percent, compared to estimates for the same year in previous Inventories. Upon further investigation, we found that these significantly revised estimates appear to arise from a reclassification of lands that formerly met the national definition of forest land, but have now been reclassified as grasslands because they no longer meet one or more of the criteria of the forest land definition. Furthermore, the estimates of biomass in these newly reclassified grasslands appear to rely on Intergovernmental Panel on Climate Change (IPCC) default values, consistent with a Tier 1 approach. We commend the efforts in this draft to improve the quality and transparency of the information used to develop the Inventory. In this case, we are concerned that the use of IPCC default values for U.S. grassland carbon stocks may actually diminish the accuracy of the estimated emissions from these lands, and hence of the entire inventory. Since this single factor seems to account for a change in the emissions estimate on a scale of hundreds of millions of tons CO2-e, it seems important to construct the most accurate estimate possible.

In our view, while the 2006 IPCC Guidelines allow for the use of Tier 1 data when necessary, it is good practice for countries to use country-level (Tier 2) or spatially explicit data (Tier 3) whenever possible. And in this case, the Tier 1 default values are probably not representative of the carbon stocks in lands that were recently forested. In many cases, these areas may still have significant amounts of carbon present in woody material in above- or below-ground biomass, dead wood, and litter, as well as in soil organic matter. To represent these areas with default values for grasslands likely significantly overestimates the emissions from these lands, in a way that diminishes the accuracy of the Inventory, rather than enhancing it. We have come to understand that Tier 2 and Tier 3 data related to carbon stocks in areas newly classified as "forest land converted to grassland" may be available from federal agencies (including the US Forest Service, Bureau of Land Management, and possibly others), national laboratories, academic institutions, and other sources. We request that EPA undertake a robust effort to identify and utilize such information in subsequent development of the Draft Inventory. In our view, the use of Tier 1 emission factors for these areas is not consistent with good practice, and we urge EPA to develop an Inventory that fulfills the IPCC principles to the greatest possible degree.

Response: **The Inventory Team identified that the IPCC Tier 1 approach and default stock estimates used in the Public Review version of the Inventory may not accurately characterize the carbon stock**

transfers from Forest Land to Grasslands in the Great Plains and Western United States. The team undertook additional analyses during the Public Review period that included a more refined disaggregation of land use changes using Forest Inventory and Analysis data. These analyses included estimation of state-specific carbon stock estimates for grasslands where a fraction of the carbon stocks from forest land are transferred to the grassland land use category rather than assuming all carbon is lost to the atmosphere in the year of conversion. Please see the Land Converted to Grasslands section for details on the refined disaggregation of land use changes and the estimation of state-specific grassland carbon stocks which resulted in changes in the estimates reported in the Public Review version of the Inventory. To learn more, review the Supplementary USFS Briefing Paper and Technical Summary available here:
https://www.epa.gov/sites/production/files/2017-04/documents/usfs_brief_techsummary.pdf

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Commenter: Climate Accountability Institute

Richard Heede

Comment: I fully support the annual publication of the US GHG inventory. I rely on it in my own work, it is an essential foundation for the data submitted to the UNFCCC, and it is critical that this work be funded and continued. Please tell Administrator Pruitt to support its publication and continuance. Data is not political.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: Climate Action Reserve

Trevor Anderson

Comment: Thank you EPA for your continued commitment to submit and publish annual GHG inventory reports and for helping the USA meet its UNFCCC treaty obligations. The USA has been a leading developer of new and improved methodologies for estimating emissions and sinks, and I'd like to see it continue to be one. I use and rely on GHG estimation methods and U.S. GHG data daily at my job and so do countless others across the globe. They are of critical importance, and as a U.S. citizen, I am personally proud the U.S. inventory continues to be such a high quality analysis.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: Climate and Land Use Alliance

Donna Lee

Comment: I wanted to thank you for the transparency you provide on US emissions and removals and the opportunity for public comment. The US is an important country when it comes to climate change and the data and information you generate is critical to ensuring we avoid what could be very expensive

needs in the future from global warming impacts. In general, having looked at many GHGIs across the world, the US inventory is well written and organized (many countries could usefully emulate the US documentation); the level of detail provided is also extremely useful.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Comment: The most noticeable difference in the 2017 draft is the reduction in the land sector sink. While there is a short explanation of methodological changes that have occurred that may explain the significant difference in quantification (especially F>GL and F>Settlements), it may be useful to provide a bit clearer explanation and some sense of where method changes resulted in the largest quantified changes (e.g. was it the addition of new transitions, new pools for those transitions, or changes in the model itself?)

Response**: In finalizing the 1990 through 2015 Inventory, EPA made several methodological changes from the Public Review version that resulted in reduced losses of carbon from conversion of forest lands to croplands, grassland and settlements. These changes are fully documented in the final 1990 through 2015 Inventory under the "Methodology" and "QA/QC and Verification" sections of 6.5 Land Converted to Cropland, 6.7 Land Converted to Grassland, and 6.11 Land Converted to Settlements. To learn more, review the Supplementary USFS Briefing Paper and Technical Summary available here:** ***https://www.epa.gov/sites/production/files/2017-04/documents/usfs_brief_techsummary.pdf***

Comment: It seems one key (new) "source" category is F>GL, but there is no explanation of what is driving this change. It may be that (spatially explicit) data is not available, but it seems to be critical for policymaking. I've continued to look at the GHGI numbers, particularly the significant reduction in the total (net) land sector sink... and was concerned about the large new source related to forest conversions (in particular, forests converted to grasslands). I applaud your efforts to include these new conversions in the inventory, per IPCC guidelines... although, I wonder if it may be worth reexamining the methods you used for this new transition category? It seems rather critical, given its impact on the overall land sector sink.

Response: **Please see the response to the question above.**

Comment: The GHGI states that Agroforestry systems that meet the definition of forest land are not included in the GHGI as they are not currently inventoried by the US. I assume this is simply a current gap. It would be useful to understand how significant are such systems (i.e. how big is the gap)?

Response: **The United States does not have reliable databases at this time that can be used to estimate carbon stocks or stock changes on Agroforestry systems. Research efforts are underway by USDA to develop an approach that will use data from the National Resources Inventory, but it will be several years before the data is available for use in the Inventory. While the carbon stocks of these Agroforestry lands may be substantial, preliminary indications are that on a national level the carbon stocks are not likely to be changing significantly through growth or loss.**

Comment: Page 6-31, line 50-51: "reduces the managed forest area by approximately 5%" - is this 5% of total managed forest area, or just the managed forest areas in Alaska?

Response: **The 5 percent reduction is referring only to the managed forest area in southeastern/southcoastal Alaska. Please see page 6-32 of the final 1990 through 2015 Inventory under the Recalculations Discussion section of *Forest Land Remaining Forest Land*; this has been clarified in the text.**

Comment: Table 6-84: Small issue, but it was really nice in this Table to have total figures for F > Settlement (in bold, followed by the breakdown by pool); in other transitions (F > Cropland, F > Grassland) there was no total, so I had to add up the various pools myself to get the totals.

Response**: In the final 1990 through 2015 Inventory, Tables 6-31, 6-32, 6-41 and 6-42 have been updated to provide totals for each conversion category.**

Commenter: Climate Trust

Jacoba Aldersebaes

Comment: Thank you for the EPA's ongoing commitment to update the United States' sources and sinks of Greenhouse Gas emissions. I'm writing to strongly urge the EPA to continue this work for many years to come. The Inventory has been an essential source over the years for determining innovative activities on behalf of businesses and landowners. As one such example, the foundation provided by the Inventory has directly contributed to our efforts to design a first of its kind market transaction to financially reward farmers for conserving grasslands. Looking forward the opportunities to engage land-based emission reduction projects is poised to grow and the continued publication of updated information will no doubt guide future initiatives.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: Climate Trust

Matthew Baird

Comment: Thanks for your continued work to maintain a national greenhouse gas inventory report. Not only does it meet the UNFCCC treaty, but it provides a foundation of climate change policy. It would be impossible to significantly reduce greenhouse gases without something to measure against.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Comment: As the country looks at natural gas as a transition fuel from coal, I encourage the EPA to look at methane leakage at gas extraction sites. The full life-cycle of a fossil fuel should be understood as all GHG emissions affect the world, not just where they're burned. Some studies show that natural gas may be worse than coal when considering the methane that is leaked during extraction.

Response: **The Inventory reports emissions from natural gas production in section 3.5 Natural Gas Systems. In 2015, methane emissions from the natural gas production segment were 107 MMT CO_2 Eq.**

Commenter: Climate Trust

Mik McKee

Comment: Thank you for the EPA's ongoing commitment to update the United States' sources and sinks of Greenhouse Gas emissions. I'm writing to strongly urge the EPA to continue this work for many years to come. The Inventory has been an essential source over the years for determining innovative activities on behalf of businesses and landowners. As one such example, the foundation provided by the Inventory has directly contributed to our efforts to design a first of its kind market transaction to financially reward farmers for conserving grasslands. Looking forward the opportunities to engage land-based emission reduction projects is poised to grow and the continued publication of updated information will no doubt guide future initiatives.

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Commenter: Climate Trust

Peter Weisberg

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Commenter: Climate Trust

Sheldon Zakreski

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based emission reduction projects is poised to grow and the continued publication of updated information will no doubt guide future initiatives.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: Dogwood Alliance

Tyson Miller

Comment: At Dogwood Alliance, we appreciate all that the EPA does and support EPA's evolving work on carbon accounting in the new US greenhouse gas emission inventory. We specifically want to commend what we interpret as more accurate accounting compared to previous years. As an example, in Section 6.1 (pg 369/370), the tables show a decrease in forest carbon stocks from 1990 - 2015 and we feel that this new accounting approach shows a more accurate methodology and appreciate model updates that reflect this dynamic on the ground.

Response: **In finalizing the 1990 through 2015 Inventory, EPA made several methodological changes from the Public Review version that resulted in reduced losses of carbon from conversion of forest lands to croplands, grassland and settlements. These changes are fully documented in the final 1990 through 2015 Inventory under the "Methodology" and "QA/QC and Verification" sections of 6.5 Land Converted to Cropland, 6.7 Land Converted to Grassland, and 6.11 Land Converted to Settlements. To learn more, review the Supplementary USFS Briefing Paper and Technical Summary available here: https://www.epa.gov/sites/production/files/2017-04/documents/usfs_brief_techsummary.pdf**

Comment: In terms of suggestions for improving the methodology, Dogwood Alliance believes that while it is good that EPA is now counting emissions from forest fires separately, the agency should also separate out emissions from logging, as logging represents a larger share of carbon loss/emissions in forests. (See new carbon accounting framework approach published in Carbon Balance and Management for reference). We also feel that full accounting for emissions from soil disturbance due to logging using the latest methodologies is critical and are unsure whether the new methodology is integrating heterotrophic emissions.

Response**: While the carbon losses from timber harvesting are not explicitly reported in the Inventory, they are inherent in the carbon stocks and stock changes reported within the *Land Converted to Forest Land* and *Forest Land Remaining Forest Land* sections. Further, the products in use and land filled are included with Harvested Wood Products reported in the *Forest Land Remaining Forest Land* section. The Inventory Team continues to refine approaches allowing for more spatially and temporally resolved estimates of carbon stocks and stock changes associated with the Forest Land category including changes associated with natural and anthropogenic disturbances. Members of the Inventory Team were collaborators on the Harris et al. 2016 paper in CBM and this represents some of the research currently underway to improvement estimation and reporting in the Forest Land category.**

The new modeling framework for estimating soil carbon stocks and stock changes is based on Forest Inventory and Analysis data and broad climate and geological data. This approach was developed to use plot-specific information that is available nationally. At this time respiration is not explicitly

included in the modeling framework. As additional soil attributes become available the modeling framework with be re-evaluated and improvements will be made.

Commenter: Environmental Defense Fund and Colorado State University

David Lyon

Comments: *Technical Recommendations for Revision to Revisions to Draft 2017 GHGI.* EDF supports EPA's efforts to continuously improve the Inventory by incorporating the best available data, but we are concerned that the lower estimate of total methane emissions from Petroleum and Natural Gas Systems in the Draft 2017 GHGI, compared to the 2016 GHGI, does not agree with recent data. Although some of the agency's revised methodologies are rigorous and well-supported, the Draft 2017 GHGI fails to fully account for superemitters. If properly accounted for, emissions from these sources would likely counteract the agency's proposed downward revisions and, result instead in total Petroleum and Natural Gas System methane emissions that are similar to or slightly higher than the 2016 GHGI estimate of 9.8 Tg CH4.

Response: **EPA will continue to assess studies that include and compare both top-down and bottom-up estimates and could lead to improved understanding (e.g., identification of emission sources and information on frequency of high emitters) of unassigned high emitters or "super emitters," as recommended in stakeholder comments. See the Planned Improvements sections in 3.5 Petroleum Systems and 3.6 Natural Gas Systems.**

Comments: *Major Methodological Changes.* In the 2016 GHGI, EPA estimated 2014 methane emissions from Petroleum and Natural Gas Systems (O&G) are 9.8 Tg CH4.8 In the Draft 2017 GHGI, EPA revised 2014 emission estimates to 8.3 Tg CH4 based on several methodological changes to sources in the production and processing segments. The largest changes in emission estimates are due to two methodological revisions: 1) an updated method to estimate oil well count activity data, and 2) the use of EPA Greenhouse Gas Reporting Program (GHGRP) data to estimate processing plant emissions. As discussed in our stakeholder feedback on EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2015: Revisions Under Consideration for Natural Gas and Petroleum Systems Production Emissions* (Production Memo), we agree that the revised oil well counts are more accurate than previous estimates.

Regarding the second change, we are concerned that the current method of utilizing GHGRP data underestimates processing sector emissions. The Draft 2017 GHGI estimate of 445 Gg CH4 is approximately 20% lower than the estimate of 546 Gg CH4 in a 2016 study by Marchese et al.10 We believe the Marchese et al. estimate is a more accurate estimate of national processing sector emissions because it is based on a study with industry participation that collected emissions data at 16 processing plants across the U.S. As discussed in our joint stakeholder feedback with Colorado State University on *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2015: Updates Under Consideration for Natural Gas Systems Processing Segment Emissions* (Processing Memo),11 we recommend a method that uses the Marchese et al. estimate of processing plant emissions to scale up GHGRP-based source-specific emission estimates so that total emissions agree with the national study while providing the detailed source breakdown of the GHGRP method currently used in the Draft 2017 GHGI.

Response: **In the 1990 through 2015 Inventory, EPA updated the emission estimates for processing plants using data from the over 400 plants which have been reporting annual data to EPA's GHGRP since 2011. Data reported to EPA's GHGRP undergo a multi-step verification process, as discussed in the QA/QC and Verification section of 3.6 Natural Gas Systems. As noted in the Planned Improvements section of 3.6 Natural Gas Systems, EPA will continue to review data from new studies which may be used to update the Inventory.**

Comment: *In general, EDF supports the revised methodologies for production sector liquids unloading, storage tanks, and associated gas venting, but we have some concerns about the underlying data. As discussed in our feedback to the Production Memo, we recommend that EPA carefully quality assure the GHGRP data used in the GHGI emission estimates. Our response to the memo also addressed concerns about potential issues related to GHGRP reporting methodologies such as the use of emission factors for small tanks. In particular, EPA should evaluate the accuracy of tank control efficiencies reported to the GHGRP. As supported by the EPA compliance alert,12 Noble Consent Decree,13 and a national helicopter-based infrared camera survey of over 8,000 well pads in 7 U.S. basins,14 many controlled storage tanks may have higher emissions than expected due to poor design or malfunctions of their tank control systems. If tank control issues are not reported to the GHGRP, then the Draft 2017 GHGI method will underestimate storage tank emissions.*

Response: **Data reported to EPA's GHGRP undergo a multi-step verification process, as discussed in the QA/QC and Verification section of 3.6 Natural Gas Systems and 3.5 Petroleum Systems. As noted in the Planned Improvements section of 3.5 Petroleum Systems and 3.6 Natural Gas Systems, EPA continues to seek new data that could be used to update or assess the estimates in the Inventory, including tank malfunction and control efficiency data.**

Comment: *EPA Should Avoid Double-Counting Emission Reductions.* As noted in the Draft 2017 GHGI, the calculation of net emissions obviates the application of regulatory or voluntary emission reductions, which were previously applied to potential emission estimates to account for changes in equipment and practices following the development of potential emission factors. Since the Draft 2017 continues to apply Natural Gas STAR based voluntary reductions to sources that now are calculated as net emissions, some reductions will be double counted, and therefore, the GHGI will underestimate emissions. In the final 2017 GHGI, EPA should no longer apply regulatory or voluntary emission reductions to sources that are based on net emission calculations.

Response: **EPA agrees that Gas STAR reductions should be removed for sources which are calculated with net emissions approaches. In the Inventory, Gas STAR reductions have been removed from the petroleum production segment and the natural gas processing segments, which are now calculated using a net emissions approach. For the natural gas production segment, though many sources in production are now calculated with net factor approaches, several sources are calculated with potential emissions approaches, and therefore some of the Gas STAR reductions are subtracted from the production segment estimates. To address potential double-counting of reductions, a scaling factor is applied to the "other reductions" to reduce this reported amount based an estimate of the fraction of those reductions that occur in the sources that are now calculated using net emissions approaches. The fractions were recalculated in the current Inventory to take into account that tanks are now calculated with net emissions approaches, and to address minor errors in the previous calculation. Please see the Recalculations Discussion section of 3.5 Petroleum Systems and 3.6 Natural Gas Systems.**

Comment: *EPA Should Account for Recent Data on Emissions From Power Plants and Refineries*.
A recent paper published in the journal Environmental Science & Technology used the aircraft mass balance approach to estimate methane emissions at three refineries and three natural gas power plants (NGPP) in the U.S.15 Measured emission rates were 21–20 and 11–90 times higher than reported to the GHGRP for NGPPs and refineries, respectively. The authors scale up emissions by throughput to estimate that these two sources contribute 610±180 Gg CH4 in the U.S., which is about 20 times higher than the estimate in the GHGI. Although this estimate is based on a small dataset, it suggests that the GHGRP and GHGI greatly underestimate emissions from these sources. EPA should evaluate this study and other data sources to increase the accuracy of their emission estimates for refineries and NGPPs.

Response: As noted in the Planned Improvements section of 3.5 Petroleum Systems and 3.6 Natural Gas Systems, EPA continues to seek new data that could be used to update or assess the estimates in the Inventory.

Comment: *The Inventory Underestimates Emissions from Superemitters*. Superemitters are relatively infrequent, large emission sources that result from malfunctions or abnormal process conditions. A recent meta-analysis found that superemitters are ubiquitous across the oil and gas supply chain with a general rule of the top 5% of sources accounting for 50% of total emissions.16 The Draft 2017 GHGI partially accounts for superemitters by including emissions from the Aliso Canyon storage facility well blowout and production sector stuck separator dump valves.

Although the partial inclusion of superemitters is a step in the right direction, the current approach nonetheless greatly underestimates emissions from these sources. For instance, in addition to Aliso Canyon, there are many other superemitters in the transmission and storage sector (T&S). Zimmerle et al. estimates that T&S superemitters were responsible for 353 Gg CH4 emissions in 2012.17 For the final 2017 GHGI, we recommend that EPA use Zimmerle et al. to estimate emissions from T&S superemitters in addition to including the emission estimate from the Aliso Canyon blowout.

Response: **EPA will continue to assess studies that include and compare both top-down and bottom-up estimates and could lead to improved understanding (e.g., identification of emission sources and information on frequency of high emitters) of unassigned high emitters or "super emitters," as recommended in stakeholder comments. See the Planned Improvements sections in 3.5 Petroleum Systems and 3.6 Natural Gas Systems.**

Comment: For the production sector, the Draft 2017 GHGI incorporates emission estimates from stuck separator dump valves in their revised methodology for storage tank. As discussed in our feedback on the Production Memo, we have concerns that the underlying GHGRP data used to estimate stuck dump valve emissions greatly underestimates their emissions due to a flawed calculation methodology. In brief, the GHGRP method assumes that tank emissions are approximately 3–4 times higher than normal flashing emissions during stuck dump valve conditions, but in reality, emissions can be several orders of magnitude higher up to the entire natural gas production of a well. Additionally, production superemitters may include other causes such as poorly operating separators or malfunctioning pressure relief valves.

Response: **Data reported to EPA's GHGRP undergo a multi-step verification process, as discussed in the QA/QC and Verification section of the 3.6 Natural Gas Systems and 3.5 Petroleum Systems. As noted in the Planned Improvements section of 3.5 Petroleum Systems and 3.6 Natural Gas Systems, EPA continues to seek new data that could be used to update or assess the estimates in the Inventory.**

Comment: In addition to these specific sources, we generally recommend that EPA evaluate other approaches for estimating superemitter emissions, such as top-down and bottom-up comparisons of basin-level emissions. For example, a recent study estimated that one-third of site-level well pad emissions in the Barnett Shale could not be attributed to component-level emissions and were likely caused by superemitters resulting from abnormal process conditions or otherwise avoidable emissions.18 In context, the Draft 2017 GHGI estimate of stuck dump valves only accounts for 0.2% of production emissions. For future inventories, it is critical that EPA fully account for superemitters since these sources may account for a substantial portion of total oil and gas supply chain emissions and likely counteract the downward revisions made to other sources.

Response: **EPA will continue to assess studies that include and compare both top-down and bottom-up estimates and could lead to improved understanding (e.g., identification of emission sources and information on frequency of high emitters) of unassigned high emitters or "super emitters," as recommended in stakeholder comments. See the Planned Improvements sections in 3.5 Petroleum Systems and 3.6 Natural Gas Systems.**

Commenter: Environmental Interface Limited

John Cowan

Comment: My concern relates to EPA's accounting for the generation of the CO2 exported by pipeline from North Dakota as part of a Carbon Capture and Storage system. I note on page 3-27, lines 1-3, that EPA states, "Since this CO2 is not emitted to the atmosphere in the United States, energy used to produce this CO2 is subtracted from energy consumption statistics." Though this same statement was accepted by the ERT in 2011, it strikes me as incomplete because it does not identify what constitutes the energy used to produce the CO2. I presume you do not actually subtract all of the fossil fuel used in the generation of CO2, since that would mean the CO2 not captured at the site is ignored, though it is clearly a US emission.

Also your statement relates to the energy used to "produce" the CO2. Creation of the CO2 from fossil fuel combustion is only part of what it takes to produce the CO2 for export. So your "produce" statement implies that the energy used for capturing the CO2 (e.g. for scrubbing, liquefaction, pumping) is also subtracted, even though the energy is probably in the form of electricity. Such methodology departs from the principle of assigning emissions to their sources. If this principal is to be broken, then why couldn't the energy used to create exported electricity (or exported anything) be ignored in the inventory?

So presuming you subtract only the fraction of the fossil fuel representing the recovered fraction of the CO2, a more clear statement about this would be: Since this CO2 is not emitted to the atmosphere in the United States, the associated fossil fuel burned to create the exported CO2 is subtracted from fossil fuel consumption statistics. The associated fossil fuel is the total fossil fuel burned at the plant with the CO2 capture system multiplied by the fraction of the plant's total site-generated CO2 that is recovered by the capture system.

Response: **EPA agrees with the characterization of how the adjustment for CO_2 export was made. It only reflects the C in the CO_2 exported, not C in fuels used to produce the CO_2. The language in the Inventory report was adjusted to reflect this comment.**

Commenter: Federal Highway Administration

John Davies

Comment: Table ES-3, p. ES-11: Given the increased penetration of battery electric and plug-in hybrid vehicles, it's surprising to see a reported decline in transportation electricity CO2 emissions (down about 10 percent between 2014 and 2015, and down over 20 percent between 2005 and 2015). The Electric Drive Transportation Association estimates cumulative U.S. sales of about 400,000 light-duty vehicles by the end of 2015, up from nearly zero vehicles in 2010. See http://electricdrive.org/index.php?ht=d%2Fsp%2Fi%2F20952%2Fpid%2F20952. See also Transportation Energy Data Book Edition35 Table 6.2 (2010 to 2015 sales).

Response: **Consistent with previous Inventory reports, the current Inventory accounts for the electricity used to charge electric vehicles primarily in the residential and commercial sectors. Therefore, higher electric vehicle market penetration rates would not increase the reported transportation sector CO_2 emissions. As a planned improvement, EPA will look into the possibility of breaking out electricity used to charge electric vehicles and reporting that electricity use under the transportation sector. See Section 3.1 Planned Improvements for more information.**

Comment: Table 2-13: As noted in footnote 7, FHWA changed its methodology to apportion on-road and non-road gasoline consumption in its Highway Statistics 2015 document, so applying the published on-road / non-road ratios from Highway Statistics is causing a noticeable discontinuity in the Inventory's estimates between 2015 and earlier years, especially for on-road transportation. It is suggested that the 2015 on-road / non-road ratio be applied retrospectively to estimate on-road gasoline consumption for 2014 and earlier years.

Response: **As noted by the commenter, FHWA changed its methods for estimating the share of gasoline used in on-road and non-road applications, which resulted in a break in the time series between 2015 and previous years in the allocation of gasoline among transportation and other sectors in the current Inventory. EPA plans to conduct further research to better understand FHWA's method update and to evaluate and potentially update the method for allocating gasoline across sectors to improve accuracy and create a more consistent time series in future versions of the Inventory report. See Section 3.1 Planned Improvements for more information.**

Comment: Table 2-13: If the Inventory estimates are adjusted to reflect an increase in on-road gasoline GHG emissions, it would be worth noting that this trend has been significantly influence by the recent growth in light-duty VMT. Following a period of stagnation (lasting from 2009 to about 2013), light-duty increased by 1.6 percent from 2013-2014, and 2.5 percent from 2014 to 2015 (see 2014 and 2015 Highway Statistics Table VM-1).

Response: **Annex 3.2 of the Inventory report includes information on vehicle miles traveled (VMT) by vehicle type and fuel type (see Tables A-96 through Table A-98) as well as estimates of VMT**

distribution by vehicle age and vehicle class. More information on recent VMT trends were also incorporated into Section 2.2 and Section 3.1 of the Inventory report.

Comment: Table 2-13: Suggest including an italicized line item at the bottom of the table showing biofuel CO2 emissions, as is done for Table 2-4.

Response: **Table 2-13 has been updated to include biofuels.**

Comment: p. 3-19: Might also note the recent VMT trends, especially the accelerating growth in 2015 and 2015 mentioned above.

Response: **Annex 3.2 of the Inventory report includes information on VMT by vehicle type and fuel type (see Tables A-96 through Table A-98) as well as estimates of VMT distribution by vehicle age and vehicle class. More information on recent VMT trends were also incorporated into Section 2.2 and Section 3.1 of the Inventory report.**

Comment: Figure 3-13: Orange line should be labeled % passenger cars.

Response: **Figure 3-13 has been updated**.

Comment: Table 3-12, italicized line item: Suggest including biodiesel and labeling this biofuels.

Response: **Table 3-12 has been updated to include biofuels.**

Commenter: Ford Foundation

Penny Davies

Comment: I note the potential for improvement in the forest carbon reservoir and stock, which, in the light of current political trends, might be something worth highlighting.

Response: **As noted in the Planned Improvements section of the *Forest Land Remaining Forest Land* chapter, efforts are underway to improve the ability to estimate carbon stock and stock change for forest lands.**

Comment: As an addendum, it is interesting that Scotland, a place close to President-elect's heart, recently published its climate action plan (reported by the BBC), and the Scottish parliament's debate of it, and Scotland's new target of reducing greenhouse gas emissions by 66% by 2032. They agreed to assign budget to it. It was criticized, however, for not including enough on the need for cuts in emissions from the transport sector, insufficient was made about the potential positive role of the forest sector, and not enough was made of incentives to encourage behavioral change.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: Ford Foundation

David Kaimowitz

Comment: I believe that the EPA has done a good job with this draft inventory. It is good to see how a consistent concerted effort has gradually improved the quality of these reports, which are essential for the future of the planet. We at the Ford Foundation regularly use these inventories, as well as inventories from other countries for our own work and analysis. We certainly hope that the EPA continues to invest in improving these reports.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: George Washington University (GWU) Environmental and Energy Management Institute (EEMI)

Joseph Cascio

Comment: First, let me thank EPA for their continued commitment to meet its UNFCCC treaty obligations to submit and publish annual GHG inventory reports. These are both extremely valuable and necessary to continue progress on GHG mitigation and adaptation. The U.S. can be proud of its contributions for leading the development of new and improved methodologies for estimating emissions and sinks, both of which are used widely by domestic audiences, as well as by the international community. In academia, U.S. GHG data is necessary to educate students on trends and on the scope of the issues to be addressed.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Comment: Is there any ready explanation of how electricity imports from Canada are accounted for?

Response: **The Inventory focuses on emissions occurring in the United States. Therefore, emissions from electricity production are based on energy used to produce electricity in the United States. The data come from fuel consumption data for U.S. electricity production provided by EIA. Emissions from producing electricity imported into the United States are accounted for in the country in which the electricity was produced**.

Commenter: Greenhouse Gas (GHG) Management Institute

Michael Gillenwater

Comment: On behalf of the Greenhouse Gas Management Institute, I want to thank the USEPA on their ongoing work to rigorously quantify and publicly report emissions and removals of greenhouse gas (GHG) emissions from the United States. Since President George H.W. Bush signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, the United States has dutifully fulfilled its treaty commitment to preparing an annual inventory of GHG emissions and removals. The GHG

inventory program at the USEPA has been an international leader in developing good practice for this scientific process. Specifically, many of the methodologies encoded in the international guidelines published by the Intergovernmental Panel on Climate Change (IPCC) got their start through technical work lead by the USEPA.

This 2017 report, specifically, presents valuable developments in the integration of facility level data from the GHG Mandatory Reporting Program as well as important technical work to better understand methane emissions from the petroleum and natural gas industries. The USEPA GHG inventory program has always upheld a strong standard for scientific rigor and unbiased analysis. Many government programs, including those operating within the USEPA itself, would like to have their activities featured and promoted in the U.S. inventory. Yet, over the 20 years of annual reporting, USEPA's GHG inventory program has always focused on unbiased technical rigor, while also striving to inform both the technical community and public at large with clear data and insightful analysis.

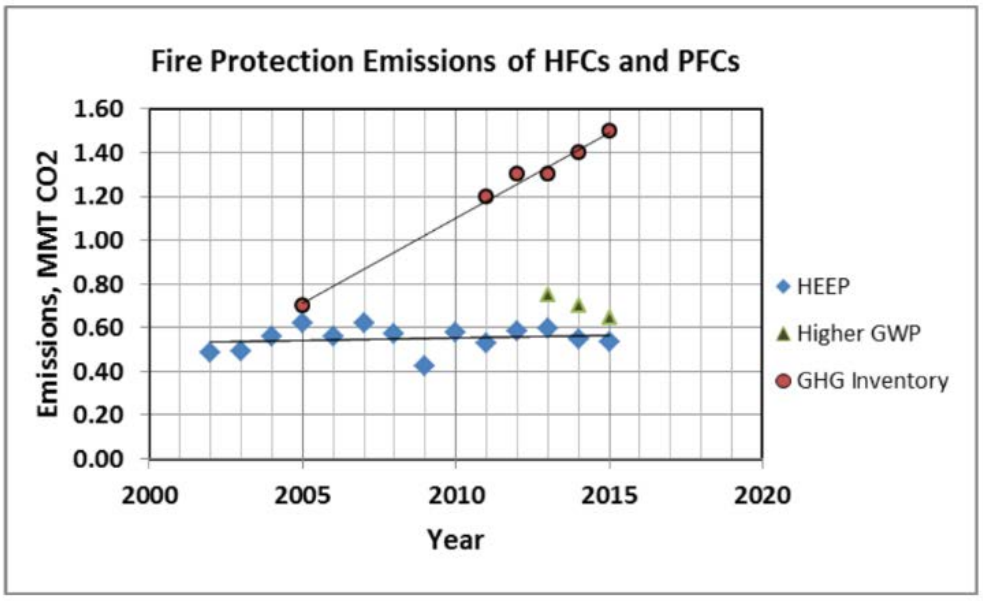
Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: Halon Alternatives Research Corporation, Inc. (HARC)

Thomas Cortina

Comment: *Comparison of HEEP data and U.S. GHG inventory data on fire protection***.** The HFC Emissions Estimating Program (HEEP), conducted by HARC, is a companion to the Voluntary Code of Practice for the Reduction of HFC & PFC Fire Protection Agents (VCOP) that provides a format to help industry minimize emissions by setting benchmarks, by providing the incentives to make improvements to current standards and practices, by documenting the industry's commitment to safety and responsible use, and by providing data to support the goals of the VCOP. HEEP collects data on sales of HFCs and PFCs used for recharge of fire protection systems and extinguishers as a surrogate for emissions. Compiled data of estimated emissions is submitted to EPA and published each year.

Enclosed is the most recent HEEP report, which shows that between 2002 and 2015 annual emissions of HFC and PFC fire protection agents averaged 0.550 MMTCO2. HARC acknowledges that there is some potential leakage in the program from recharge agents that are directly recycled by users and systems that discharge and are never recharged, however, we believe the data reflects close to 90% of the U.S. fire protection industry's actual emissions. Since 2002 the HEEP data has been calculated using GWPs from the 2nd IPCC Assessment Report. The draft U.S. GHG inventory uses GWPs from the 4th IPCC Assessment Report that are higher for all of agents measured under HEEP. We recalculated the HEEP data for 2013-2015 using the 4th Assessment Report GWPs and the values increased by between 21-28%. For the most recent year, 2015, the adjusted HEEP value was 0.643 MMTCO2 while the draft U.S. GHG inventory value for fire protection was 1.5 MMTCO2. Overall the fourteen-year HEEP trend line suggests that the reported emissions have been stable over the measurement period. When the HEEP program began in 2002, the expectation was that emissions of HFCs from fire protection would continue to increase each year as the size of the installed base grew. This expectation is reflected in the draft U.S. GHG inventory, which shows a 114% increase in HFC emissions from fire protection between 2005 and 2015. Instead what the HEEP data show are essentially invariant emissions of GHGs over the 2002 through 2015 period. Below is a graph of the HEEP and draft U.S. GHG inventory data that illustrates these differences.



HARC attributes the invariance of fire industry emissions to steadily improved stewardship of installed systems by owners and the high level of recycling of halogenated clean agents. When the HEEP program began in 2002 about 13% of the reported HFCs sold for recharge came from recyclers. In recent years this number has ranged from 70-80% and in 2015 it reached a high of 84%. At a time when EPA is promulgating regulations to increase recycling of HFCs in other sectors, the fire protection industry has achieved this high level of recycling without a regulatory mandate.

HARC has provided input to EPA in recent years on the vintaging model that provides the basis for the data on emissions of fire protection agents presented in the draft GHG inventory. Based on our previous review of the model's assumptions, we believe that the vintaging model may not accurately account for the return of recycled agent to the market for recharge, and that this may contribute to the model's predictions of steadily increasing emissions. HARC has been invited by ICF to participate in a peer review of the EPA vintaging model and hopes to contribute to making improvements in the model's accuracy that might be reflected in future inventories.

Response: **EPA looks forward to working with the commenter to understand the following specific issues related to improving these estimates:**

- **Emission estimates from the segment of the fire protection industry not reporting to HEEP;**
- **Emission estimates of HFCs and PFCs disaggregated by chemical species;**
- **Whether emission rates in EPA's Vintaging Model over the time series are too high, which are currently consistent with the *IPCC Guidelines*;**
- **Whether growth rates in EPA's Vintaging Model for streaming agents and total flooding agents are too high and which available resources can inform more accurate growth estimates; and**
- **Whether EPA's Vintaging Model methodology is somehow not accounting for the recycling described in the comments.**

Commenter: Integrated Sustainability Solutions LLC

Keith Forbes

Comment: For the last 25 years or so, EPA has been a leader in GHG inventory methodologies. I authored the LULUCF chapter of the EIA (DOE) GHG inventory for the U.S. for 7 years using data from the EPA and USDA/USFS, so am intimately familiar with the guidelines. EPA's methodologies have been widely adopted and integrated into IPCC guidelines for GHG inventories for all countries. EPA methods have also been used by numerous state and voluntary registries in the U.S. and elsewhere, as well as for private sector GHG reduction efforts by numerous corporations. Therefore, it is critical that EPA inventory methodologies remain based upon the best science and are transparent. Thank you for the opportunity to comment.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: Ionia Farm

Jane Fisher

Comment: I just quickly want to say how incredibly important the EPA is and cannot imagine in a time like this, with so much environmental destruction and environmental health problems, etc that the EPA (budget, staff, goals) is at risk. Thank you for doing what you are doing for all of us and of course for many generations to come.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: National Council for Air and Stream Improvement, Inc. (NCASI)

Brad Upton

Comment: EPA characterizes production of the pulp and paper sector as the sum of wood pulp production plus paper and paperboard production, based on data from the Food and Agriculture Organization of the United Nations (FAO). Summing wood pulp, paper, and paperboard production results in double counting, because the majority of wood pulp production is used to produce paper and paperboard at integrated mills (an integrated mill includes both pulping and papermaking at the same facility, with a single wastewater treatment system). Therefore, production statistics used by EPA to represent the pulp and paper sector are too high. As we have suggested before, a more appropriate method for characterizing total pulp and paper sector production would be to sum paper production, paperboard production, and market pulp production. The American Forest and Paper Association (AF&PA) publishes this information annually in its Statistical Summary reports, which are submitted each year to the US Library of Congress.

Average Outflow. EPA characterizes wastewater generation per ton of production based on water discharge statistics from AF&PA Sustainability Reports. These are the most current and relevant data for this characterization, and NCASI submits no comments on this use other than to emphasize that the agency should ensure it is using the most current version of the report.

Organic Loading in the Outflow. EPA characterizes the organic load in untreated wastewater using a legacy value of 0.4 gram BOD per liter of untreated effluent and a multiplier of 2 to convert from BOD to COD. NCASI has very limited data on untreated effluent organic load. Therefore, until additional data are available, we cannot suggest an alternative value.

In summary, use of FAO statistics overstates the pulp and paper industrial sector's production by double counting pulp used to produce paper and board at integrated mills, which in turn results in estimates of pulp and paper sector industrial wastewater treatment methane emissions being far too high. EPA should use production data from AF&PA's Statistical Summary reports to avoid this double counting. This will result in more accurate characterization of industrial wastewater treatment methane emissions from this sector.

Response: **As stated in past Inventory reports and in the Planned Improvements section for Wastewater Treatment of the current 1990 through 2015 Inventory, EPA is working with the National Council of Air and Stream Improvement (NCASI) to determine if there are sufficient data available to update the estimates of organic loading in pulp and paper wastewaters treated on site. These data include the estimates of wastewater generated per unit of production, the BOD and/or COD concentration of these wastewaters, and the industry-level production basis used in the Inventory. Data on the industry-level production basis to date has been received and will be incorporated, but in order to incorporate that data, the production basis in relation to the wastewater generation rate and the organic content of the wastewater needs to be evaluated to ensure it is incorporated correctly into the Inventory. Based on NCASI's recommendation in these comments, the *2016 American Forest & Paper Association Sustainability Report* will be evaluated to ensure the most current wastewater generation rate for the pulp and paper industry is used in the Inventory.**

Comment: A new component of this draft inventory is the inclusion of drained organic soils on forest land. The approach identifies planted forests on mesic or xeric sites (based on forest inventory plot data) that coincide with organic soils (according to spatial soil datasets). The result (70.85 k ha) is multiplied by a simple emissions factor to obtain the annual flux. However, this approach does not distinguish between permanent "deep drainage" and shallow, temporary alteration to surface hydrology (such as bedding), which is widely implemented in the US South to establish forest regeneration. Nor does it use forest age to accommodate changing emissions rates with time since drainage. We encourage EPA and USDA Forest Service to work towards continual refinement and improvement of this estimation approach, perhaps moving to a Tier II estimate, although the flux remains small relative to other components of the inventory.

Response: **This is the first year the Inventory Team has estimated emissions from drained organic forest soils. EPA will continue to explore data sources and approaches to move from the Tier I approach implemented in the current Inventory to more country-specific estimates in the years ahead.**

Commenter: The Nature Conservancy

Lynn Scarlett

Comment: The Nature Conservancy applauds the Environmental Protection Agency for its leadership and science-based approach in producing consistent annual greenhouse gas inventory reports going back to 1998 that allow us to understand trends across every sector of the economy, including the contribution to climate change mitigation made by carbon sequestration in our forests and lands. The latest of these is the Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015. Transparent accounting for our GHG emissions and sinks is a critical part of the solution to protect our environment and prudently manage the risks presented by climate change. A rigorous, science-based greenhouse gas inventory is the foundation for evaluating and undertaking prudent actions to manage the very significant risks posed by climate change to our society and economy. The U.S. has long been a leader in the transparency and comprehensiveness with which it reports on its greenhouse gas emissions, and we are pleased to see that continuing here. It has done so by applying basic scientific principles of data collection: transparency, accuracy, completeness, consistency and comparability.

EPA works with every industry to do the best possible job of characterizing their emissions, and regularly updates the estimation models for each industry based on the best available science. The effort over the last few years to refine methane emissions from oil and gas emissions reporting – even in the face of controversial debates over fracking – is a good example. It is worth noting that no industry has advanced a concerted attack on EPA estimates for its emissions.

The greenhouse gas inventory is also an important part of ensuring that countries transparently report their emissions under the UN Framework Convention on Climate Change. By implementing a rigorous, science-based approach to our inventory, the U.S. sets an important model for other countries to follow and improve their own reporting. Indeed, U.S. assistance to help other countries improve their data collection and reporting capacity has been an important complement to our own inventory process, enhancing overall global transparency. We also appreciate the EPA's efforts to draw upon in this latest draft inventory the information and proposed guidance from recent IPCC special reports, including the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands. As one of the first countries to implement this guidance, the United States has demonstrated leadership in advancing the understanding and importance of the relationship between these vital ecosystems and climate change solutions.

The United States thoughtfully spends millions each year to monitor a wide variety of potential security and public health threats, such as flu strains in wide circulation, microbes resistant to antibiotics and viruses on the Internet that may shut down our electric grid. Carefully measuring greenhouse gas emissions and their sources is part of this same effort to protect our health, jobs and environment from threats that can alter our environment and cripple our economy in ways that have the potential to cause untold damage. In sum, the inventory is a critical part of a responsible science-based insurance policy to avoid devastating impacts on the physical systems of our planet that we could not have anticipated if we failed to collect the data. We welcome this Draft Inventory, and applaud EPA and its partner agencies for their efforts to produce it.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: Portland Cement Association

Michael Schon

Comment: *Request for Revision of EPA Estimation Method Used to Calculate the Cement Industry's Process Emissions*. In this year's Draft Inventory, EPA estimates the process emissions from cement manufacturing using the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines. See Draft Inventory at 4-8. Those guidelines are scheduled for refinement in 2019 and are no longer the best method for estimating process related emissions from cement manufacturing. The World Business Council for Sustainable Development (WBCSD) issued Version 3.0 of its report titled "CO2 and Energy Accounting and Reporting Standard for the Cement Industry" (WBCSD Report) in May 2011 (This report is available at http://www.wbcsdcement.org/pdf/tf1_co2%20protocol%20v3.pdf). The WBCSD Report shows that the B1 Method (described in the report) can be used to estimate process related emissions from cement manufacturing, based on clinker production, in a manner which addresses certain limitations of the 2006 IPCC Guidelines. The B1 Method is therefore more accurate than what appears in the IPCC Guidelines. See WBCSD Report at 15-17 & App'x 3.

Of note, the B1 Method accounts for the CO_2 emissions resulting from both organic material and magnesium carbonate in the raw material, while the IPCC method does not. The difference is significant. The base emission factor in the IPCC Guidelines is 0.507 tons of CO2 per ton of clinker while the updated default WBCSD factor is higher, at 0.525, plus an upward adjustment for organic material in the kiln feed. We recommend that the EPA re-calculate the process emissions from cement manufacturing considering this WBCSD method. PCA would welcome the opportunity to facilitate further dialogue between PCA, EPA, and the WBCSD on the specifics of this issue.

***Response*: Please refer to Planned Improvements discussion in section 4.1 Cement Production of the Inventory Report, where EPA references engaging with PCA to review the current emission factor and the basis and applicability of the WBCSD method and default factors to U.S. clinker production processes, to refine the current country-specific emission factor used to estimate CO_2 emissions from clinker production for future Inventory reports in order to better account for other components of raw kiln feed.**

Comment: *Request for EPA Inclusion of Carbonation as a Sink*. While the Draft Inventory accounts for process emissions that are emitted when cement is manufactured, the Draft Inventory does not occur for the carbonation that occurs later in cement products' life cycle. Cement products in-use, post-demolition, and post-recycling reabsorb atmospheric CO_2 over time because of a physiochemical process called carbonation (*See, e.g.,* Fengming Xi, et al., "Substantial global carbon intake by cement carbonation," *Nature Geoscience* (2016), http://www.nature.com/ngeo/journal/v9/n12/full/ngeo2840.html). The significant sink of carbonation is not discussed in the 2006 IPCC Guidelines. EPA should refine its Draft Inventory to account for this sink. Again, PCA would welcome the opportunity to discuss this request in further detail.

Response: **Please see the Planned Improvements discussion in section 4.1 Cement Production of the Inventory report for additional information regarding EPA's planned efforts to address this long-term improvement.**

Commenter: Rhodium Group

Kate Larsen

Comment: The GHG inventory is an extremely useful document and dataset that we use on a regular basis in providing analysis that informs our clients' corporate and policy decision-making. We have come to rely on the regular public release of this data and on EPA's engagement with academia and industry experts in the field to improve methodologies over time. I look forward to seeing the final 2017 Inventory in April.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: Trakref

Ted Atwood

Comment: *Emissions from CFCs and HCFCs should be included in the Inventory*. Fluorocarbons (CFCs, HCFCs, and HFCs) continue to dominate the market share in the United States. In fact, in 2015, approximately 462 million pounds of fluorocarbon refrigerants were consumed in the United States, and that number is expected to rise to approximately 508 million pounds in 2020 (Markets and Markets 2015). Above all, when looking at the U.S. refrigerant market size, an important factor is that the leak rate in the United States has averaged ~25% of the share growth in the market, and neither CFCs nor HCFCs are excluded from the outlook.

Yet, Section 1 of the Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015 (hereby referred to as Inventory) does not include usage emissions from CFCs and HCFCs, even though these are two of the most prominent greenhouse gases (GHGs) with significant ozone depleting potential (ODP) and global warming potential (GWP). Section 1.1 attempts to provide an explanation for their exclusion: "As stratospheric ozone depleting substances, CFCs, HCFCs, and halons are covered under the Montreal Protocol on Substances that Deplete the Ozone Layer. The UNFCCC defers to this earlier international treaty. Consequently, Parties to the UNFCCC are not required to include these gases in national greenhouse gas inventories." Though including CFCs and HCFCs may not be "required," this does not discount their emissions and their significant impact. Excluding them from the Inventory misrepresents our GHG emissions and means that we are without a clear view of the total GHG inventory. This is where the discrepancy with the refrigerant numbers originates. Thus, the following is argued: 1) the emissions from CFCs and HCFCs should be included in the Inventory and 2) fluorocarbon emissions (CFCs, HCFCs, and HFCs) are undercounted across the board, particularly when factoring in reclaim rates, equipment sales, and leak rates. The former shall be explained with a case example of HCFC-22 usage; the latter shall be explained with an overview of market consumption.

First, Section 4.13 of the Inventory details HCFC-22 Production in the United States, particularly the emissions of its byproduct, HFC-23. In fact, it states, "In 2008 and 2009, U.S. production declined markedly and has remained near 2009 levels since." It goes on to describe a "long-term decrease in the [HFC-23] emission rate" and explains that this is in large part due to the decline in production of HCFC-22. However, principally, a decline in production does not equate to a decline in market demand (as evidenced by the stockpiles consumed amid the phaseout). Nowhere in this Section 4.13 is there a

mention of a decline in market demand of HCFC-22. In the Final Rule for HCFC Allowances in 2015-2019 published in October 2014, the EPA concluded "that there is still significant servicing need for HCFC-22."(1) Yet, the consumption of HCFC-22—which is millions of pounds annually—for servicing equipment currently in use has been disregarded in the Inventory. What ends are achieved by doing this? The fact that this particular fluorocarbon refrigerant, HCFC-22, is under a phaseout is secondary, what is primary and most important is the fact that this refrigerant is one of the most commonly used refrigerant and also has a very high GWP that of 1,760. When you take the widespread use of this refrigerant and its high-GWP coupled with the national leak rate average of 25%, that translates to significant emissions into the atmosphere, not to mention reclaim rates of R-22 have been less than expected and recent news reports of a possible impending R-22 shortage (i.e., supply demand imbalance) indicate significant venting of R-22 has occurred. This case example with R- 22 is not an anomaly but rather a symptom of the much larger problem: The undercounting of fluorocarbon emissions.

Response: **As indicated by the commenter, Parties to the United Nations Framework Convention on Climate Change (UNFCCC) are not required to include emissions from CFCs and HCFCs in national greenhouse gas inventories, as these gases are covered under the Montreal Protocol on Substances that Deplete the Ozone Layer. Therefore, the United States does not include emissions from CFCs and HCFCs in Table 4-94 of the Inventory. However, emission estimates of CFCs and HCFCs are summarized in Table A-295 of Annex 6.2 Ozone Depleting Substance Emissions.**

Comment: *Fluorocarbon emissions (CFCs, HCFCs, and HFCs) are Under-counted*. Additionally, if we look to Section 4.23, the problem only enlarges. Specifically, the Section states that 168.6 MT Co2e was emitted from HFCs and PFCs in 2015, and it was the refrigeration and air-conditioning sector that "contributed the most towards emissions of HFCs and PFCs … in 2015 (144.9 MMT CO2e, or approximately 86 percent)." While this number (i.e., 144.9 MMT CO2e from refrigeration and air conditioning) is much too low (and this will be explained momentarily), it should be noted that it does go on to state that "these refrigerants are emitted to the atmosphere during equipment manufacture and operation (as a result of component failure, leaks, and purges), as well as at servicing and disposal event." Thus, HFC emissions from usage and servicing—not just manufacturing (as with HCFC emissions discussed in the preceding paragraph)—are acknowledged. However, despite this acknowledgement, there is still an underreporting of HFC emissions in regards to refrigeration and air-conditioning (144.9 MT CO2e) occurring, which, of course, translates into the HFC and PFC total emission number of 168.6 MT CO2e being too low as well. Let me explain further.

As stated previously, in 2015, approximately 462 million pounds of fluorocarbon refrigerants were consumed in the United States. This consumption number for 2015 alone indicates that the emissions are much more than what is reflected in the Inventory. For instance, take this approximation: Essentially, we have 462 million pounds of refrigerant, attributed to HFCs and HCFCs. Assuming a 1 to 1 correlation between pounds and MMT CO2e, we have an estimated 462 million MT CO2e. Now, 18 million MT CO2e of R-22 was allocated for 2015. By deducting 18 million MT CO2e of R-22 from 462 million MT CO2e, that leaves 444 million MT CO2e. So, in sum, the assumption is 444 million MT CO2e from supply and market activity. Now, let's deduct the following from that number: 145 million MT CO2e for HFC emissions from the Inventory report; 32 million MT Co2e for installation into new equipment (i.e., using a 7% growth rate, which is higher than the actual 4% growth rate in 2015(4), 3 million MT CO2e for destruction, 0 for reclaim (although 10 million pounds recovered, it is assumed they were resold and vented, and the 18 million MT CO2e for HCFCs/CFCs. Once these deductions have been subtracted from the 444 million MT CO2e, that leaves 246 million MT CO2e unaccounted for—This is the

discrepancy. If we add this 246 number to the approximate 145 million MT CO2e found in Table 4-96 of Section 4.23, we get 391 million MT CO2e—In other words, that's our determination of the approximate amount being vented into the atmosphere for 2015 alone. That's staggering (and we haven't even included any assumptions about those numbers in regards to stockpiles). Accordingly, we estimate that for the years 1990 through 2015 nearly 8 billion pounds of F-gas have been vented into the atmosphere. However, the emissions reporting found in the Inventory is not based on venting but rather on a complex tailing report to 65 critical use paths for F-gas, which is essentially demand reporting.

Here's the crux: What does it matter if we consume 462 million pounds of fluorocarbon refrigerants, if there is only one end life: venting? As an illustration, only 1% of all fluorocarbon refrigerants are properly destructed at the end of their lives; the other 99% end up vented into the atmosphere, as there is no destruction requirement for these compounds. With this in mind, it's important to point out: Demand reporting is in conflict with traditional EPA controls. For good reason, EPA doesn't have resources to adequately capture the complex nature of inventory movements in each vertical of consumption space. So naturally, if EPA is using supply controls to manage F-gas phaseout, then we should follow the same path in reporting. That means accounting for consumption through service deployment, through leak emissions and then replacement, etc. Consequently, further research needs to be conducted to determine the actual values of F-gas inventory from a supply perspective—not a demand perspective—so that the EPA can reasonably and accurately calculate it without having to survey industries for their consumption. Importantly, there is one major indication that service ultimately leads to venting: the case of SF6 reporting through the EPA's own Facility Level Information on Greenhouse gases Tool (FLIGHT). Indeed, consumer emissions from SF6 are reported. Therefore, we see and document SF6 usage and their emissions value, but we have no such value for all F-gas refrigerants currently. So, to reiterate, the 391 million MT CO2e of F-gas vented in 2015 is off-the-books. And think of this: if we were to include SF6 emissions into our approximation of the total amount of F-gas vented, that 391 million MT CO2e number would only increase.

As shown above, F-gas emissions are grossly undercounted for, and unless the described reporting issues are addressed and rectified, we will most likely, and unfortunately, continue on this same path: Venting millions of pounds of F-gas without any visibility to the real impact that it has to the bottom line for carbon accounting.

Response: **IPCC guidance (Volume 3, Chapter 7 of the *2006 Guidelines for National Greenhouse Gas Inventories*) indicates that it is not good practice to equate emissions with consumption (i.e., the amount of virgin chemical produced or imported annually in the country minus the amount of chemical destroyed or exported in the year of consideration) as this method does not take into account accumulation or possible delayed release of chemicals in various products and equipment. As explained in the Inventory, estimates of emissions of ozone depleting substance substitutes are from a "bottom-up" model that tracks equipment sales rather than a "top-down" method which would start with chemical sales and reclamation rates as discussed by the commenter. Rather than the commenter's assumption that each pound of fluorinated greenhouse gas is exactly one metric ton of carbon dioxide equivalent, specific Global Warming Potentials (GWPs) are applied to each chemical. See Annex 6.1 of the Inventory report for more information on GWPs. Emissions of sulfur hexafluoride (SF_6) are discussed in Chapter 4 of the Inventory report in sections 4.19, 4.22 and 4.24. These estimates are included in the estimates of total U.S. greenhouse gas emissions.**

Commenter: U.S. Geological Survey

Hendrik G. van Oss

***Comment*: *"Global Warming Potential" Nomenclature*.** In the Ch. 1 Introduction, I was struck by the EPA's adoption of the phrase "Global Warming Potential" (Sec. 1, p. 8) for the title of the table of GHG equivalences. I would urge the EPA to use a less prejudicial phrase. Popular as this phrase may be, it is not well-grounded in science.

Logically, a global warming potential of a GHG ought to be cast in terms of °C/ton or even °C/ton-year, but the units instead are given as tons of CO2e (equivalents), where CO2 itself is defined as 1. This, then, forces the user to rely on whatever warming is ascribed to CO2 by this or that model, over some specified time frame. There is no well-defined global warming potential for a single ton of CO2; the argument is made that XXX zillion tons of anthropogenic releases of CO2 over ZZ years has led to a Y°C increase in average world temperature over that which was occurring naturally (post-Little Ice Age etc...). How long does it take 1 ton of CO2 to begin to have an effect? There are a vast number of variables; the models dealing with these require supercomputers, and come up with different answers. And none of these models have much to go on re. dealing with most of the other GHGs.

Regarding CO2 itself, one cannot, of course, define a °C/ton relationship, and one does not know the destiny of a specific ton of emitted CO2--it may be sucked up by the nearest forest, get absorbed into the ocean, stay in the lower atmosphere, etc...etc.... All of this is poorly constrained. Thus, the EPA should STICK TO WHAT YOU KNOW. The relative (vs. CO2) heat retentions of the various GHGs can be demonstrated in the lab under controlled conditions--this is what you know!--although different studies come up with somewhat different equivalences, as your table shows. What you don't know is the effect, real or potential, of these various gases on the climate; the lab is NOT the global climate. The assumption is made that all the GHGs remain in the atmosphere (long-term) and are uniformly mixed therein, and that there are essentially no sinks--all of which are dubious, especially for some of the more exotic GHGs. I would thus urge the EPA to drop the phrase "Global Warming Potentials" and instead provide the same data under non-prejudicial phrasing such as: Greenhouse Gas Equivalences or Greenhouse Gas Heat Retention Equivalences. And then you can use straightforward phrasing such as "..emissions of CO2 and CH4 (in terms of CO2- equivalents)....." You can measure (or calculate reasonably well) the emissions, right now, this year, next year... The emissions are what you know.

***Response*: See also Annex 6.1 of the Inventory report. Global Warming Potential (GWP) is intended as a quantified measure of the *globally averaged relative radiative forcing impacts* of a particular greenhouse gas. It is defined as the cumulative radiative forcing–both direct and indirect effects–integrated over a specific period of time from the emission of a unit mass of gas relative to some reference gas (*Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*). Carbon dioxide (CO_2) was chosen as this reference gas. Direct effects occur when the gas itself is a greenhouse gas. Indirect radiative forcing occurs when chemical transformations involving the original gas produce a gas or gases that are greenhouse gases, or when a gas influences other radiatively important processes such as the atmospheric lifetimes of other gases. GWP values allow policy makers to compare the impacts of emissions and reductions of different gases.**

More information on global warming potential and other metrics for comparing different emissions can be found in the IPCC *Fifth Assessment Report (AR5), Working Group I: The Physical Science Basis*.

Comment: *Cement Production.* I looked also at the Ch. 4 Industrial Processes & Product Use, most closely at the section on Cement (I developed the cement methodology for the IPCC). I have a few minor quibbles: Table 1-4 and in the cement section (Sec. 4, p. 3): the USGS has yet to publish a (Minerals Yearbook--MYB) production number for clinker for 2015, but the USGS monthly reporting (December 2016 edition) now shows USA (including Puerto Rico) production of clinker = 76,603,356 mt; if past MYB reporting is a guide, the MYB number for 2015 will be very close to this number (because I allow no more than a 5,000 short ton/year difference for a specific plant's monthly vs. annual reporting and most agree within a few tons). Where larger (> 5,000 st) discrepancies are found, I ask the companies to review their data, and usually some revisions are then forthcoming. This comparison and revisions to 2015 data have been ongoing throughout 2016, and with the December 2016 monthly report, the final monthly data for 2015 are provided. Unfortunately, we are still missing nearly 20 annual forms for the 2015 survey as of 3/16/2017, so I do not know when the 2015 MYB tables will be available. Anyway, this new monthly data total for 2015 would yield process emissions of 39.9 Mt CO2, using the 0.5101 EF and a CKD adjustment of 2% (i.e., clinker x 0.5101 x 1.02), not the 39,587 kmt/39.6 Mt CO2 figure that you give (which was based on a now obsolete clinker number). Monthly data for 2016, by the way, show a small (1.22%) decline for 2016 vs. 2015, but the 2016 data remain subject to revision for the next 12 months. The 2016 decline was a surprise--our 2017 Mineral Commodity Summaries had a small estimated increase for 2016, as indeed was indicated at the time of its writing (data in hand at that time were for 1-8/2016, I believe).

Response: **The latest data provided by USGS and published in early March 2017 is integrated into the Inventory report. In addition, this year EPA integrated clinker production data from EPA's GHGRP (Part 98) into the time series for 2014 and 2015. Updated USGS data were used as QC for 2014 and 2015; see Table 4-4 on p. 4-10. Consistent with previous Inventory reports, EPA will update historical data and recalculate emissions with final publications of USGS data (for 1990 to 2013) for the next Inventory and will continue to use more recent years for comparison. EPA plans to continue regular engagement with the USGS commodity expert on clinker production values as EPA compiles the next Inventory report. Please also refer to the Methodology and Recalculations Discussion sections in section 4.1 Cement Production for more information on the data utilized in estimating 2015 emissions.**

Comment: Line 4-5: please refer to the USGS as the U.S. Geological Survey **National Minerals** Information Center. You have a slightly different wording.

Response: **This change has been made in the Inventory diagram on p. 1-12.**

Comment: On line 7 your wording (as to what goes on in the kiln) is slightly misleading--you need to describe the calcination reaction as (from a GHG process emissions perspective) as being the key reaction (current wording makes it sound like a lime kiln). The equation given (CaCO3 + heat = CaO + CO2) is correct, but this reaction takes place in the temperature range of about 700 - 1000°C, not 1450°C. The 1450°C is the temperature that the raw materials are then (post-calcination) taken to so as to achieve a reasonable rate of formation of the alite mineral phase (C3S in shorthand via the reaction C2S (belite) + C = C3S, where C = CaO and S = SiO2)--this is the so-called sintering phase of clinker formation, and includes partial melting. Alite starts to form at 1338°C, but because there is only slight melting at that temperature, the reaction is very slow; given practical residence times in the kiln, they

take the temperature higher (to 1450°) so as to have 20-30% melting, which speeds the reaction significantly. But, the sintering reaction has essentially no effect on process emissions.

Although the emissions from fuel combustion are, of course, dealt with in a separate section, some mention of them should be made because clinker manufacture is highly heat-intensive. The fuel combustion emissions will, however, depend on the kiln technology (re-use of heat, hence less fuel; use of a precalciner) and the type of fuels. What likely is not estimated adequately are emissions from burning of waste fuels (the data are poor), and the contribution of kerogen in the raw materials (as well as any other carbon, such as graphite, or soot in, say, fly ash) fed into the kiln.

If we are using a wet kiln, the 30-40% slurry water will first need to be evaporated (c. 1.8 GJ/ton clinker), the nowdry raw material mix needs to be raised to calcination temperatures (i.e, preheating), which is another ~ 1.8 GJ/ton clinker, then the calcination is done while raising the temperature to about 1000°C (yet another 1.8 GJ/t), and then the sintering is done (to 1450°C)--which only adds ~ 0.2 GJ/t because the alite-forming reaction noted above is highly exothermic. Anyway, depending on the technology, a lot of fuel gets burned to provide this heat--typically 150-200 kg of coal or similar per ton of clinker. So the process emissions are only about half the story!

Response: **The change regarding the description of the calcination reaction process has been made in the Inventory report. With regard to combustion emissions, note the first sentence of section 4.1 states that *"*Emissions from fuels consumed for energy purposes during the production of cement are accounted for in the Energy chapter."**

Comment: Line 16: you earlier describe clinker as being 65% CaO (all from CaCO3) and quote me as saying that this is reasonable (which it is). You should thus adjust the EFclinker derivation equation to use the CaO factor of 0.65 and NOT 0.6460. The latter number is inherited from older summaries, and derives from a straight arithmetic average of a few sample clinker analyses given on an old cement chemistry book--it is too precise. We can justify an average of 65%, but cannot justify 64.60%. Using the rounded CaO content of 0.65 changes the derived EF clinker to 0.5101 t CO2/t clinker (and then we multiply this by 1.02 to given a token accounting for "lost" CKD).

Response: **This change has been made in the Inventory report, see section 4.1 of Chapter 4.**

Comment*: Other Process Uses of Carbonates*. Other carbonate use: you show a CO2 fraction of limestone of 0.43971--this implies that the limestone is 100% CaCO3, which it will almost never be. I'd round it to something more like 0.43 (= 98% CaCO3), or deduct a couple of percent from the calculated CO2 to better represent an actual high-purity limestone.

Response: **This change has been made in the Inventory report, see section 4.4 of Chapter 4.**

Comment: *Iron and Steel*. Page 4-60, line 9-2--I noted a statement along the lines of "...62% of U.S. steel was produced in one of seven States..." -- I think you meant to say: "...62% of steel produced in the USA was from seven States..." (I do not believe that 1 of these 7 did 62%...). I did not have time to review the iron and steel section very thoroughly.

Response: **This change has been made in the Inventory report, see section 4.16 of Chapter 4.**

Comment: **Blast Furnace and Steel Furnace Slags.** One issue not addressed, and as the Fe slag specialist at the USGS, I cannot actually answer, is the possibility that there is a small carbon content of blast furnace and steel furnace slags--either as a minor component of the silicate slag phases or as a modest component of any entrained metal. Perhaps one of your steel company specialists can address this possibility. All of my books on slag have chemical analyses that make no mention of carbon. But because we would, in the carbon balance of the blast furnace, deduct c. 4-5% C in the crude (or pig) iron (although most of this will be subsequently burned off in the steel furnace), there is a possibility that some elemental C gets caught up in the slag (possibly as entrained kish or even within entrained crude iron).

Response: **EPA will consider this comment in making future improvements, pending review of literature to understand and address this possibility.**

Commenter: University of Virginia

Deborah Lawrence

Comment: Thank you for all the work that went into the inventory of US GHG emissions and sinks. Without this knowledge, we cannot begin to contemplate effective action to limit climate change. Without this knowledge, we cannot honor our obligations to the UNFCCC, and more importantly, to the most vulnerable on this planet and to future generations. Thank you for all you do.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Comment: I would like EPA to take a closer look at the way they account for emissions and sinks in the land use sector. Being from the southeast, I am very concerned that much of the apparent 'timber' extraction is actually much more like 'pulp' extraction in its effects. Wood is being removed to create wood pellets, not to create long-lived carbon sinks in houses. Wood pellets go straight back into the atmosphere within the year. Very different fate from wood that is actually made into timber.

Response: **The Forest Inventory and Analysis (FIA) program captures harvest removals, but those are not attributed to a particular product or use. Furthermore, there is a lag in the removals within the FIA program and there are other sources that provide more timely estimates that have historically been used in the WoodCarb II model used for the Inventory of Harvested Wood Products (HWPs) estimates. The Inventory team intends to use Timber Products Output data from the FIA program (**https://www.fia.fs.fed.us/program-features/tpo/**) in the years ahead as EPA moves towards an annual, design-based sampling framework which will provide more timely information useful in assessing product use and appropriately tracking emissions and removals from HWPs.**

Comment: In general, I would like to see EPA account for biofuels more fully—especially when they come from forests. Wood-based biofuels are not carbon-neutral. Burn wood, emit CO2—and emit more CO2 per BTU of energy than many fossil fuels. I'd like to see EPA account for that.

Response: **EPA has added accounting of biodiesel used in the transportation sector to Section 3.10 of the Inventory report for more transparency.**

Commenter: Waste Management, Republic Services, National Waste & Recycling Association, Solid Waste Association of North America, SCS Engineers, and Weaver Consulting Group

Kerry Kelly

Comment: *The Inventory of U.S. Greenhouse Gas Emissions and Sinks is a valuable and necessary data source.* The U.S. Greenhouse Gas (GHG) inventory is a credible data source, rather than a policy document, and provides important information, based on sound and transparent methods for many public and private stakeholders. The landfill sector relies on the U.S. GHG inventory for variety of purposes. These include tracking GHG emission trends at the national and state levels, in total and by sector (e.g., waste), and by source category (e.g., MSW landfills). Because the inventory covers the six major greenhouse gases – carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride – GHG-specific trends in emissions can also be developed at the national and state levels, in total, and by sector, source category. This information is important to private companies seeking to compare their emissions performance to national trends, and to educate customers and communities. The information is also important to public sector waste officials to educate the public and to make more informed decisions about solid waste management planning.

Other stakeholders, including states rely on the U.S. GHG Inventory as a model for developing their GHG emissions data. The inventory data are used in policymaking contexts by Federal agencies, state governments, corporations and trade associations, and non-governmental organizations. In addition, the data are used by investment firms, academics, companies and many others seeking information on GHG emission trends. Scientists also use the GHG inventory data to develop atmospheric models and to compare airplane or satellite emissions monitoring to the GHG inventory's bottom-up approach.

The U.S. GHG inventory provides useful and detailed data on GHG emissions in the United States across many sectors. Since EPA began preparing the U.S. GHG inventory in the early 1990s, the Agency has refined the GHG inventory in several important ways. First, in addition to calculating the emissions each year, EPA also quantifies uncertainties for all source categories, implements quality assurance and quality control, and updates new methodological approaches as needed. Second, over the years the GHG inventory development process has been improved to incorporate significant stakeholder input and transparency. Specifically, EPA has added two opportunities for comment – one for technical experts and the other for the public.

EPA has engaged with industry stakeholders concerned about emission levels, methodological approaches, or other topics related to their sector emissions. In fact, the landfill sector raised such concerns over the last year, and we appreciate EPA's efforts to understand and improve the methodology used to quantify MSW landfill emissions.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Comment: *We support EPA's use of net CH4 emissions from the GHGRP.* We strongly support EPA's decision to use landfill-specific emissions data from the GHGRP in the Inventory as we conclude it is more reliable and accurate data for estimating emissions from MSW landfills. In previous comments on this issue, we explained why using GHGRP data is the preferred approach.

The MSW landfill sector (Subpart HH) emissions data are significantly more detailed and up-to-date than the estimation approach used in previous GHG Inventories;

Every MSW landfill reporting to Subpart HH is subject to annual validation via EPA review of submitted data – a level of scrutiny that does not occur in the GHG Inventory;

Each MSW landfill that reports under Subpart HH has a "designated representative," who must certify – under penalty of law – that the data submitted by the site are accurate and developed in accordance with regulatory requirements.

These data provide a more detailed and accurate approach to emissions quantification for the majority of U.S. MSW landfills. Subpart HH data elements include historical and current waste disposal quantities by year, CH4 generation, gas collection system details, CH4 recovery, CH4 oxidation, and CH4 emissions, and thus, are considered "Tier 3" (the highest quality) data under the IPCC Guidelines.

The landfill sector recognizes that the new methodology uses both the first-order decay model and back-casting methods. We agree with EPA's approach of (1) using the actual GHGRP data for years 2010 to 2015; (2) back-casting emissions based on overlap between the GHGRP and the FOD model for the years 2005 to 2009; and (3) using the FOD model with some updates for the years 1990 to 2004. It is our view that this approach leverages the GHGRP data in a useful way, while also recognizing that an over-reliance on GHGRP data in the early years of whole time-series could create uncertainty.

We also agree with EPA's decision to rely on Environmental Research and Education Foundation (EREF) reports on waste disposal, which are to be published every three years. As EPA notes, "data were extrapolated for 2014 and 2015 based on national population growth because no data are available from these sources [State of Garbage (SOG) or EREF] for those years. Upon publication of the next EREF report, the waste landfilled for 2014 to the current Inventory year will be updated." (U.S. EPA, Draft U.S. Inventory, Annex 3.14, p. 393)

Response: **EPA appreciates the commenter's support of the methodology changes to the MSW landfill emissions calculations in the 1990-2015 Inventory.**

Comment: *Applying a scale-up factor to the GHGRP data.* Recognizing that the GHGRP does not include every landfill in the country – small landfills and industrial landfills do not report to the GHGRP – we support EPA's decision to use a scale up factor to estimate emissions from non-reporting landfills. In the current U.S. Inventory, EPA has applied a scale-up factor of 12.5 percent to cover the non-reporting landfills, and the Agency also states "this scale-up factor may be revised in future years after a thorough review of available data for the non-reporting landfills is completed" (p.7-11). We are concerned that the scale-up factor of 12.5 may be high, and remind the Agency that we recommended that a scale-up factor of 10.0 would be sufficiently conservative to avoid underestimating emissions. We thus urge EPA to move expeditiously in reviewing emission estimates for non-reporting GHGRP landfills.

Response**: As stated in the Planned Improvements of Section 7.1 Landfills of the 1990 through 2015 Inventory, EPA will continue to investigate the annual waste disposal quantity for landfills not reporting to EPA's GHGRP and engage with stakeholders to develop a more precise scale-up factor to**

apply to the GHGRP data. The LMOP database, WBJ database, and other datasets will be reviewed against the GHGRP waste disposal data.

Comment: *We support the Agency recalculating MSW generation and disposal data and CH4 generation estimates for the years 1990 to 2004.* For the period 1990 to 2004, EPA is relying "on the previous methodology, … whereby a disposal factor is applied to nationwide, annual MSW generation amounts."4 Based on a recent EREF report, "the MSW generation data were modified for the years 1990 – 2013 to reflect recently published data and to align with how MSW quantities are applied under Subpart HH of the GHGRP to estimate CH4 generation." 5 Specifically, EPA revised earlier SOG survey data "to exclude construction and demolition waste and inert materials from the annual quantities of waste generated used in the first order decay model."6 SOG surveys are available for 2002, 2004, 2006, 2008, 2010, and 2013, and EPA used these data to extrapolate MSW generation for the years 1990 and 2001, and to interpolate for 2003. The landfill sector supports this methodological approach, as the data show a relatively consistent downward trend, which contrasts with the initial trend line in the Draft Inventory for 1990 – 2014, where CH4 emissions began increasing around 2002.

Response: **EPA appreciates the commenter's support of the methodology changes to the MSW landfill emissions calculations in the 1990 through 2015 Inventory.**

Comment: *The Agency's Merging methodologies for time series consistency appear appropriate.* We have concluded that EPA used the IPCC's methodologies for time series consistency in an appropriate manner. We note that EPA used the "overlap" method during the period when the previous method and the new method could both be applied (e.g., 2010 to 2015), and used the back-cast method, based on the trend lines in 2010 to 2015 data, to estimate CH4 emissions from 2005 to 2009. Finally, EPA applied its previous method to estimate CH4 emissions from 1990 to 2004, with certain modifications described in the previous section. Overall, we find that EPA's revised approach to the MSW Landfill category of the GHG Inventory is much improved, and we appreciate EPA's efforts to update the GHG Inventory estimation methodologies.

Response: **EPA appreciates the commenter's support of the methodology changes to the MSW landfill emissions calculations in the 1990 through 2015 Inventory.**

Comment: *EPA's Planned Improvements.* As noted previously, EPA is planning to investigate annual waste disposal quantity for landfills that do not report under GHGRP Subpart HH. In addition, EPA "will also investigate options to adjust the oxidation factor for those non-reporting landfills from the default 10 percent currently used, to another value such as those included in the EPA's GHGRP." The landfill sector strongly supports EPA's plan to adjust the oxidation factor from 10 percent. We note, however, that EPA appears to be considering the use of "another factor" for non-reporting landfills. To the extent most non-reporting landfills are likely to be small, old, or both, we urge EPA to apply appropriate factors to different types of landfills, based on the range of oxidation factors provided in Subpart HH.

Response: **As stated in the Planned Improvements of Section 7.1 Landfills of the 1990 through 2015 Inventory, EPA will investigate options to adjust the oxidation factor from 10 percent currently used, to another value such as those included in EPA's GHGRP.**

Comment: *We support EPA's decision to use the oxidation factors currently being used in Subpart HH for the years 2005 to 2015 and change oxidation factors in the 1990 – 2004.* It also appears that EPA has

decided to revise the long-standing approach of using 10 percent oxidation for all landfills based on the following statement in Annex 3.14:

> Results from this research consistently point to higher cover soil methane oxidation rates than the 2006 IPCC Guidelines default of 10 percent. A continued effort will be made to review the peer-reviewed literature to better understand how climate, cover type, and gas recovery influence the rate of oxidation at active and closed landfills. At this time, the IPCC recommended oxidation factor will continue to be used for all landfills for the years 1990 to 2004. (emphasis added)

We support EPA's decision to use the oxidation factors currently being used in Subpart HH for the years 2005 to 2015. Further, it seems reasonable to change oxidation factors in the 1990 – 2004, as the non-reporting facilities are largely old small closed landfills with final cover material compatible with RCRA Subtitle D requirements, which took effect May 1991.

Response: **As stated in the Planned Improvements of Section 7.1 Landfills of the 1990 through 2015 Inventory, EPA will review peer-reviewed literature to determine options for updating the oxidation factor to better reflect oxidation rates for the years 1990 to 2004.**

Comment: *We urge EPA to make additional enhancements in next year's inventory, particularly with respect to the DOC factor and Lo.* EPA should review and incorporate updated DOC values, based on EREF's research. As noted in our previous comments related to key revisions in the Draft Inventory for 1990 – 2015, we urge EPA to develop updated DOC values, based on research provided by EREF. We recommend that EPA acknowledge that the long-standing default DOC values are obsolete and initiate a process to update them. Per EREF:

> "The implicit assumption with a guideline value … is that the types and proportion of MSW materials, both degradable and inert, is relatively constant and uniform. If the proportions of either degradable or inert waste materials going into a landfill changes, the fraction used in the DOC calculation may also change and potentially result in a different DOC value. In such instances, the DOC guidelines would yield estimates of landfill gas emissions that are less representative of real-world conditions. An additional complicating factor in the use of a single representative DOC value as a guideline is that, in addition to MSW, MSWLFs in most states may accept one or more non-MSW Subtitle D wastes (Staley, B.F. and D.L. Kantner, Environmental Research and Education Foundation (EREF), "Estimating Degradable Carbon in MSW Landfills and the Impact of Non-MSW Materials," 2015, p. 2).

As EREF has explained to EPA during the recent MSW landfill stakeholder process, for MSW-only landfills, EREF's analysis found that "an average DOCMSW of 0.184 was computed from the state study data, with values ranging from 0.142 - .209 (p. 6)" A default value of 0.2028 is the DOC value currently used in the CH4 generation estimates from MSW-only landfills. EREF also analyzed non-MSW materials going into MSWLFs, and notes that "Given a third of incoming waste to MSWLFs consists of non-MSW materials, there is significant potential for non-MSW materials to impact the relative fraction of organics and degradable organic carbon (DOC) of the MSWLF waste stream" (p. 9).

Based on this analysis, EREF concludes: The average computed DOC value for MSW waste using state data was 0.184, or roughly three-fifths of the MSW guideline value. The average computed DOC value

for bulk waste using state data was 0.161, or roughly four-fifths of the bulk waste guideline. This analysis suggests that the U.S. EPA's guideline DOC values of 0.31 for MSW-only landfills and 0.20 for facilities accepting non-MSW Subtitle D wastes overestimate DOC at these landfills and, as a result, may result in inaccurate estimate of landfill gas generation and methane emissions (p. 13).

We recognize that EPA has not yet engaged in updating the DOC, Lo, and k values, and we also note that EPA has determined that "a value of 100 m3/Mg appears to be a reasonable best estimate to use in the FOD model for the national Inventory for years 1990 through 2004, and is the value used to derive the DOC value of 0.2028" (US EPA, Draft US GHG Inventory p. A-395). At the same time, we strongly urge EPA to begin updating the DOC default values next year, focusing on the years 2004 to 2015. EREF's research shows that changes in the waste stream disposed in landfills over the last decade – specifically, the decline in organics and the increase in non-MSW waste in MSW landfills – have led to DOC values that are lower than in previous years. Based on EREF's more recent research, particularly with respect to the decline in organic waste going into landfills, we recommend that EPA to review the information available in the GHGRP to determine whether data in that dataset would be more useful. Presuming that Subpart HH contains the necessary data elements, it may be possible for EPA to develop a more scientifically sound approach to updating the DOC values, which would rely on significantly more landfills.

Response: **As stated in the Planned Improvements of Section 7.1 Landfills of the 1990 through 2015 Inventory, EPA will continue to review the DOC value used in the first order decay model, review peer-reviewed literature, and engage with stakeholders to determine options for updating it, as appropriate.**

Commenter: Water Environment Federation

Patrick Dube

Comment: Change "sewage sludge" to "biosolids" throughout the document to be more in line with EPA's own preferred nomenclature.

Response: **This change has been made in the Inventory report.**

Comment: Page 6-47 Line 17 - The land application of biosolids have been shown to significantly increase soil organic carbon.

Response: **EPA agrees with the commenter that land application of biosolids can increase the organic carbon contents of soils. While biosolids are not specifically mentioned on page 6-47, lines 17 through 19 of the draft Inventory report, biosolids would be considered as an "organic amendment," and a carbon input. Currently, biosolids are only considered to be applied to Grasslands as EPA does not have data that would allow us to distinguish between application to different land uses. See page 6-66 in the final Inventory report under the heading "Additional Mineral C Stock Change Calculations" for information on how biosolids are currently treated in estimating soil carbon stock changes.**

Comment: Page 6-66 Line 22-23 - In regard to the line "Cropland is not likely to be amended with sewage sludge due to the high metal content and other pollutants in human waste": Biosolids are safe

to be land applied to cropland when following EPA's federal biosolids rule 40 CFR Part 503. Part 503 rule limits the amount of metals, pathogens and dioxins that can be applied while also outlining a process for crop harvesting, record keeping and reporting standards. The proper land application of biosolids can increase crop growth and yield while reducing fertilizer costs and improving soil health.

***Response*: This line has been edited in the final Inventory report to state: Although biosolids can be added to land managed for other land uses, it is assumed that agricultural amendments only occur in Grassland Remaining Grassland.**

Comment: Page 7-32 Line 11 - Replace 'www.wef.org/biosolids' with the more direct link 'http://www.resourcerecoverydata.org/'

***Response:* This change has been made in the Inventory report.**

Commenter: A. Aoki

Private Citizen

Comment: I am writing (as a non-scientist) to voice my support for the Draft GHGI and EPA's continuing work in documenting greenhouse gas emissions. We need to keep these kinds of records so that our society has accurate information on both greenhouse gases and how to reduce emissions. This data is needed to protect our public health and well-being, our food and water security, and our economic growth. Without the EPA's work on the GHGI and the public availability of data, scientists will find it harder to develop atmospheric models. Policy makers will not be able to make science-based decisions about emissions policies or know if the policies are working. Regulatory agencies and corporations won't have a way to establish and measure compliance with emissions policies. Businesses, the public, and interest groups will be uninformed about greenhouse gases.

***Response:* EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: L. Aoki

Private Citizen

Comment: I am writing to voice my support for the EPA's work in documenting greenhouse gas sources and sinks in the United States. We need to sustain this record of US emissions so that our society has accurate information on both greenhouse gas emissions and efforts to reduce those emissions. By making this inventory publicly available, the EPA provides an invaluable service to policymakers at all levels of government, to leaders in industry and business, and to individual citizens. Climate change is a threat to all Americans - to our public health and wellbeing, our food and water security, and our economic growth. EPA should continue this critical work on the greenhouse gas inventory so that we have the knowledge we need to move forward in addressing climate change.

***Response:* EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: S. Aoki

Private Citizen

Comment: This is a valuable report that provides data on a natural source/sink and industry-by-industry basis in a consistent format. It is particularly important to have validated longitudinal series for future scientific and economic analysis.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: B. Chadwick

Private Citizen

Comment: page 2-10: "The remaining 18 percent came from other energy sources such as hydropower, biomass, nuclear, wind, and solar energy (see Figure 2-5 and Figure 2-6)": Add the '2015 U.S. Energy Consumption by Energy Source' pie chart (e.g. Figure ES-12 on page ES-19) to show all categories of energy sources. Figure 2-5 and Figure 2-6 are incorrectly referenced for this statement. Add a statement to the introductory paragraph about what is presented in Figures 2-5 and Figure 2-6.

Response: **The text was adjusted to reflect the figures being referenced. EPA will consider further edits to respond to this comment in future versions of the Inventory.**

Comment: page 3-7: Figure 3-4: "U.S. Energy Consumption (Quadrillion Btu)": (1) change the scale of the y axis to provide more detail; (2) add gridlines so that energy consumption can be read more easily from the graph; (3) It appears that data for energy consumption + consumption of fossil fuels for non-energy use have been graphed with a peak of about 100 qBtu in 2007. From my estimates, using fossil fuel energy data provided in Table A-18 of EPA's draft Inventory and nuclear and renewable energy provided in the EIA's MER, total energy consumption in 2007 peaked at about 93 qBtu.

Response: **The values in Figure 3-4 have been updated to reflect the values used in the final release of the Inventory report. EPA will consider further edits to the Figure 3-4 to add clarity. According to Table 1.3 of EIA's MER, total primary energy consumption was greater than 100 QBtu in 2007.**

Comment: pages ES-19 and 2-10: "In 2015, approximately 82 percent of the energy consumed in the United States (on a Btu basis) was produced through the combustion of fossil fuels...": From my estimates, in 2015, total fossil fuel energy in the US (not including US Territories) amounted to 71.8219 qBtu (using data in Table A-11 of the EPA's Inventory Annexes). Nuclear and renewable energy (including geothermal energy) and imported electricity amounted to 18.014 qBtu (using data in EIA's February 2017 Monthly Energy Review, Tables 1.3 and 2.6). So fossil fuel energy was about 80% of total energy consumed in 2015.

Response: **Table A-11 in the Inventory report is adjusted to account for non-energy uses. Just using EIA MER data for 2015 in Table 1.1, fossil energy accounted for 81 percent of total energy consumption.**

Comment: page 2-10 and 3-1: Figures 2-5, 3-1: "2015 Energy Chapter Greenhouse Gas Sources (MMT CO2 Eq.)": The scale of the bar chart deemphasizes the significance of fossil fuel combustion:- Shorten the "bar titles" so that the bar representing "fossil fuel combustion" can be lengthened.
Redoing the adjacent piecharts of these figures, to show "fossil fuel combustion emissions" as a percent of total US greenhouse gas emissions (5,049 MMTCO2 Eq. is 77% of 6,586.2 MMTCO2 Eq) would help readers see why climate change policy should be centered on reducing fossil fuel consumption.

Response: **EPA will consider edits to respond to this comment in future versions of the Inventory.**

Comment: page 2-3: "Energy-related CO2 emissions also depend on the type of fuel or energy consumed and its C intensity. Producing a unit of heat or electricity using natural gas instead of coal, for example, can reduce the CO2 emissions because of the lower C content of natural gas": Explain that the carbon intensity of an energy mix is the energy-weighted average of the CO2 emission factors of all energy sources in the mix including carbon-free/neutral energy sources. Provide a table of CO2 emission factors for all energy sources including nuclear and renewable energy and/or refer readers to Table A-39: "Key Assumptions for Estimating CO2 Emissions" in the Annexes to the Inventory with an explanation on how to convert "carbon content coefficients" to "CO2 emission factors". Describe the decarbonization of the US electric power sector between 2005 and 2015, as done on page 3-14.

Response: **A reference to Table A-39 was added to the text. A discussion of the decarbonization of the electric power sector was added to the Energy portion of the Trends chapter**.

Comment: page ES-12 : (a) "Recently, a decrease in the carbon intensity of fuels consumed to generate electricity has occurred due to a decrease in coal consumption, and increased natural gas consumption and other generation sources. Including all electricity generation modes, electricity generators used natural gas for approximately 33 percent of their total energy requirements in 2015": Clarify the decarbonization of the primary energy consumed to generate electricity (qBtu) (e.g. 37% coal; 36% nuclear and renewable; 26% natural gas; 1% oil products in 2015) and/or the electricity generated (kWh) (e.g. 34% coal; 33% nuclear and renewable; 32% natural gas; 1% oil products in 2015) with a breakdown of energy groups in the mix and provide a piechart.

Response: **A discussion of the decarbonization of the electric power sector was added to the Inventory report, including a figure showing relative contribution of different energy sources and emission trends.**

Commenter: K. Grote

Private Citizen

Comment: Thank you for the EPA's continued commitment to meet its UNFCC treaty obligations for submitting and publishing annual GHG inventory reports. I also appreciate that the USA has been a leading developer of new and improved methodologies for estimating emissions and sinks, which are used widely by domestic audiences and the international community. In my two previous roles at Pacific

Gas and Electric Company and at EOS Climate, Inc., I relied heavily on GHG estimation methods in my work. At PG&E, I was working with local governments in the San Francisco Bay Area to reduce their greenhouse gas emissions. All of our community inventories relied heavily on your GHG estimation methodologies. At EOS Climate, we sought to develop new environmental commodities traded on blockchain technology. Again, our accounting methodologies relied heavily on your work.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: A. Haber

Private Citizen

Comment: I am writing in support of continued work on the national Greenhouse Gas Inventory. I greatly appreciate that your agency does this work, and that it is publicly available. The continuance of data on US GHG emissions is non-partisan, and will benefit everyone nationally as well as globally. In addition to ensuring the well-being of our planet, this is critical for public health and food security.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: M. Horn

Private Citizen

Comment: Thank you for your ongoing commitment to meeting UNFCCC treaty obligations for reporting and publishing annual GHG inventory reports. As an American living overseas, I'm proud the USA has been a leader in developing new and improved methodologies for estimating emissions and sinks that have gained acceptance at home and serve as a model overseas. GHG estimation methods and U.S. GHG data is important for enabling global GHG emission management. If the quality of those data are compromised, it would cause enormous headaches later when much of the world moves to a CO2 emission "budget" regime, as proposed in IPCC assessment review V. It would be a nightmare if US data has to be adjusted in the future because quality issues such as tinkering, discrepancies, and gaps come to light that require "margins of safety" to be added to ensure US emissions remain on budget. Let's not move backwards now! The world is watching.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Comment: I'm especially concerned about fugitive methane leaks at the well head in hydraulic fracturing. As reduced emission completions (green completions) were phased in by the Obama administration in consultation with the American Petroleum Institute, I thought the industry had realized upholding this standard was in its best interest but the Trump administration seeks to roll them back at API's bequest. This would be a major setback and likely make the task of accounting for methane emissions from fracking even harder and uncertain.

Response: **Methane emissions from hydraulic fracturing (HF) completions and workovers are included in the Inventory for both natural gas and petroleum systems. For natural gas systems, EPA calculates national HF completion and workover emissions using data from EPA's GHGRP on completions and workovers that vent without controls, that flare, that use RECs and that use both RECs and flaring. For petroleum systems, EPA calculates national HF completion and workover emissions using data from DrillingInfo on gas production from oil wells, assumptions on duration of completion and workover events, and an estimated flaring rate. EPA will review upcoming data from the GHGRP on hydraulically fractured oil well completions and workovers, available in 2017 for the first time, for potential updates to the Inventory.**

Commenter: P. Lawrence

Private Citizen

Comment: I cannot see any issue more important than climate change. We must have data to deal with that. Hence there is a desperate need for the relevant data gathering which the EPA is in charge of. It is of utmost importance that this data inventory continue with the funds necessary to maintain it.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: M. Macrae

Private Citizen

Comment: I would like to thank the EPA for their continued commitment to meet is UNFCCC treaty obligations for submitting and publishing annual GHG inventory reports. The USA has been a leading developer of new and improved methodologies for estimating emissions and sinks, which are then used widely by domestic audiences and the international community. This data helps support institutions such as Harvard in evaluating their own carbon footprint and developing adaptation and resiliency planning. Please continue this effort.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: R. Palomaki

Private Citizen

Comment: I am writing to express my support for continued EPA funding for programs like the Greenhouse Gas Inventory. As the most powerful nation on Earth, the United States has a duty to be a global leader in combating climate change. We can only continue to serve in this role with sufficient funding to agencies like the EPA. Reports like the GHG Inventory will ensure that our scientists, and indeed scientists across the globe, are provided with up-to-date, factual evidence about greenhouse gas emissions and the effects that those emissions have on our atmosphere. Climate change is not a partisan issue. The effects of greenhouse gas emissions will cross all political, racial, and class divides.

We owe it to future generations to continue this research and do all in our power to reverse the trends already in motion.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: C. Ridenour

Private Citizen

Comment: Thank you for the inventory of US GHG emissions. The inventory is critical to let industry and others know how we are doing – and to live up to our commitments to the world community. Working hard on understanding sources and sinks is critical, and as a US forest owner, I am always especially interested in the methods for measuring sequestration from forests. Transparency is key.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: F. Seymour

Private Citizen

Comment: I write to express my appreciation for the EPA's work on producing an inventory of US GHG emissions and sinks, and for making the report available for public review. I work on international forest and climate policy, and the USG attention to producing such reporting, and undertaking public consultation, is both essential for US leadership on climate change, and useful for modelling best practices for other countries. I do not have detailed comment on the report itself, but am grateful to have been offered the opportunity.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: C. Tingley

Private Citizen

Comment: I find this inventory valuable. It is only by tracking this inventory over time that we can determine how we are doing. Climate change is the greatest existential threat to the United States and we must remain on focus to address it.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**

Commenter: J. Venezia

Private Citizen

Comment: Thank EPA for your continued commitment to meet UNFCCC treaty obligations for submitting and publishing annual GHG inventory reports. The USA has been a leading developer of new and improved methodologies for estimating emissions and sinks, which are then used widely by domestic audiences and the international community. I use GHG estimation methods and U.S. GHG data all the time in my work and analysis, helping my clients do carbon footprinting and looking for ways to reduce their GHG emissions.

Response: **EPA appreciates the commenter's support for the annual development of the Inventory of U.S. Greenhouse Gas Emissions and Sinks.**
